Exploiting Digital TV Users' Preferences in a Tourism Recommender System based on Semantic Reasoning

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Abstract — *Tourism recommender systems match the user preferences against the huge diversity of tourist resources, helping to decide where to go and what to do. Current approaches require the users to initialize manually their profiles by expressing their interests accurately, which is a very tedious process. We propose a system that automatically infers the users' preferences from their TV viewing histories, i.e., the tourism resources the users might appreciate are selected by considering the TV contents they enjoyed in the past. To this aim, we have developed a context-aware semantics-based recommendation strategy that considers both the users' preferences and the interests of like-minded individuals. The resulting recommendations shape a tailor-made on-move travel plan the users can access via (domestic and) handheld consumer devices*[1].

Index Terms — Context-aware recommender systems, personalized tourism, Digital TV, Semantic Web, Web Services.

I. Introduction

Personalization capabilities are undoubtedly valuable in tourism because there are many options of destination, events and activities for someone who goes sightseeing, were it for adventure, cultural/historical or holiday reasons. Bearing this in mind, users often need advice about where to go and what to visit, to see and to do in a specific destination. There exist recommender systems that help to decide a travel plan, indicating places to visit, road maps, options for hotels, air companies and so on, by matching the users' preferences (modeled in personal profiles) against all available tourism resources. Besides making trip planning much easier, existing systems support the user on move by providing ubiquitous access to tourism information of interest at anytime, from anywhere and any media [1]-[3].

In the last years, most of the existing tourism recommender systems have adopted technologies borrowed from the Semantic Web, conceiving *semantics (meaning)* as a key fact to finding the way in the expanding web space, where currently most web resources can only be discovered via keyword-based syntactic matching. Really, the goal is to semantically connect isolated pieces of information in order to alleviate the users' burden of finding, understanding and using tourism-related information sources [4]-[6]. To this aim, semantic descriptions of the available resources (*metadata*) are formalized in ontologies, which define a common vocabulary including concepts and relationships typical in a specific domain.

The proliferation of semantics-based tourism recommender systems has revealed important limitations related to: (i) the personalization capabilities offered by the systems, (ii) their process of user profiles initialization, and (iii) the semantic matching techniques adopted by the recommendation strategies to compare the users' preferences against the metadata of available resources.

- **Personalization-related capabilities**: Even though some systems select lists of tourist resources adapted somehow to the users' personal preferences (e.g. COMPASS [7], CRUMPET [8], GUIDE [9] and OnTour [10]), others just offer location-aware services displaying *all* the tourist resources situated near the current position of the user, which have not previously been filtered out as per his/her particular interests. In the absence of full personalization capabilities, these systems (e.g. Gullivers Genie [11], Lol@ [12], MobiDENK [13], m-ToGuide [14], PinPoint [15], and Sightseeing4U [16]) just provide the users with *non-personalized predefined tours*, multimedia information about sights, routing functionalities and multimodal interaction (e.g. speech control) based on an electronic map where the location of the user and nearby sights are shown.
- **Initialization of users' profiles**: To the best of our knowledge, all existing systems annoy the users by requesting them to enter manually their personal preferences and interests accurately, which is a cumbersome task.
- **Semantic matching techniques**: Existing tourism systems match the users preferences against the available tourist resources by recommendation strategies with limited capabilities to reason about semantics, which greatly impoverishes the quality and accuracy of recommendations [17]. Specifically, these void-of-reasoning systems are based on logical inferences and syntax-based queries by declarative languages that do not support sophisticated inferential procedures, as explained in [10].

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In order to bridge the gap between existing semantics-based tools and next-generation tourism systems, we propose TripFromTV, a recommender that provides the users with *tailor-made* tourism offers –accessible from domestic and handheld consumer devices– by exploiting Digital TV (DTV) capabilities and semantic reasoning techniques.

- First, TripFromTV *automatically discovers the preferences of the users* (with no involvement from them), by tracking the kind of DTV contents they enjoyed in the past. This makes it possible to learn valuable information to offer tourism recommendations, like interest in sports, nature, gastronomy or culture.
- Next, the list of favorite programs is processed by a recommendation strategy that relates these DTV contents to potentially appealing tourist resources. To this aim, TripFromTV resorts to *advanced reasoning techniques* that explore thoroughly the semantics formalized in an ontology in order to discover extra knowledge about the users' preferences, thus enhancing greatly the personalization capabilities of our system.

TripFromTV supports the users during the whole life-cycle of a journey, covering *pre-trip*, *on-trip* and *post-trip* stages: first, typically before the trip, our semantic reasoning-based strategy identifies interesting tourist resources starting from the user's DTV viewing history (e.g. a Japanese restaurant for a lover of documentaries about Asian gastronomy). Next, during the trip, our strategy searches for information about activities associated to the selected tourist resources, which is permanently adapted to the current context of the user (e.g. to have a lunch in the Japanese restaurant that is closest to the user position). In order to shape this *context-aware on-move travel plan*, we retrieve information relevant for the user from external sources (e.g. opening times and ticket prices for tourist resources, location of infrastructures, booking services, etc). Finally, after the trip, the users can provide their opinions about the recommendations. This *relevance feedback* (which can also be inferred automatically from the user-system interaction) is harnessed to select *collaborative recommendations*, where each user is suggested with tourist resources that were well-appreciated by individuals with similar interests.

This paper is organized as follows. Section II describes diverse technologies involved in TripFromTV. Next, section III and section IV detail the main components of the semantic reasoning framework of our system: (i) the domain ontology, (ii) the technique adopted to model the users' preferences, and (iii) our recommendation strategy. Then, section V focuses on the architecture of the system, whereas section VI outlines preliminary testing experiences. Lastly, section VII highlights our main research conclusions.

II. Technological Landscape

Deploying TripFromTV requires to explore technologies bound to diverse fields: Semantic Web, Web Services, context-aware personalization, wireless communication networks and Digital TV.

As disclosed previously, the tourism domain –characterized by a significant heterogeneity of the market and information sources [6]– can especially benefit from Semantic Web technologies. As this initiative uses metadata to provide explicit meaning to the information and services available on the Web [18], an automated processing is possible that prevents the users from searching manually appealing tourist resources. The technological cornerstone for that purpose are the ontologies, conceptualizations that provide a commonly-accepted description of the domain of interest [19] and whose application meets most of the challenging requirements related to the tourism field:

- Firstly, the provision of a common semantic base (vocabulary) fights the interoperability problem that comes along with the integration of heterogeneous data sources.
- Secondly, an ontology provides a formal basis which is the prerequisitive for adoption of semantic reasoning mechanisms.
- Lastly, thanks to these mechanisms, ontologies pave the road for valuable services in the tourism domain, ranging from information search to provision of fully automatic personalization capabilities.

Providing these reasoning-based personalization capabilities in TripFromTV requires not only to annotate the tourist resources available on the Web (e.g. accommodation options, flights or museums), but also to describe the functionalities provided from the web sites in order to automate searching for information the users might appreciate (e.g. possibility of querying location of a hotel, price of a flight ticket or opening times of a museum). For that purpose, we exploit the potential of *Semantic Web Services* annotated by OWL-S (*Web Ontology Language for Services*), a language that provides a computer-interpretable description of the service (i.e. the semantic meaning of data) along with the means by which it is accessed [20]. Specifically, OWL-S Web Services adopt SOAP (*Simple Object Access Protocol*) for exchanging XML data, and are published in a semantics-enhanced UDDI (*Universal Description, Discovery and Integration*) registry that describes the protocol bindings and message formats required to interact with the web services listed in its directory.

By exploiting OWL-S Web Services, it is possible to provide the users with relevant information, permanently adapted to their particular context. These context-aware tourism services are built on application environments operating on top of 2.5G/3G networks with a permanent wireless connection such as GPRS (*General Packet Radio Service*) or UMTS (*Universal Mobile Telecommunication*

Systems). One of the main features in the user context is his/her location, whose identification requires a *Geographical Information System* (GIS) that receives data from handheld devices equipped with GPS (*Global Positioning System*) capabilities. Since location plays a crucial role in tourism systems, it is also a vital feature in the presentation of the list of resources suggested to the tourist. Technologies involved in this process have to do with services developed by the *Open Geospatial Consortium* (OGC), such as *Web Map Service* (WMS) that serves georeferenced map images over the Internet which are generated by a server using data from a GIS database.

Before concluding the technological landscape of TripFromTV, we must allude to the Digital TV, whose capabilities have never been exploited in personalized tourism systems. Specifically, our system harnesses the following features:

- first, the existence of a huge diversity of contents and theme channel in the digital stream, thanks to a greater bandwidth; and
- second, the possibility of transmitting audiovisual contents together with applications to be executed in the DTV receivers (Set-Top Boxes) [21].

The first feature provides a huge amount of valuable information about the preferences and interests of the user who is watching DTV, whereas the possibility of running applications in the user's Set-Top Boxes permits to automatically track this list of programs (and exploit it for initialization of his/her tourist profile). One of the most important technologies concerning these applications is the Multimedia Home Platform (MHP) [22], a standard developed by the Digital Video Broadcast Consortium that defines a generic common framework to enable inter-operable applications to be broadcast and executed on receivers with specific hardware and software implementations from any manufacturer. MHP normalizes the application model, the integration with the software of the DTV receiver and the API (Application Programming Interface) to access the hardware resources in any compliant equipment.

III. Reasoning Framework of TripFromTV

Before focusing on our recommendation strategy, we describe the two main components of the reasoning framework that supports TripFromTV: domain ontology and user profiles.

A. The Domain Ontology

By its nature, TripFromTV deals with two domains referred to TV and tourism, which has been jointly formalized by reusing publicly available ontologies and management tools such as Ontolingua (an environment that allows creating, browsing, editing and modifying ontologies [23]) and Chimaera (a software system aimed at merging multiple ontologies by reorganizing taxonomies and resolving name conflicts [24]).

- In order to formalize the TV domain, we have imported the ontology developed in our previous works in personalized Digital TV. As explained in [25], our TV ontology has been automatically generated from TV-Anytime metadata specification [26], which provides very fine-grained semantic descriptions of generic audiovisual contents, including concepts referred to *topics*, *genres* and *credits* involved in the TV programs.
- Regarding the field of tourism, several ontologies have been developed such as OnTour [10], Harmonise Ontology [27], Hi-Touch [28], ebSemantics [29], EON Travelling Ontology [30], and TAGA Travel Ontology [31]. Bearing in mind the reasoning requirements of our system, we have adopted the ontology with the highest number of concepts and relationships of interest in the tourism domain. Specifically, we have enriched OnTour ontology by adding new formal concepts referred to *tourist resources*, typical leisure *events* and *activities*, *infrastructures* and even *geographic data* for location-aware recommendations.

Specific TV contents and tourist resources are represented in our domain ontology as instances of classes that are categorized in an *item hierarchy*, as depicted in the micro-excerpt of Fig. 1, where "*Cares for your poodle*" is a program about dogs care tips, and "*Diving in Res Muhammad National Park*" is a tourist water activity in the coral reef of an emblematic Egyptian spot.

Lastly, even though it has been omitted in Fig. 1 for the sake of clarity, classes and instances referred to tourism resources in our ontology are linked to a list of *relevant context features*, so that each class inherits the context features associated to its immediate superclass in the tourist resources hierarchy, whereas each instance inherits those features from the classes it belongs to. Specifically, relevant context features associated to each tourism resource are matched by our recommendation strategy against the particular situation of the user at anytime, as we will describe in section IV-B (e.g. the relevant context features for "*Diving in Res Muhammad National Park*" might include *opening times* and *dates*, *duration* and diving equipment renting *price*).

B. User Modeling

The users' profiles in TripFromTV combine miscellaneous information including identification data, DTV viewing histories, tourism information, context-related data and specific levels of interest associated to both TV contents and tourist resources.

Firstly, **DTV viewing history** includes a list of the programs the user has watched over the channels available in the digital stream. These programs are automatically spied by an application running in the user's Set-Top Box, and stored for personalization purposes once the user has given his/her consent. Actually, the programs are referenced by unique identifiers (IDs), by which it is possible to query the semantic descriptions of the programs in the domain ontology. Besides,

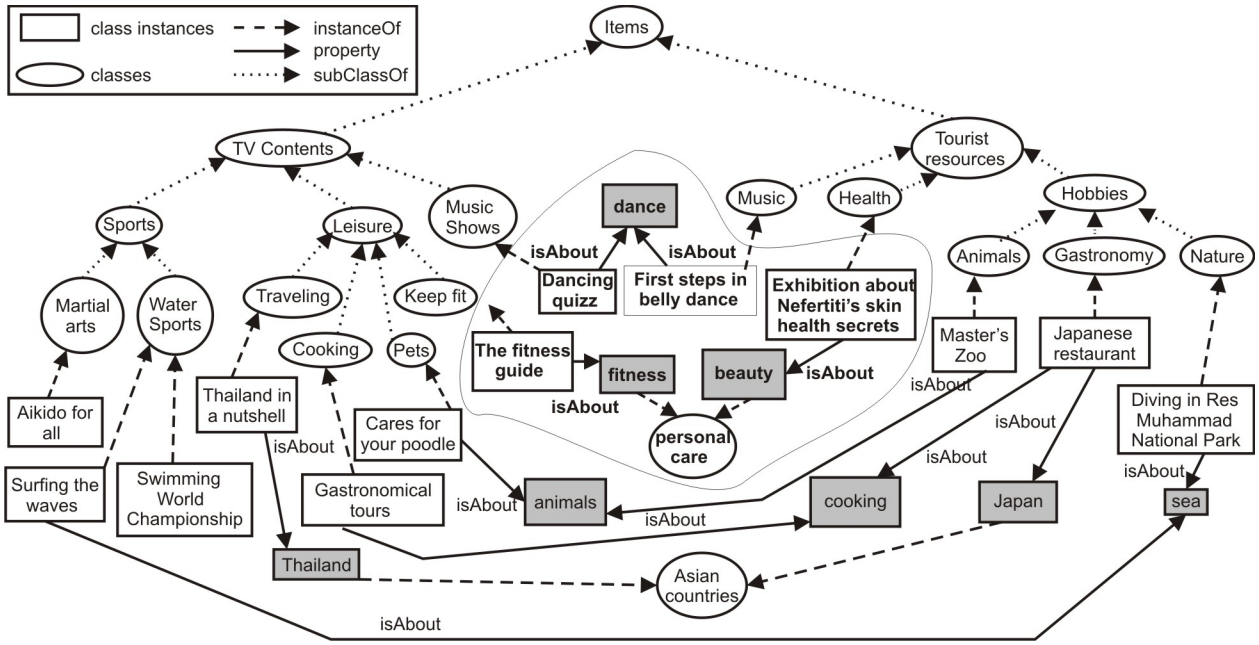

Fig. 1. Micro-excerpt from our domain ontology

each program is linked to an index, measuring the Degree Interest (DOI) of the user in that content. These indexes can be either explicitly given by the user (by pressing a button on the remote control) or implicitly inferred from the user's viewing behavior (e.g. by considering the proportion of each program the user has viewed or the number of programs belonging to the same genre he/she enjoyed in the past, as explained in [32]).

Concerning **tourism information**, the profiles store the relevance feedback the users have issued about the tourist resources previously recommended by TripFromTV, which is easily provided via a handheld device by simply pressing a specific button of the keypad to say "*I like it*", "*I dislike it*"or "*I feel neutral*". Analogously to what we commented before, the tourist resources are also referenced by unique IDs in the domain ontology, and linked to explicit or implicit DOIs.

Lastly, the users profiles also keep track **context-related data** that are relevant for on-move tourism recommendations, such as travel dates, personal preferences about accommodation options, level of income, location, etc. As we will describe in the next section, our recommendation strategy processes and matches this information against the available tourism offerings by exploiting OWL-S Web Services.

IV. Our Recommendation Strategy

TripFromTV relies on a two-phase strategy to elaborate tourism recommendations.

- **Reasoning-driven phase**: The goal of the first phase is to select a list of tourist resources potentially appealing to each user, starting from the domain ontology and the list of DTV contents he/she enjoyed in the past.
- **Context-driven phase**: The second phase is aimed at filtering the previously selected list, by removing the tourist resources that do not match the current context of the user (and giving permanently up-to-date useful information about them).

While the second phase resorts to Web Services technologies toward context-aware recommendations, the first one exploits synergies between semantic reasoning and traditional personalization paradigms.

A. Reasoning-driven Phase

Two of the most popular personalization paradigms are *content-based filtering* and *collaborative filtering*. In traditional void-of-reasoning approaches, content-based filtering suggests to the user tourist resources which are similar to those he/she liked in the past, whereas collaborative filtering recommends to a user resources that individuals with similar preferences (called *neighbors*) have enjoyed before. In order to overcome limitations of both approaches (mainly stemmed from syntax-based matching techniques [17]), we rely on (i) the knowledge formalized in the domain ontology and (ii) the adoption of advanced semantic reasoning techniques. As a result, our reasoning-driven phase consists of two filtering processes that select *content-based recommendations* and *collaborative recommendations* as follows:

- **Our content-based filtering**: The content-based process suggests to the user tourist resources that are *semantically related* to the TV contents he/she liked in the past. Specifically, two items in our ontology are related when both share either *common attributes* or *sibling attributes* (i.e. belonging to a common parent class). For example, assume that Mary resorts to TripFromTV to obtain a personalized travel plan for her next visit to Egypt. Her DTV viewing history

includes contents of very diverse genres: hobbies-related contents (such as "*The fitness guide*", "*Gastronomical tours*", "*Thailand in a nutshell*" and "*Cares for your poodle*"), sports (such as "*Aikido for all*" and "*Surfing the waves*"), and music shows (such as "*Dancing Quiz*"). As depicted in the area marked in Fig. 1, Mary's preferences are related to some of the available tourist attractions: specifically, the TV program "*Dancing quiz*" is associated to the tourist resource "*First steps in belly dance*" through the common attribute "*dance*", whereas "*The fitness guide*" and "*Exhibition about Nefertiti's skin health secrets*" share the sibling attributes "*beauty*" and "*fitness*" belonging to the "*personal care*" class. Exploring in Fig. 1 the existing *common* and *sibling attributes* (denoted by gray squares), Mary gets an all-round travel plan with the following recommendations:

- ✓ Mary likes music and personal cares, hence the fact that our system suggests her (i) an attraction to learn rudiments of belly dance, and (ii) the exhibition about the skin health secrets of the Egyptian queen Nefertiti.
- ✓ Mary seems to be a lover of the international cooking and Asia (because she enjoyed programs about gastronomy tours, martial arts and Thai culture), so our strategy recommends her to have lunch in a Japanese restaurant.
- ✓ Since Mary likes the animals (she has viewed "*Cares for your poodle*"), she might like *Master's Zoo* in Egypt.
- ✓ Lastly, from the programs "*Surfing waves*" y "*The fitness guide*", our system infers that Mary likes the sea and playing sports. So, she maybe feels like diving in the coral reef in Res Muhammed National Park.

- **Our collaborative filtering**: Social factors are important in tourism since people tend to go sightseeing in groups. In this scenario, users are typically willing to provide information about visited/known tourist resources that could be of interest for other tourists. Our strategy exploits the social nature of tourism by harnessing the user-provided feedback in order to elaborate collaborative recommendations, which offer the same resources to individuals with similar interests. Given a user, first, the strategy exploits the hierarchical structure of the domain ontology and finds his/her neighbors in the system, that is, individuals who have enjoyed similar items (either similar tourist resources or similar TV programs). Specifically, two users are neighbors when the classes of the tourist resources or TV contents defined in their respective profiles share a common ancestor in the hierarchy of our ontology. For instance, a user who has liked the program "*Surfing the waves*" would be included in the neighborhood of a user who has enjoyed "*Swimming World Championship*", because both of them share interest in "*Water Sports*".

  Once the user's neighborhood has been formed, our collaborative filtering process recommends him/her the resources his/her neighbors enjoyed (considering their relevance feedback about previous tourism recommendations, as described in section III-B).

Lastly, both content-based and collaborative recommendations are put together, resulting into a XML-format list of tourist resources that is finally refined and enhanced with context-aware information, which is located and retrieved in the second phase of our recommendation strategy.

B. Context-driven Phase

During the trip, users of TripFromTV act in a highly mobile environment where it is crucial to deal with context-aware information due to frequent happening of dynamic changes that might force to completely reschedule the travel plans and look for alternatives (e.g. attractions can be temporarily closed, and open-air events can be canceled due to bad weather conditions). In order to cope with these unexpected facts, the context-driven phase (i) decides which of the tourist resources selected by the reasoning-driven phase fulfill best the particular context of the user, and (ii) gives tailor-made information about them.

For that purpose, the context-driven phase exploits the potential of Semantic Web Services, which are published in a *semantics-enhanced UDDI registry* that contains OWL-S annotations providing information about types, inputs, outputs, capabilities, functionalities and constraints of each available web service. The adaptation process between tourist resources and user context is organized as follows:

- First, the OWL-S annotations are exploited by a *semantic matchmaker*, whose goal is to search (in the UDDI registry) Web Services that give information about the *relevant context features* of each tourist resource (see section III-A).
- Next, after locating and invoking these OWL-S Web Services, our matchmaker filters out the results as per the context-related data stored in the user's profile (see section III-B), which enables TripFromTV to react more appropriately to his/her particular situation. For example, from among all the museums that a user – who has viewed many art-related documentaries– might appreciate, the context-aware phase must select the one that best matches his/her particular context, by considering features such as *availability*, *location* and *ticket prices*. After retrieving this information, our phase might recommend a museum as close as possible to the user position (e.g. in case of unavailability of transport means), which can be visited during the travel

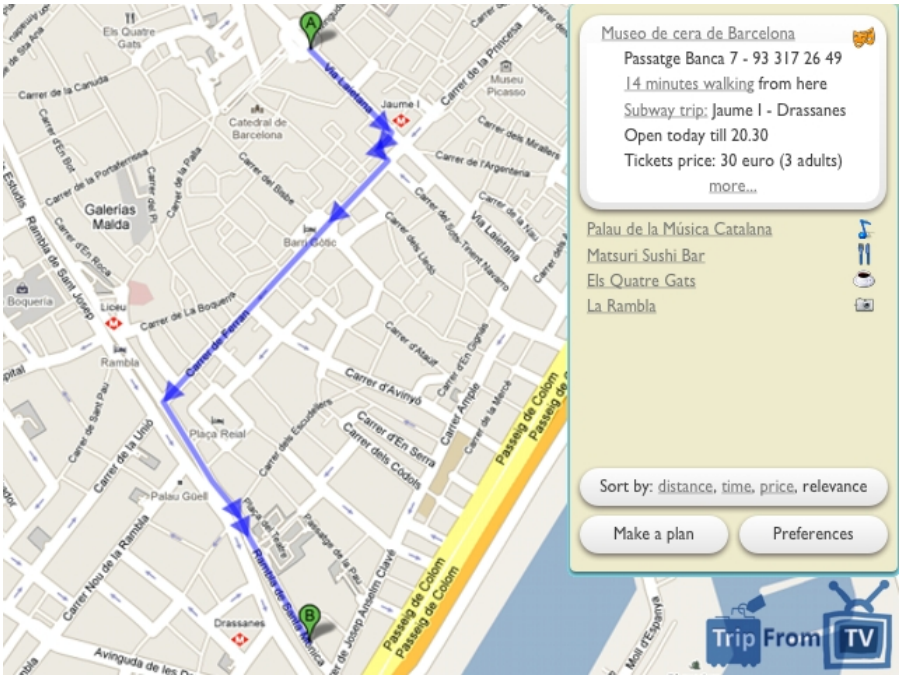

Fig. 2. Sample of tourism recommendation in TripFromTV

dates and offers tickets with a price according to income level of the user. This scenario is represented in the snapshot shown in Fig. 2, where TripFromTV gives information (e.g. address and contact data) about the recommended tourist resources (specifically, about a museum in the Spanish city of Barcelona). As depicted in the figure, recommendations can be sorted as per multiple criteria, such as distance, duration, price or relevance according to the user's preferences. Besides, the user is provided with orientation-related functionalities to arrive at each tourist resource on foot or via public transport means, as well as the possibility of making a trip plan from the system recommendations and even updating his/her personal profile.

Information about the user context is directly notified from his/her handheld device by harnessing the communication capabilities of a mobile network, as we will describe in the next section.

V. Architecture Of TripFromTV

TripFromTV has been designed as a client-server system with XML-technology for content exchanging. For communication with server, we assume a permanent connection via GPRS or UMTS based on HTTP protocol.

A. Client-side

As depicted in Fig. 3, the tandem between DTV and personalized tourism exploited in our system requires the development of two applications to be executed in the client-side: firstly, a MHP application that runs in the Set-Top Box of the user (in his/her role as DTV viewer); and secondly, the TripFromTV application that is executed in the handheld de-vice employed by the user (as a tourist) to access our on-move context-aware recommendations.

Concerning the *MHP application*, its aim is to track the list of DTV contents the user liked in the past. As usual in personalization services [33], [34], in order to deal with privacy concerns, the users sign a service-level agreement with the service provider: the later commits to the provision of trustworthy servers that never reveal the users' personal preferences and their DTV viewing histories, whereas the users explicitly allow this information to leave their terminal. Information about the user's favorite DTV contents is sent though the 2.5G/3G mobile network to the server where the personalization logic is lodged. For that purpose, the MHP application uses (i) a Web Services-based interface provided by the server-side module that is in charge of updating the user's profile (called *Feedback engine*, as we will describe later), and (ii) SOAP protocol for exchanging XML-format data.

Regarding the *TripFromTV client application* executed in the user's handheld device, it comprises three main modules that are shown in Fig. 3:

- **Context manager**: Just as its name suggests, this module keeps track information about the situation of the user at anytime, and notifies immediately to the server of the occurrence of any dynamic change in his/her context. Specifically, for location-aware recommendations, the context manager relies on a GPS receiver that automatically derives the user position.
- **Presentation & interactivity manager**: On the one hand, this module is in charge of presenting the server-selected recommendations by exploiting a map-oriented

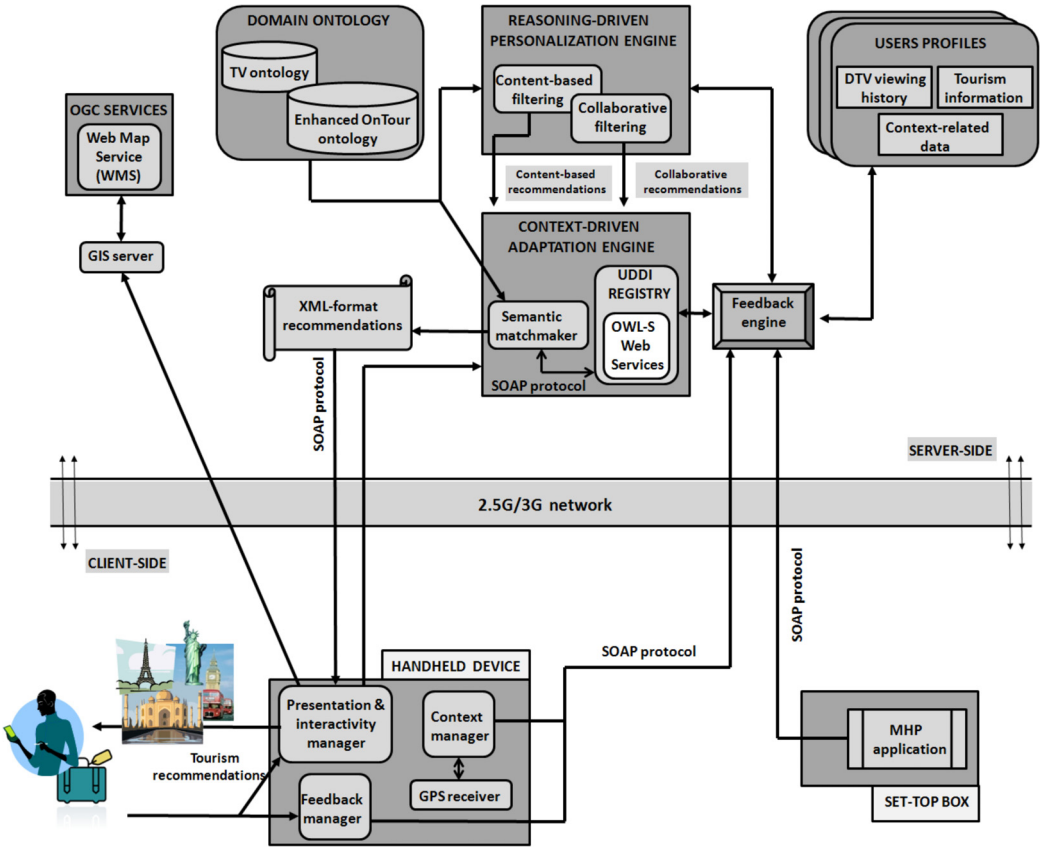

Fig. 3. Modular architecture of TripFromTV system

paradigm, where the position of the user as well as the suggested tourist resources are highlighted. For that purpose, the module receives geospatial information from a GIS server using the OGC Web Map Service. On the other hand, through the presentation-aimed module, the users can also access (via links) context-aware information related to the recommended resources, and even interactivity options (e.g. in order to book tickets for a specific activity in the infrastructure and dates suggested by the system), as shown in the snapshot of Fig. 2. These context-aware interactivity options exploit the communication capabilities of the mobile network and the potential of Web Services technologies adopted in the server side.

- **Feedback manager:** Lastly, after presenting the recommendations, this module takes charge of gathering the relevance feedback –explicitly or implicitly received from the users (see section III-B)– and sending it to the TripFromTV server through the 2.5G/3G network.

B. Server-side

Along with the domain ontology and users' profiles, the TripFromTV server lodges the following components:

- **Feedback engine**: The goal of this module is to query and update the users' profiles. As this task needs data coming from the client-side (see Fig. 3), the feedback engine offers an interface based on Web Services, which relies on SOAP protocol for receiving data about the user's DTV viewing history (from the MHP application running in the Set-Top Box), his/her current context and tourism-related preferences (from the context manager and feedback manager placed in the TripFromTV client application, respectively).
- **Reasoning-driven personalization engine**: This module implements the reasoning-driven phase of our strategy (described in section IV-A). Consequently, it selects automatically content-based and collaborative recommendations by accessing the users' profiles (via the feedback engine) and the knowledge formalized in the domain ontology.
- **Context-driven adaptation engine:** The goal of this module is to adapt the reasoning-based recommendations to the user context, by removing the tourist resources that do not match his/her particular situation during the trip. As depicted in Fig. 3, the context-driven adaptation engine delegates this task to the semantic matchmaker, which compares the user context (permanently updated by the context manager in the client side) against the information retrieved from the OWL-S Web Services published and located in the semantics-enhanced UDDI registry (see section IV-B). Lastly, the selected tourist resources (as well as the interactive links providing context-aware

personalized information) are sent to the presentation manager in the user's handheld device, by exploiting the SOAP protocol on the top of the mobile network, as represented in Fig. 3.

VI. Preliminary Experimental Evaluation

For validation purposes, we have developed our system as a 440 KB Java package to be executed on fixed and handheld devices, which accesses a personalization web server where our two-phase recommendation strategy is running. This server also lodges the domain ontology and the DTV viewing histories of 117 users involved in our tests.

- On the one hand, the domain ontology was populated with tourist resources from Galicia (a historical region in northwest Spain), resulting into 20000 nodes referred to tourist resources and their semantic attributes, which were automatically retrieved from the tourism website TurGalicia.
- Regarding the users involved in the tests, they visited multiple Galician cities during Holy Week and received our on-move recommendations for their specific destinations through handheld devices (which were equipped with GPS capabilities to get context data about location). The users were recruited among our (under)graduate students and their relatives and friends, incentivized by the possibility of winning recharge vouchers for mobile phones and cash prizes. We ended up with a diverse audience, with disparate demographic data and educational backgrounds, including nearly as many men as women (52% vs 48%) whose ages range from 13 to 55 years old.

After the 7-days validation period, the users were asked about various aspects of our recommender system, such as quality of our personalization capabilities and intention usage. From the users' answers, we got interesting statistics: briefly, we found that around 75% of the users rated our recommendations as "*very positive*" or "*positive*", whereas 68% of them told that they would be willing to pay for our personalization service. Also, more than 62% of users revealed that our system discovered many appealing tourist attractions they had never considered on their own, which evidences the potential of semantic reasoning as personalization mechanism in tourism field.

VII. Conclusions

We have detailed TripFromTV, an adaptive recommender system that helps the users to find tourist resources matching their personal preferences, which are dynamically adapted as the user context changes. Our system can be accessed through domestic and mobile consumer devices, which allows both to prepare the travel plan in advance before leaving home, and to request permanently updated on-move recommendations once the users have settled in the tourist destination.

In the paper, we have discussed how context-awareness and personalization capabilities fit together in TripFromTV and how both have been integrated in its modular architecture. Specifically, our context-aware personalization capabilities are reached by resorting to reasoning mechanisms borrowed from the Semantic Web and to Web Services. Both technologies have been harnessed due to their potential benefits in the field of tourism:

- On the one hand, by reasoning about semantics our system automatically shapes a personalized tourism offer, by considering both the kind of DTV contents the users enjoyed and the interests of like-minded individuals. Such reasoning techniques uncover interesting bounds between the user's favorite programs and appealing tourist resources, which remain unexplored in existing semantic approaches to personalized tourism due to their limited inferential power.
- On the other one, Web Services exploit the possibilities of enhancing our recommendations by locating and retrieving –from external sources– information about the suggested tourist resources, which is permanently adapted to the particular situation of each user. This leads to a novel model of tailor-made tourism, where the focus is put on the preferences and needs of each individual user at anytime in anywhere.

Our system has been experimentally evaluated with a set of 117 users, who were asked about the personalization quality of our reasoning-driven tourism recommendations. In the light of the results, TripFromTV can be seen in the field of consumer electronics as a step forward in the next-generation of tailor-made tourism systems, standing out because of the exploitation of synergies among semantics-enhanced technologies (including Web Services and advanced reasoning mechanisms), Digital TV capabilities and wireless communication networks.

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