Reputation as a Service

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Abstract— **In this research work, we introduce the concept of a reputation service to evaluate user collaboration towards community or system goal. Online reputation mechanisms allow members of a community to submit their opinions (feedback) regarding other community members and their publication activity. Submitted opinions are analyzed, aggregated with feedback posted by other members and made publicly available to the community in the form of member feedback profiles. We propose a conceptual system that can be used in several contexts, namely in our public transportation recommender system developed in the framework of the European Project START.**

Keywords-Reputation; Recomemnder System; Public Transportation; Service

I. INTRODUCTION

Online reputation mechanisms allow members of a community to submit their opinions (feedback) regarding other community members. Submitted opinions are analyzed, aggregated with feedback posted by other members and made publicly available to the community in the form of member feedback profiles. Several examples of such mechanisms can already be found in a number of diverse online communities. Perhaps the best-known application of online reputation mechanisms are the trust system in electronic markets. The first Web sites to introduce reputation schemes were on-line auction sites such as eBay.com. They are now also used by company reputation rating sites such as BizRate.com, which ranks merchants on the basis of customer ratings. Consumer Reports Online's eRatings rates merchants on the basis of test purchases carried out by Consumer Reports staff.

Online reputation systems have appeared as a viable instrument for encouraging cooperation among strangers in such settings by guaranteeing that the behavior of a player towards any other player becomes publicly known and may therefore affect the behavior of the entire community towards that player in the future. Knowing this, players have an incentive to behave well towards each other, even if their relationship is a one-time deal. The rise of online reputation systems is already indirectly changing people's behavior. Circumstantial evidence suggests that people now increasingly rely on opinions posted on such systems in order to make a variety of decisions. The growing importance of online reputation systems in different subject raise new challengers in the study of participant's behavior in the communities where they are introduced. We have developed several recommender systems for Electric vehicles [1], transportation system [2], electric market [3] and the study of user behavior was always created. This raise the question of a definition of a service that can be used for several systems (recommender or not) in order to evaluate user performance towards the system or community goal.

This work is divided eight sections. In Section I, we define the problem context. Section II describes the European project associated with our work. Section III describes the recommender engine used to send user relevant information. In Section IV, we present the collaboration system used by the registered users to create and share transportation related information. Section V presents the reputation system to motivate and evaluate user participation towards a common system goal. In Section VI, we describe the developed approach based on services. Section VII presents the system (Social Mobility Advisor) developed. Finally, conclusions are drawn in Section VIII.

II. START PROJECT

This work describes ISEL (Instituto Superior Engenharia de Lisboa, Portuguese polytechnic) contribution of a reputation system applied for a public transportation recommender system for the Seamless Travel across the START project (Atlantic Regions using sustainable Transport). START Project is a European Commission's Transnational Territorial Cooperation Program with 14 partners from the UK, France, Spain and Portugal. Its mission is the establishing of a transnational network of regional & local authorities to promote enhanced accessibility, giving tools to make easy to travel to, from, and around the Atlantic regions using environmentally friendly, collective modes of transport greater interconnectivity between transport systems clearer information within regional gateways, airport hubs ports & rail interchanges. The focus on this work is aligned with the "Integra concept" [4], whose aim is to provide a single brand that links together and provides information on the different public transport operations across the Atlantic Area. So, the system should allow the query of multiple information sources through a unique interface. The queries and answers to them should reflect a single data model. The existence of this common data model takes the software applications with the difficult task of dealing with various technologies and their relational schemas. Different public transportation systems can be added from the end user point

of view. Also, this integration allows the creation of mobile systems oriented for tourism purposes, other main goal of Integra, where "low budget tourism" can be guided, to reach POI (Point of Interest) by public transportation.

III. RECOMMENDER ENGINE

The Recommender Engine (RE) is the same engine used for the recommendation of electric vehicles defined in [1]. This engine matches information dedicated to public transportation from web and our social network with the user profile to bring the right information to a mobile device. Applied to the reality of smart cities with increasing mobility and sustainability needs the proposed system integrates a diversity of functionalities. The main system modules are: (1) GPS module: The RE receives the information of the geographical positioning information on the current position of the vehicle and the features that enable the calculation of distances between two points; (2) Public transportation Information module: a system with public transportation routes, schedules. The reception of such information is through an exchange file in XML format that contains information prepared and compiled by different operators. The file includes the geographical location of sites where you can embark on public transport scheme. The public transport information is incorporated into items of candidate recommendation system by allocating an item property that indicates whether or not is close to public transport. This information is another dimension that enters the calculation of the usefulness of each item positively or negatively affects your score accordingly to the choices that have been made before by the driver; (3) collaboration system to handle user participation towards community goal.

IV. COLLABORATION SYSTEM

Users can also interact and collaborate among themselves to improve their knowledge, or by allowing them to express their needs, preferences and also create valuable information related to public transportation. The features presented below are created to keep users informed, motivated and with intention to collaborate more frequently:

- Cooperation Area: An area where users can ask or provide different kinds of knowledge to cooperate in Public transportation information;
- Helping Area: An area where users can post questions and answers and some sort of help of any topic. This space could be accessed and viewed by any registered user. The system gives credits to users that provide good helping answers to posted questions, based on the following modules;
- Abuses or Faults Reporting Area: An area provided to report abuses of different kinds, like comments or bad use of the System. The system manager can penalize the users for inappropriate behavior. The

reason for providing this area is essentially for discouraging users to commit abuses or faults;
- Request: An area where users can ask for specific questions. The system manager can use those requests to tune the community;
- Reward: Created in order to promote and recognize outstanding behavior (for example, no changes in the profile). The awarded users increase their reputation;
- Community Newsletter: The system Manager publishes a digital newsletter with Community information and Public transportation related information;
- Users Reputation: User reputation represents the most valuable collaborators, see reputation system;
- Alerts Subscription: Users can subscribe to different kinds of alerts: notifications, comments or other Public Transportation interactions.

V. REPUTATION SYSTEM

A reputation system collects, distributes, and aggregates feedback about participants' past behavior, helping users to decide whom to trust and encouraging trustworthy behavior [5]. There are many empirical studies reputation system, see Resnick et al. [6] for an overview. Various trust and reputation systems have been proposed or implemented in different areas. Some proposed classifications use their application areas [7], algorithms [5] or some combined characteristics [8] as criteria. These classifications allow looking at trust and reputation systems from different perspectives always from zero development phases. Since there are common modules and strategies among different systems, the idea is to build one based on a modular structure using a service approach.

The Reputation system implements a model that is generally composed of the main functions:
- AddPoints/SubPoints – Add or remove user points based on pre-defined criteria;
- DemoteUser/PromoteUser – Change user reputation level based on points criteria;
- GetReputationToLevel – input is the current user reputation and gives the points necessary to go to the next level;
- Rate/Vote – user item evaluation for other user annotation and gives as output the new rate for that annotation item.

Several reputation algorithms can be implemented. At this moment, we implemented binary rate and the start algorithm.

A. Reputation Level

The reputation levels system is inspired from videogames like World of Warcraft [9], which needs exponential requirements to level up. Equation 1 illustrates the adopted formula to generate reputation level requirements for the next level, supplying the current level.

$$PN = (8 * NX) * (45 + (5 * NX)) \tag{1}$$

PN is the reputation for next user level
NX is the reputation for current user level

So, from the first to the second level, the user needs 400 points, from the second to the third level, 880 points, from the third to the fourth level, 1440 points, and from the fourth to the fifth level, 2080 points. The reputation level is an important issue in our reputation system, since it will define the weight of the user's ratings, described below, as well as their role/privileges in Social Network.

B. Ratings

Our system provides an input for users to express their opinion related to item's information quality by rating it as being helpful or not helpful (+1, -1), as shown in Fig. 1. This range permits a less ambiguous evaluation, since it will influence the reputation of those who submitted the item. Using this schema, it is possible to filter and organize information by its quality and, at the same time, indirectly rate the user who submitted that information. This approach aims to decrease public reputation of those who submit poor information and, inversely, reward those who submit relevant information. Item's information reputation is determined using the Equation 2, which consists on a summation of all positive and negative ratings weighted by rater's reputation level. Rater's reputation level is used to avoid unfair ratings [1], one of reputation systems known problem, in assumption that users with better reputation provide more reliable ratings.

$$A_i = a * b - (c' * d') + c * d \qquad (2)$$

a – Item i current rating (in cache);
b – Summation of item i raters reputation (in cache);
c – New rating for item i of active user;
d – Item i active user reputation level (in cache);
Reevaluation factors:
c' – Old rating for item i of active user;
d' – Reputation level of active user when submitted the old evaluation (in cache);

In order to calculate the mobility item's quality itself (e.g., how good is a gate, operator, transport, etc.), our system also provides an input for users to express their mobility experience quality by a quantitative rating from 1 to 5 stars, plus comment.

The item's quality reputation is calculated by the Equation 3 and it consists in a weighted average between evaluations and raters reputation. Rater's reputation level is used to avoid unfair ratings as mentioned before.

$$A_i = (a * b - (c' * d') + c * d) / (b - d' + d) \qquad (3)$$

a – Item i current rating (in cache);
b – Summation of item i raters reputation (in cache);
c – New rating for item i of active user;
d – Item i active user reputation level (in cache);
Reevaluation factors:
c' – Old rating for item i of active user;
d' – Reputation level of active user when submitted the old evaluation (in cache);

C. User's reputation

As mentioned before, users indirectly rate others by rating their submitted items as being helpful or not helpful, according to the Equation 4:

$$R = - (a' * r') + a * r \qquad (4)$$

R – Reputation increment; a – Rater reputation level;
r – New rating (+1, -1);
Reevaluation factors:
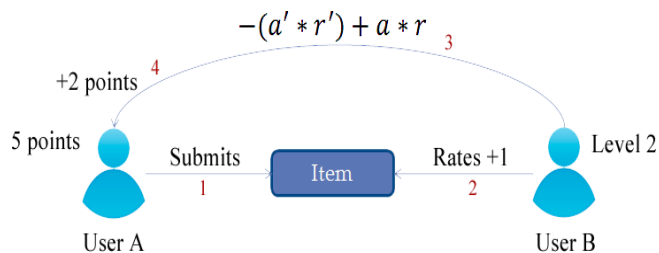a' – Old rater reputation level; r' – Old rating;

Figure 1. Evaluation example.

For example, when a user A submits an item and a second user B on level 2 rates that item as useful (+1), the user A gets two points of reputation as presented in Fig. 1.

D. Interaction Incentives

Due to the lack of incentive for users to provide their mobility experiences and ratings, we included incentive mechanisms in our reputation system. Users are rewarded for data submission, where the importance of the submitted item defines the assigned reputation points. Table 1 shows the possible configuration values of rewarded points.

TABLE 1: POSSIBLE CONFIGURATION FOR INCENTIVES.

Action	Reputation
Binary rating	+2
Start rating	+1
Mobility item submission, except route	+4
Route submission	+6
Comment submission	+1
Collaboration action	+3
Reevaluation	0

For example, someone that submits a new gate will be rewarded with 4 reputation points.

We also adopted a badge reward system, used by systems like Stackoverflow [10] and Foursquare [11] with great acceptance by the community, where users are rewarded by reaching certain objectives.

In our context, we reward the users when they reach, for example, a pre-defined number of done routes or rated items.

E. Moderation

In our approach, the information is strongly dependent on user's collaborative interactions. Consequently, moderation actions are needed. To reduce the amount of necessary staff to keep the system, we included a role based moderation mechanism, inspired by Slashdot, which takes advantage of

user's reputation to delegate them moderation actions. This way, most reliable users are assigned to perform some moderation actions. Our mechanism has two moderation roles, where the first, called "collaborator", are assigned to manage regular users by editing/hiding comments and item's information. The second role, called "moderator", was introduced to reduce the number of unfair collaborators, as described by Slashdot [5].

VI.   SOFTWARE DEVELOPMENT

The concept normalization in public transportation area is achieved by the introduction of domain ontology. We use same recommender process to several problems in the transportation domain, such as a recommender engine for electric vehicle [1] and current proposal.

Ontologies are very powerful in the sense that they are developed with the human understanding of the domain in mind, instead of taking a pure application-oriented approach, as it is mostly done with database schemas. Ontologies can help bridge the gap between human understanding and machine understanding of a domain. We developed a domain ontology based on Web Ontology Language (OWL) and UML2 profile and a mapping process between different database schemas to a central Information Model or to other database schemas, and in that way enable better understanding of this information by the users in the organization. Public Transportation ontology (PTO) can play an important role providing mechanisms to handle automatically data integration among different Public transportation data and all related data acquired with user participation. PTO is described in [2]. PTO is built on top of RDF, thus it inherits its concepts: resource, propriety, datatype and class: (1) resource is one of the bases of RDF, it represents all things described and is the root construction. It is an instance of MOF classes; (2) property, defines the relation between subjects and object resources and is used to represent relationships between concepts. Ontology class attributes or associations are represented through proprieties; (3) ontology is a concept that aggregates other concepts (classes, properties, etc). It groups instances of other concepts that represent similar or related knowledge; (4) classifier is the base class of concepts that are used for classification and is divided in: (i) datatype, a mechanism for grouping primitive data; (ii) abstract class; and (5) instance that is the base class and is divided in individuals and data values, for details see [2].

Taking into account a recommender system to be developed, in our approach, the system developer can use reputation service and chose the available reputation algorithms. To obtain that, it is necessary to use a Service-Oriented Architecture (SOA) [12], which is a component-based software architecture. This architecture defines the description of the services' interface and implementation. The interface is defined in an unbiased way, independent of the hardware platform, operating system and programming language of the services implementation. For implementing service request software architecture, SOA changes the manner of the traditional software development. The usage of Web Services, the combination of the related technologies and the software architecture above are the basis for the implementation of the Web Services. This Web Services model is divided into three main parts: (1) Services Interface; (2) Services Mapping; and (3) Services Implementation. Services in SOA also include Services Contract, and Service Contract is the definition of the Services interface and Services Implementation. Services Interface in this model is realized by Web Services Definition Language (WSDL) [14], following the criterion of the WSDL. Services implementation follows the criterion of the special platform. Because of the universal property of WSDL, the services in this model own the universal property.

Representational State Transfer (REST) [15], describes a series of architectural constraints that exemplify how the web's design emerged. Several implementations of these ideas have been created throughout time. As a set of design criteria, REST is very general. In particular, it is not tied to the Web. Nothing about REST depends on the mechanics of HTTP or the structure of URIs. So, Web Service is designed according to resource. Every Web Service represents a kind of resource, which is operated by the operations of Web Service. The Resource Oriented Architecture (ROA) is a way of turning a problem into a RESTful [16] web service: an arrangement of URIs, HTTP, and XML that works like the rest of the Web.

A new, rational structure, high consistency, low connection of SOA-based application architecture is constructed, which also follows ROA, implements services by encapsulation of the entity object and its operations using Web Services, implements the business processes in the client PC. Compared with the traditional software architecture, the new services layer is added between the entity object layer and business logic layer. In the new layer, data and its operations are packaged to Web Services. The implementation of services is based on the "Interface-First" principle, for sharing the data fully and safely. In the entity object layer, based on the OOP (Object-Oriented Principle), the entity objects and their operations are delivered to three parts: (1) Entity Class; (2) Interface of Data Access; and (3) Data Access [17]. An overview of this process is illustrated in Fig. 2.

According to ROA, Web Service is designed around the resource. To simplify the development, the extension of the resource's definition is reduced, and the table of the database is a basic kind of resource. In the period of object oriented development, O/R mapping (Object/Relational mapping) is adopted to resolve the problem of Object-relational impedance mismatch [10]. This strategy combines business logic and data access for stripping. It increases the performance of the business logic for the persistence of the interaction between objects, instead of directly operating on the database tables and fields.

Web Service is used to disjoin the business logic and the operation of persistent object. The simple operation of the persistent object is packaged to Web Service, to share the resource commonly and easily.

According to the basic operations of the table, the operations of the Web Service are designed as list: (1) Add object to the database; (2) Delete object from the database;

(3) Edit the object, and save the result to the database; (4) Find object in the database; (5) Find a list of objects in the database.
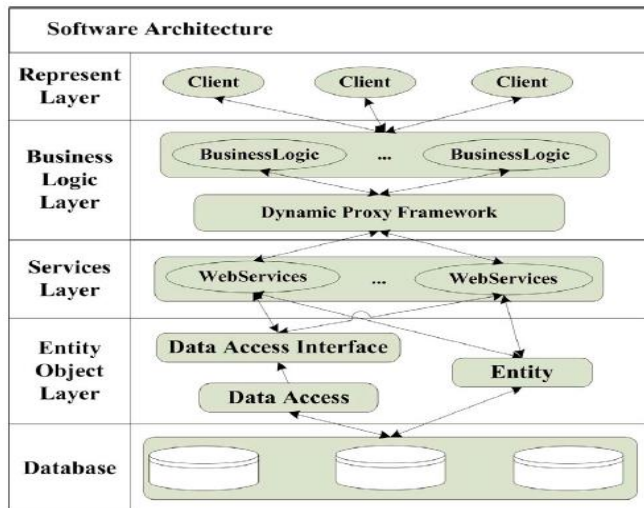

Figure 2. Software Architecture Based on SOA [16].

VII. SOCIAL MOBILITY ADVISOR

Social Mobility Advisor (SMA), was our Public Transportation Recommender system developed for START project using a service oriented approach. The main services introduced are: (1) geo-location, based on HTML 5 – API, from the user IP address, is possible to know the approximate location; (2) historical navigation data based on Address.js [17]; (3) Public transportation data were imported based on a semantic approach developed [2]; (4) external information from Google Maps and Google Places (maps and points of interests [19]), Brighter Planet for CO_2 calculation of carbon footprint taking into account trip start and end point [20], Wikipedia to get information not available in internal data base [21] and Facebook to get information about users (name, friends, e-mail, photo); (5) user authentication LDAP; (6) user reputation; (7) matching algorithm; and (8) user profile.

SMA main menu, illustrated in Fig. 3, is a collaborative solution that aims to assist travelers to share their experiences and find the best suitable mobility alternatives, bearing in mind the best sustainable options. Those actions are supported by the collaborative community interactions, in other words, under the social network concept. This approach leads to a credibility problem, which we took into account by assuring both users and information are cataloged by confidence levels. We also propose an automated moderation mechanism that tries to reduce the number of required staff to administer the system.

The SMA project aims to contribute to a more accessible, social and sustainable mobility across the Europe, dealing with reputation and recommender systems in order to build a social network.

VIII. CONCLUSIONS

The Integra social network, built from the experience of the SMA Project, has exceeded the testing phase, which counted with more than two hundred users. The present database includes more than ten thousand items (gates, transports, operators), covering mobility information in a worldwide context, and about one thousand rates and comments. This recommender system for public transportation was developed in a service based approach. Everyone can obtain more information using [22] and join the Integra social network accessing [23] and a full implementation description available at [24].

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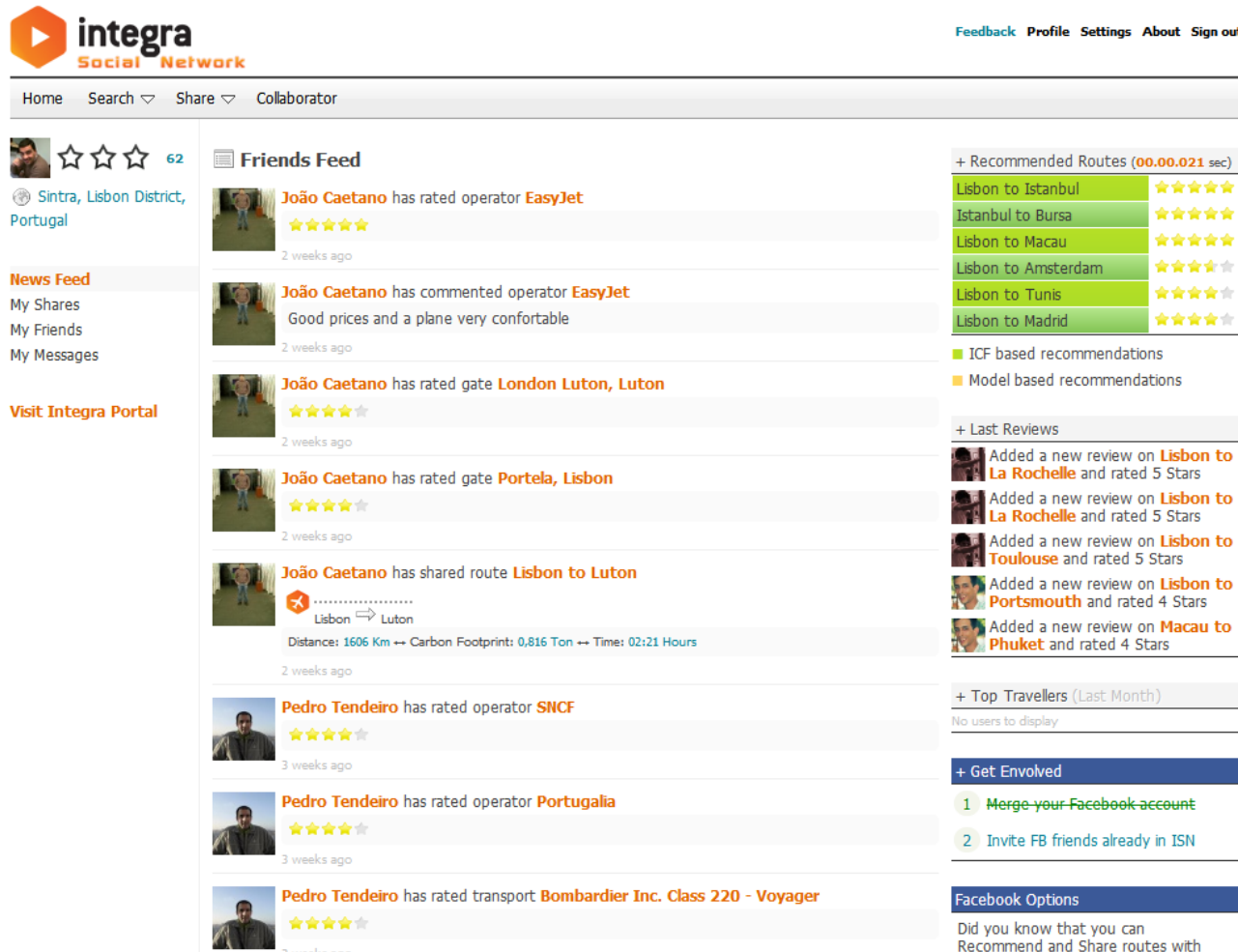[25] Social Mobility Advisor, available at http://start.isel.pt/publications.html, [retrieved: April, 2013].

Figure 3. SMA application screen (Integra Social Network).