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MOBILE AND WEB RECOMMENDATION APPLICATION IN THE SEMANTIC WEB PARADIGM. A CASE STUDY[1]

Abstract: This paper focuses on a Mobile and Web-based Recommendation application operating on the Semantic Web's resources, called *Taste It! Try It!*. The application consumes Linked Data (while creating the reviews), producing semantic annotations (about the reviewed entities), and then querying the gathered data using the reasoner in order to offer personalized recommendations. Within this paper, we present the final prototype of the tool and its functionalities.

Keywords: Recommendation System, semantic annotations, incentive mechanisms.

1. Introduction

Recommender Systems (RS) are information search tools designed in order to cope with the information-overload problem, i.e. the typical state of a consumer, having too much information to make a decision [Adomavicius, Tuzhilin 2005; Łazaruk et al. 2012]. Recommender systems take advantage of software instead of users to carry out the information filtering tasks [Peis, del Castillo, Delgado-Lopez 2008]. This approach, however, has some disadvantages. The communications process, either between agents and users or agents only, is complicated due to the heterogeneity of information representation, which in turn leads to the incapability of its reuse in other processes and applications. Thus, Semantic Web technologies are more and more often used within the recommender systems.

The Web has evolved into the Web of Data [Bizer, Heath, Berners-Lee 2009] by using a set of best practices for publishing and connecting structured data on the Web known as Linked Data.[2] Examples of datasets encompass the well-known

[1] Selected parts of this article were published under non-exclusive copyright in *Proceedings of the Federated Conference on Computer Science and Information Systems FedCSIS 2012* (see [Łazaruk et al. 2012]).

[2] http://esw.w3.org/topic/SweoIG/TaskForces/CommunityProjects/LinkingOpenData.

DBpedia, Geonames or Freebase. The content of the Linked Data cloud is diverse in nature, comprising, *inter alia*, [Bizer, Heath, Berners-Lee 2009] data about geographic locations, people, companies, books, scientific publications, movies, music, television and radio programs, genes, proteins, drugs and clinical trials, online communities, statistical data, census results and reviews (e.g. Revyu system [Heath, Motta 2008]). Since 2007, the Linking Open Data cloud has expanded considerably. However, apart from some initiatives showing how to build applications using it, there is still plenty of space for more end-user applications that operate on Linked Data.

The above facts constitute a motivation for the development of a tool supporting the creation of semantic content using mobile devices in a user-friendly manner operating on Linked Data. The goal of the proposed application is to support users in the easy and intuitive creation of semantic annotations and, at the same time, provide added value through the ease of finding suitable data, and the ease of integrating the data and reasoning on them.

The conducted work encompassed both the research and practical related aspects. On the one hand, the aim was to contribute to a general understanding of the problem and on the other hand, to develop a system that could not only be used as a proof for testing, but also could constitute a fully-fledged tool to be used by users. Thus, the System Development Method (SDM) was utilized [Burnstein 2002]. According to Burstein, SDM "allows the exploration of the interplay between theory and practice, advancing the practice, while also offering new insights into theoretical concepts". The approach consisted then of three main steps. First, the concept building phase took place, which resulted in the theoretical concepts presented in the next sections. The next step was the process of system building, which was encompassing the development of a system based on the theoretical concepts established.

The system development was guided by a methodology of incentivizing users to create semantic content developed within the INSEMTIVES project.[3] Some core concepts of created application were presented during the previous AITM conference [Abramowicz et al. 2011]. This paper presents the final version of the application (already described in [Łazaruk et al. 2012], which is an extended version of this paper) and in addition, discusses the system architecture and the obtained experiment results.

The paper is structured as follows. First, the related work in the relevant research area is briefly discussed. Then, the vision of the tool is presented. Next, we focus our attention on the functionalities supported by the system, focusing on the semantic search process. The paper concludes with final remarks.

[3] http://insemtives.eu/.

2. Related work

Within the Semantic Web's setting, the network of hyperlinked human-readable web pages is extended with machine-readable metadata, i.e. semantic annotations pointing to ontologies [Uschold, Grüninger 1996; Adomavicius, Tuzhilin 2005; Peis, Morales-Del-Castillo, Delgado-López 2008], thus enabling automated reasoning [Berners-Lee, Hendler, Lassila 2001]. Semantic Web technologies were introduced almost a decade ago, and yet their real-life impact was considerably limited for the first few years. The situation has changed dramatically by an initiative called the "Linked Data project". Based on simple semantic technologies, like RDF and URIs, used along with Linked Data principles,[4] a number[5] of datasets have been made available in a machine-understandable manner, e.g. Wikipedia's resources are available on the Web of Data in the form of DBpedia. Linked Data sets are used in more and more real-world applications. Linked Data lowers the entry barrier for data providers by focusing on publishing structured data rather than on the ontological level or inferencing, and hence fosters a wide spread adoption. However, there exist some challenges that need to be tackled by developers of real-world linked open data applications, not least of which include resource discovery, consolidation and integration across a distributed environment.

Recommender Systems can be either [Pu, Chen, Hu 2012]: *rating-based* (content-based or social/collaborative-based) – users who explicitly express their preferences by giving binary or multi-scale scores to items that they have already experienced, or *feature-based* (case-based, utility-based, knowledge-based and critiquing-based) – evaluating the match between a user's need and the set of options available [Burke 2002]. Recommendation systems attempt to predict items in which a user may be interested, given some information about the user's preferences and past behavior, i.e. a user profile [Adomavicius, Tuzhilin 2005; Kaczmarek et al. 2012]. In the domain of review and recommendation systems, the application of ontologies brings many benefits; for instance, it semantically extends descriptions of user opinions; allows completing the incomplete information through inferences; semantically extends descriptions of user contextual factors; allows for the dynamic contextualization of user preferences and opinions in specific domains; guarantees the interoperability of system resources and the homogeneity of the representation of information; improves communication processes between agents and between agents and users [Peis, Morales-Del-Castillo, Delgado-López 2008].

An interesting example of ontology-based system was introduced by Cantador and Castells in [Cantador, Castells 2006] and extended in [Cantador, Castells, Bellogn 2011]. In this work, a multi-layer semantic social network model was proposed, based on the hypothesis that since user interests are not made of a single

[4] http://www.w3.org/DesignIssues/LinkedData.html.

[5] 295 datasets up to 2011 – source: http://lod-cloud.net/.

piece, any approach that deals with them as such would have inevitable limitations. Thus, the system has been defined from different perspectives, splitting user profiles according to meaningful groups/layers of preferences shared among users, so that the similarities between users are to be established based on sub-profiles rather than the global ones. This approach is also continued in the *Taste It! Try It!* application.

The *Taste It! Try It!* application benefits from the already developed semantic technologies and tools, and offers an added value through their integration and usage in order to, on the one hand, contribute to the Linked Data by producing semantic annotations, and on the other, to offer personalized advanced discovery and clustering possibilities. For the needs of the *Taste It! Try It!* application, a distinct disambiguation solution has been designed, adjusted to the specific needs of a mobile device. All of these features taken together, make the *Taste It! Try It!* application a distinct solution.

3. Vision of the tool

Taste It! Try It! was designed as both a mobile and WWW, Web 2.0 application supporting the creation of semantic annotations describing various places and locations. It is targeted at users providing reviews of places, i.e. people creating semantically annotated reviews (data providers) and users interested in the content produced by the application, i.e. people looking for opinions about various places (data consumers). In order to address the needs of both groups, *Taste It! Try It!* enables data producers to contribute to a semantic content creation process using their mobile devices[6] (as well as a WWW interface), and it offers to data consumers a personalized, semantic, context-aware recommendation process (i.e. a personalized semantic search mechanism).

The storyboard supported by the system is as follows. A user goes to a restaurant. While at the restaurant, the user decides to share his or her opinion about the restaurant and its quality of service factors with other members of the community. He or she uses *Taste It! Try It!* to express this opinion. The application starts by capturing the position of the place (using the GPS system in a mobile device). This enables associating the semantically annotated review that is created afterwards with a specific point in space. Then, the user creates a review by providing values to selected features suggested by the application. Additionally, the user may create a free-text comment regarding the object being reviewed. The review is then uploaded to a *Taste It! Try It!* server and in the background the semantic representation is created. Based on the quantity and quality of the created annotations, the user may be awarded with a special title e.g. *Polish-cuisine expert*, *International-food expert*. This title is visible to his or her friends at the community portal, in our example the Facebook portal, with which the application is integrated. Moreover, a user may

[6] The application is developed to work with the Android system.

check the ranking among his or her friends on Facebook. If a specified number of users mark the same spot and assign the same category of place to it (e.g. restaurant XYZ), a new location appears on the map.

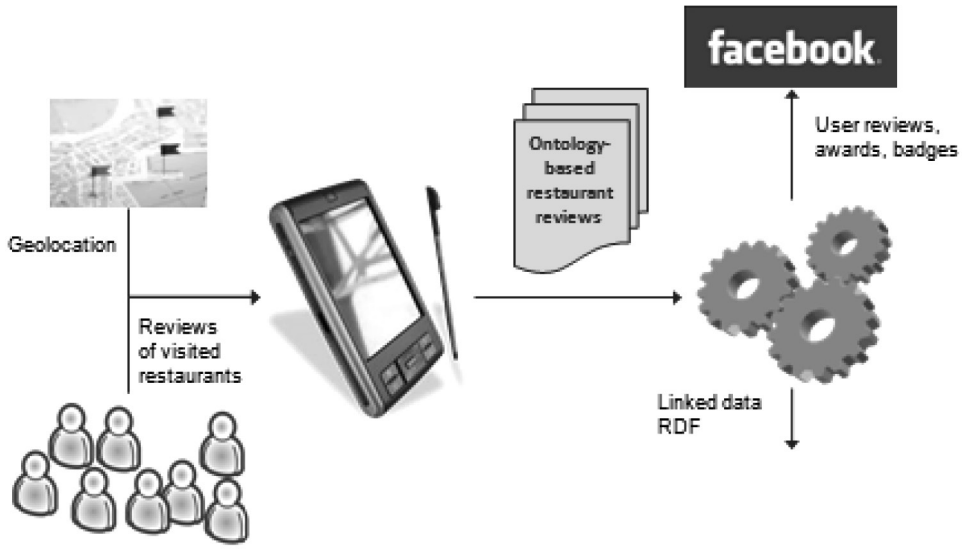

Figure 1. *Taste It! Try It!* – the conceptual model

Source: own elaboration.

In addition, based on the user behavior and data made available by the Facebook portal, the user profile is created, which is then used in the personalization process. The created annotations are then further on used by a semantic recommender system while searching for restaurants fulfilling certain criteria, e.g. vegetarian, low budget, and high quality, in the neighborhood of a user. As the semantically annotated reviews are linked to Linked Open data sets [Bizer, Heath, Berners-Lee 2009], some more sophisticated reasoning over the data is possible, extending the possibilities offered by the semantic-based recommendation system. Thus, the application is to fulfill the following goals:

– o provide semantically-enabled reviews sufficiently easy to create: the process of attaching the machine understandable semantics should be user-friendly;
– to keep a user entertained: integrating the proposed application with a social portal such as Facebook and adding the possibility of gaining badges are some of the incentives that are utilized to make the system more attractive to users;
– to offer a personalized, semantic, context-aware recommendation process.

In order to encourage users to create the semantic annotations, the application takes advantage of the incentives mechanism defined within the INSEMTIVES project as well as using some of the tools provided by the INSEMTIVES platform.

4. Mechanisms and the system flow

The system flow described within this subsection encompasses the registration process, the usage and navigation within the mobile client, creation of semantically annotated reviews, visualization of submitted reviews as well as a user profile on the Facebook portal, and finally, personalized searching for restaurants of interest.

4.1. Registration to *Taste It! Try It!* and mobile client navigation

The first step towards using *Taste It! Try It!* is to visit the Facebook *Taste It! Try It!* site and grant required permissions that are necessary for the application to work. Once the access is granted, the Facebook client retrieves from Facebook the basic information about the user and generates a verification code which is going to be used for the registration of the Android client. This code is a pseudo-random one-day-valid unique sequence of six alphanumeric chars which can uniquely identify the user.

While using the Mobile client, a user can choose any of four menu elements: create new reviews, manage reviews, check profile and search (see Figure 2). In order to ensure usability, typical Android UI elements (e.g. buttons, system menus, dialogs and view pagers) have been used. As a result, the use of the *Taste It! Try It!* application is more intuitive and user friendly.

4.2. Preparing and sending a review

Reviews can be created either using the Mobile client (see Figure 2), which is the typical and preferred way, or using the Facebook client. All reviews created using the mobile client can be saved at any time, and the edition process can be resumed whenever the user wishes, using the review-management screen.

The review edition screen is divided into three tabs providing basic and obligatory information on the restaurant (e.g. name, coordinates) – main tab, a wide range of qualitative features of the place – details tab, and finally additional star ratings and features together with a free-text comment field – more tab.

The values of some fields are suggested from DBpedia, others may take the form of star ratings, free text comments or true-false fields. While developing the application, our main motivation was to hide from users the complexity of semantics being the backbone of the application. Users do not interact directly with Semantic Web languages or technologies e.g. *SPARQL* endpoint. The semantic annotations that are created are template-based annotations. Users, while filling in some aspects of review (e.g. category of restaurant, type of cuisine, food and drinks served), are pointing to the concepts from DBpedia, taking advantage of an auto-completion mechanism suggesting possible tags to be used.

Figure 2. *Taste It! Try It!* – mobile client review creation screens

Source: own elaboration.

As we are following the faceted-based approach to the review creation, we can benefit from the additional knowledge in order to disambiguate and limit the potential tags (concepts from DBpedia) to be presented to users as an option to choose from. Therefore, for the needs of the *Taste It! Try It!* application, a disambiguation solution has been designed. For details see [Kaczmarek et al. 2012].

The reviews provided by users are stored on the server and then, after performed disambiguation (for details see [Kaczmarek et al. 2012]), serialized into the RDF format, so that they can be later on published as a linked dataset.

The created semantic annotations that are to be made available outside the *Taste It! Try It!* application, are anonymous (no information about the author of the review is revealed outside the application) and the subjective evaluation of the venue is expressed in an aggregated form. A new venue is added to the database as soon as it reaches the limit of three reviews assigned. Each new review added about the already existing venue within the knowledge base may result in updating the information on the restaurant stored there. The created RDF triples are uploaded to the INSEMTIVES platform via the SPARQL interface and stored in the local RDF repository.

As already mentioned, users are to be rewarded for their contribution, which among other mechanisms should motivate them to undertake various activities. In addition, for each review submitted to the server, users are awarded with a certain amount of points that later allow creating rankings of users of the *Taste It! Try It!* application. The badges (see Figure 3) in turn show the status of the user, his or her hobby as well as achievements.

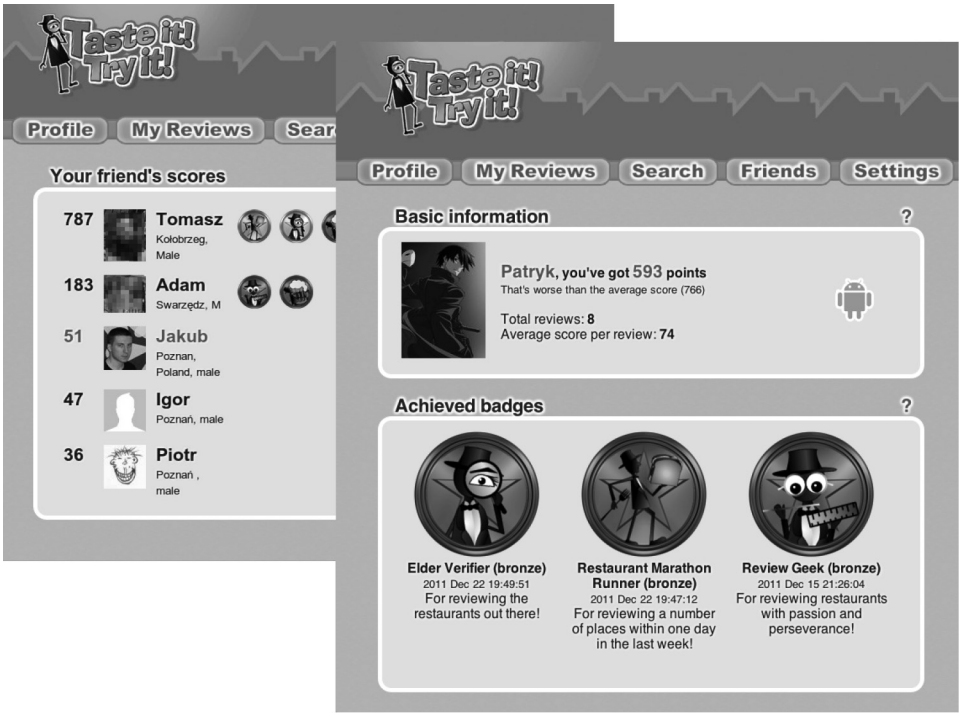

Figure 3. *Taste It! Try It!* – user profile visualization and friends ranking

Source: own elaboration.

Badges and points are all displayed on the profile and wall of the user on the Facebook portal. Facebook users can view other users' scoring and badges to compare their performance. Thus, through the application of badges and points integrated with such portals as Facebook, the following motivation levers, defined in *Incentive Models and PD Guidelines* [Zamarian 2011], are applied: reputation, competition, conformity to a group, competition, usefulness, altruism, reciprocity and self-esteem.

4.3. Search and personalization

Two key uses of the semantic annotations of restaurant reviews in the *Taste It! Try It!* application are the personalized discovery of restaurants (pull) and personalized recommendations (push). In order to support the required personalization of the mentioned processes, it is necessary to get to know the preferences of the users of the application. Thus, the creation of user profiles based on the data the user creates (i.e. reviews) and the data from the Social Web (i.e. the Facebook portal) becomes necessary. In this way, we facilitate a personalized experience without an intrusive user profiling process.

The first step is the creation of ontology-enhanced users' profiles encompassing also their preferences. Then, the clustering of the domain concept space is performed. Once the semantic clusters have been computed, it is possible to identify similarities between individuals and then use this knowledge in collaborative environments, such as *Taste It! Try It!* Within our work, we follow the approach presented in [Cantador, Castells 2006], and divide users into clusters of cohesive interest (i.e. multiple layers). Thus, for instance, users may share preferences and benefit from each other's experience in specific conceptual areas (e.g. type of food), even if they totally disagree on other aspects (e.g. taste in the décor and atmosphere). Therefore, depending on the context, only selected layers of a user profile may be considered during the recommendation process, which allows offering more accurate and context-sensitive results [Cantador, Castells 2006]. The following layers have been identified based on the data gathered by the *Taste It! Try It!* application:

– restaurants layer: reflecting the similarity in the type of visited restaurants and their locations (requires computing semantic similarity between concepts);
– taste layer: reflecting similarity in the type of food (dishes) and cuisine of the visited restaurants (requires computing semantic distance);
– reviews layer: reflecting the similarity in the assigned ratings to the features of visited restaurants (quantitative criteria) as well as similarity in features that the reviewer is interested in (qualitative criteria, e.g. always commenting on music);
– activities layer: reflecting similarities in the performed activities (number of reviews in various locations, awarded badges), as well as social information gathered about a user.

In order to assess the similarity between two concepts in DBpedia, a path between two nodes on a semantic graph needs to be found. Although DBpedia is very successful, there still seems to be a lack of semantic similarity measures available on the DBpedia data, which makes it difficult to use. By taking advantage of the SPARQL endpoint, various queries may be asked to DBpedia, achieving a high accuracy of results. In general, a similarity between two resources in DBpedia can be detected, if in the RDF graph:

a) concepts are directly linked using some property, e.g. there is a link between Hawaiian pizza and Pizza:

– http://dbpedia.org/resource/Hawaiian_pizza dcterms:subject,
– http://dbpedia.org/resource/Category:Pizza;

b) they are subject of two RDF triples having the same property and the same object, e.g. Hawaiian pizza and Mexican pizza by being a pizza:

– http://dbpedia.org/resource/Mexican_pizza dcterms:subject http://dbpedia.org/resource/Category:Pizza,
– http://dbpedia.org/resource/Hawaiian_pizza dcterms:subject http://dbpedia.org/resource/Category:Pizza;

c) they are objects of two RDF triples having the same property and the same subject, e.g. Italian beverages and Coffee beverages:

– http://dbpedia.org/resource/Latte dcterms:subject http://dbpedia.org/resource/Category:Italian_beverages,
– http://dbpedia.org/resource/Latte dcterms:subject http://dbpedia.org/resource/Category:Coffee_beverages.

In DBpedia, the hierarchical structure of categories is modeled using two properties: dcterms:subject (relates a resource to its categories) and skos:broader (used to relate a category to its parent category). Hence, the similarity between dishes' cuisines may be also discovered in case they have some ancestor categories in common (within the hierarchy). This allows one to catch implicit relations and hidden information.

The following discovery scenarios are currently supported within the system:
– searching for a restaurant with some quantitative criteria (non-semantic, e.g. number of stars assigned (not less than...));
– searching for a restaurant with some qualitative (non-semantic) criteria added, e.g. wi-fi zone, live sport events transmissions, etc.;
– searching for restaurants near some location – a map and coordinates;
– searching for a restaurant with some criteria requiring reasoning (semantic ones from DBpedia) – type of cuisine and type of dishes.

While returning the search results, the additional personalization based on the layers and clusters computation, described within this section, may be applied. Thus, the following personalization-enhanced search scenarios are supported:
– searching for restaurants recommended by people with a similar profile;
– searching for a restaurant that my friends from Facebook recommended;
– searching for a restaurant that one specific person (that I trust) likes;
– hang-out (recommend a restaurant for n-number of *Taste It! Try It!* users).

When it comes to specifying the semantic criteria, a user searches for it by typing characters in the corresponding text field. The application returns an auto-complete list of suggested concepts retrieved from DBpedia. Once the list has been populated, the user can select one (or more) of the suggested concepts.

The already mentioned personalization influences the list and the ranking of the returned restaurants. Thus, the personalized recommendation exploits both the knowledge base – information gathered by the *Taste It! Try It!* application and DBpedia (content-based approach) and the similarities between users (collaborative-filtering approach).

5. Architecture

The application has been designed according to the client-server architecture model. *Taste It! Try It!* consists of three main components: an Android client, a Facebook client and a Server. Moreover, the *Taste It! Try It!* application communicates with three other components: Facebook (FB), the INSEMTIVES platform and DBpedia. The first three components are to provide the basic functionalities of the application.

Communication with the other ones is to connect the application with Web 2.0 services (the social aspect) and Linked Data (the semantics).

The Android client provides the user with a front-end to manage reviews. For communication with the Server a RESTful Web Service interface is used. The Facebook client is a web front-end embedded in the Facebook canvas[7] and written with the use of Google Web Toolkit framework.[8] Via the FB API interface[9] the Facebook client authenticates and authorizes the user, as well as retrieves basic information about the user (name, gender, list of friends). The GWT Service interface provided by the Server is to retrieve and store information about the user's interactions with the application, including restaurant reviews and the user's personal information.

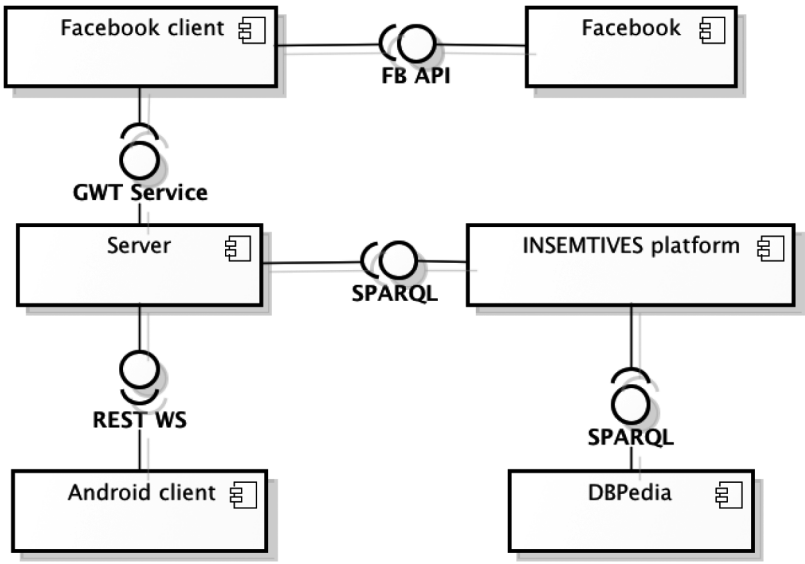

Figure 4. Architecture diagram

Source: own elaboration.

To support the semantic content creation process, the *Taste It! Try It!* application integrates with the INSEMTIVES platform and DBpedia. The INSEMTIVES platform is a tool created by the INSEMTIVES consortium on top of the OWLIM semantic repository.[10] Among others, it consists of a SPARQL end-point, which is used to store and retrieve RDF triples. A part of the semantic data is retrieved and cached from DBpedia via the DBpedia SPARQL endpoint.

[7] http://developers.facebook.com/docs/guides/canvas/.
[8] https://developers.google.com/web-toolkit/.
[9] http://developers.facebook.com/docs/reference/api/.
[10] http://www.ontotext.com/owlim.

Implementation of scenarios and functionalities described briefly in the previous section required addressing several issues. In the case of integration with DBpedia, we had to deal with the poor reliability of public SPARQL endpoints while trying to find an efficient solution to the well-known problem of querying semantic data coming from various repositories. In the case of integration with Facebook, we had to handle problems resulting from a restricted Facebook privacy policy.

The *Taste It! Try It!* application was evaluated by means of an experiment in December 2011 and January 2012. The aim of the experiment was twofold. On the one hand, it was aimed at testing the functionalities of the tools and gathering semantic annotations. On the other hand, our intention was to assess the usability embedded in the tool and the sociability aspects. In particular, we wanted to measure the effect of different combinations of incentives.

We performed the evaluation of the proposed solution with 180 participants. We gathered 2274 reviews on about 900 unique restaurants. The reviewed venues are located mainly in the *Wielkpolska* region of Poland. While filling in the review. the participants used 5667 concepts from DBpedia to annotate cuisine and dishes features. As a result 14 840 RDF triples were created describing various restaurants. The gathered data helped us to design the feature which allowed reaching a consensus in the case of contradictory information. The results of the conducted experiments show that the design of the application can have an important effect on the motivation of users to contribute to the content.

Another important finding is the poor quality of information provided by DBPedia. The coverage of DBpedia was deemed as unsatisfactory by most of the users. This does not necessarily result from the fact that the required concept is not present in the data gathered by DBpedia, but the concept could have been assigned to a non-intuitive place in the structure, which makes it difficult to be discovered.

6. Conclusion

The *Taste It! Try It!* application presented in this paper is a semantic content creation tool for a mobile device. It is to support users in the process of creation of semantically annotated reviews of various venues. It uses DBpedia as a source of data and is integrated with the Facebook portal. In order to attract the users and ensure their engagement in the semantic content creation process, a few incentive mechanisms have been applied. The creation of a user friendly and intuitive interface is one of them. In addition, the appropriate social incentives mechanisms taking advantage of Web 2.0 paradigm guarantee the appropriate quantity and quality of the created semantic annotations. This will in turn allow offering personalized and more accurate search possibilities of the application, thus constituting an additional incentive for users to use the application.

After performed evaluation and testing, we argue that the developed application shows that it is possible to create a user friendly application for a mobile device producing semantically annotated reviews and make this process as far as possible

invisible to users, and that the applied incentives mechanisms can ensure the appropriate quality and quantity of information included in the reviews and encourage the users to a more active behavior.

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SYSTEM REKOMENDUJĄCY W INTERNECIE SEMANTYCZNYM. STUDIUM PRZYPADKU

Streszczenie: Artykuł prezentuje internetowy system społecznych rekomendacji, *Taste It! Try It!*, umożliwiający tworzenie adnotacji semantycznych. Jest to aplikacja mobilna, służąca do recenzowania i rekomendowania restauracji, wykorzystująca semantyczne źródła danych oraz zintegrowana z serwisem społecznościowym. Aplikacja wykorzystuje adnotacje semantyczne znajdujące się w repozytoriach *Linked Data* (podczas tworzenia recenzji), a także tworzy takie adnotacje (o recenzowanych bytach). Następnie adnotacje tesłużą dostarczaniu spersonalizowanych rekomendacji.

Słowa kluczowe: systemy rekomendujące, semantyczne adnotacje, mechanizmy motywujące.