Towards a Unified User Profiling Scheme for Distributed Large Sporting Events' Environments

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***Abstract*— This paper presents a user modeling and personalisation framework for providing personalized services to users through their mobile devices during large sports events. The user model combines the knowledge of sports events the user physically attends and the knowledge of the user's interaction behavior when consuming multimedia content from his mobile while away from the sporting event's venue(s). The user model employs both explicit and implicit modeling techniques which is able to learn and represent shifts in the user's preferences. Ontologies are used to formalize the user model and domain knowledge thereby disabling ambiguities in preferences specification but introducing reasoning capabilities.**

Keywords- Ontology, user profile, sports, olympics

I. INTRODUCTION

Distributed large sports events (DLSE) like the Summer Olympics, Commonwealth Games, and Paralympics are often characterized by several sport events of diverse disciplines taking place at disparate venues and places and spanning a number of days. This high activity environment is becoming a melting pot for several dimensions of research into personalization in order to enable spectators make better use of the enormous amount of information that is often generated in this sort of environment [7]. Mobile devices lend themselves as a target platform for personalisation in this environment due to their small form, light weight [3] and sensors, e.g., GPS (Global Positioning System) modules which can be queried to return a device's position.

Current state of the art of personalisation systems in DLSEs can be broadly classified into two categories based on their target context of usage. While the first category focuses on the spectator who physically attends the sports events, the second category focuses on remote users who receive the content over a network. On the former category, the personalisation system delivers complementary multimedia information services, e.g., replays, game statistics etc. but these systems do not factor in other sports events the user might be interested in and has accessed through their devices. In the second category, emphasis is laid on the user's interaction with the networked (mobile) device and viewing pattern in order to deliver a personalized service but no consideration is given to what events the user has physically attended in the past. In this paper, we present a user modeling and personalisation framework that attempts to unify both worlds as they combine the sports multimedia consumption habit of users on their mobile devices and information on what sporting events they physically attend during DLSEs inferred through the user's location. This combination is done in order to offer the user a more accurate personalisation service within and without the sports arena.

In order to investigate this, we propose an ontology-based location augmented user profiling scheme which profiles users attending sports event by monitoring the sporting events content they consume within and without the events they attend. An ontology based approach is chosen because it provides a richer representation scheme which is more precise and less ambiguous than other conventional schemes [6]. In addition, it provides an adequate foundation for the representation of coarse user interests to fine-grained preferences in a hierarchical way, and can be a key enabler to deal with the subtleties of user preferences [4].

In the rest of this paper, a review of related work is presented in Section II and it is followed by the architecture proposed in Section III. The constituent ontologies of the system and the applied proposed profile learning techniques are specified in Section IV and V respectively and finally, some future work is discussed.

II. RELATED WORK

There has been several research endeavors directed towards enriching users' interest, engagement, and experience of DLSEs in different ways. In order to deliver this experience, these systems need to maintain an internal model of the user.

In [12], a personalized live sports event viewing system for mobile devices is presented. The system uses an implicit user model driven approach to enables the personalisation system which adaptively predicts a user's preferred events during live sports shows. While this work demonstrates how a personalisation system can use a user's previous viewing session to elicit the user's preferences, it does not take the user's location (which can offer more insight into the user's preferences) into consideration. In addition, a simple XML format is used to represent the user model. Hence not much of reasoning can be done with such a model.

In [2], a place-shifted sports 'snacking' application is presented. The system provides sports fans a medium to catch-up with their favorite sports when they cannot view the live event in person as it unfolds. Although this system does not explicitly describe its user model, one can envisage that a very simple user model is used to achieve this.

In [1], a mobile based in-stadium information system is presented. The system provides on-demand instant sports replay and traditional media convergence functionality to mobile devices by capturing and processing a television signal. This system assumes a generic user model for all users and does not support any out-of-stadium experience Other DLSE personalization systems include [10], which allows users to follow athletes of their choice by tracking their preferred athlete's location, speed and pulse. This idea is pushed further by [5], where users can track their preferred cyclists in a long distance cycling race and based on the tracking information, they can decide where to position themselves in order to get a good view of their preferred athlete. Although these works use the concept of location, it is used in improving the user's interaction with the associated sport and does not in any way aid the personalisation system in gaining a better knowledge of the user's preferences.

The aforementioned works show the lack of a rich user profiling scheme in the prevailing DLSE personalization domain. In order to develop a functional user profiling scheme, some requirements as outlined in [8] ought to be considered. Some of these requirements include:

Semantic Reasoning – the user model and multimedia artifacts (video, text, pictures, metadata etc) should be semantically modeled based on ontologies in order to enable semantic reasoning.

Dynamic User Profiling - human preferences generally tend to be dynamic and transient. Most of this dynamic behavior can be captured by continuously monitoring and recording the user's behavior for analysis. This record can be collected in form of a history of multimedia artifacts assessed or requested by the user as a function of the time spent consuming it. In addition this work argues that a location component ought to be added to this record.

III. System Architecture

The aim of this proposed framework is to formally elicit a location-augmented user model optimized for mobile devices aimed at large spots events. The architectural overview of the proposed framework as depicted in Figure 1 shows the main components of the system and their respective data flow. As shown, the proposed system architecture consists of a User Profile Management System, a Personalised Event Listing Service (PELS), a Sport Events Schedule Server and some domain ontologies. A brief outline on these components is as follows:

The User Profiling system consists of the User Profile Ontology, Profile Learning Module, the (Runtime) User Profile, the Profile Store and the Profiling Proxy – which runs on the personalized application installed on the user terminal. These components work together to ensure that both explicitly and implicitly collated information from the user is used to identify and represent the user's static and transient interests or preferences. The PELS is responsible for matching users with available live sport events as described in the semantically annotated event schedule and it

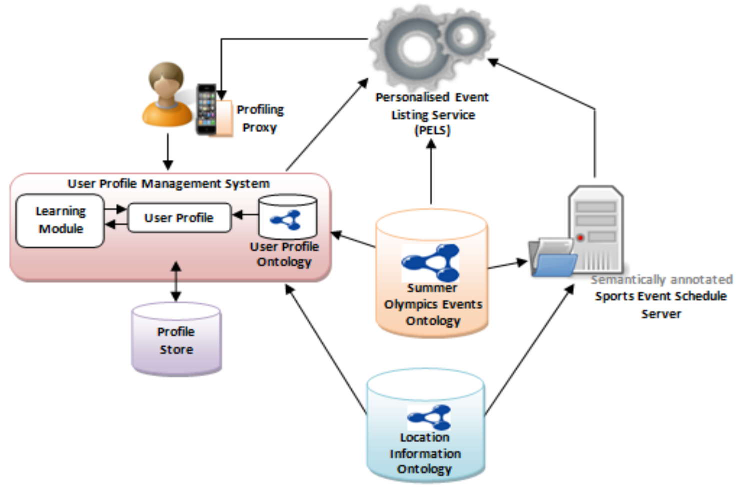

Figure 1. Overview of the proposed framework

outputs a ranked list of live events that matches the user preferences as specified in the user's profile. This is a ranked list ordered by the degree of relevance it has to the user. The associated domain Ontologies are integrated for knowledge inference and vocabulary control. In line with this, users can only express their preferences on concepts formalized in the Summer Olympic Events (SEO) ontology and concepts from this ontology are used in for annotating the schedule.

A. *The Personalization Process*

In a nutshell, the personalisation process as offered by the PELS begins when the user logs-in into the system. A successful log-in sub-process involves the transfer of a profiling proxy from the user's mobile device to the profiling service. The profiling proxy at log-in encapsulates the user's unique identifier, current location, usage history (of the last session) and location history etc. The proxy remotely and temporarily stores the user's usage information before it is sent to the Profiling system – this is done periodically. The information from the proxy is used to uniquely identify the user and retrieve his full profile from the profile store. The retrieved profile is then updated with the content of the profiling proxy (depending on which of the information is more current). The updated profile is then passed to the PELS.

The PELS receives the user's profile and reasons with it along with a semantically annotated schedule of the live sport events which includes the event venue for every given event. The output of this reasoning process is a ranked list of events that matches the user's interests and relevant to the user's current location.

IV. Domain Ontologies

The domain ontologies specified in the proposed framework are responsible for giving structure to the knowledge represented in the framework. The ontologies conceived as depicted in Figure 1 include the Summer Olympic Events (SEO) ontology, the Location Information Ontology and the User Profile Ontology. In developing these ontologies, the Web Ontology Language (OWL) was used to formalize an ontology conceptualization and produce a hierarchy of concepts. The concepts and relationships for the Summer Olympics Events domain ontology in this framework are specified based upon the structure of sports information collated from the Olympics organization website and the rules and regulation handbook for each respective sports discipline – retrieved from the website of the respective governing body for the given sport. While the Location Information Ontology contains concepts and relations that represent location information but only focusing on those that can be used to connect the domain knowledge (which include the sport events and their respective venues) with user's location(s) during the profile learning and personalisation process. On the other hand, the User Profile Ontology comprises concepts and relations that represent a user, his preferences and past behaviors.

A. The Summer Olympic Events (SOE) Ontology

The Summer Olympics Events Ontology represents the conceptualization of the domain of Summer Olympics Events. The aim of this ontology is to provide a vocabulary and background knowledge for eliciting user preferences as well as annotating the events schedule in order to streamline the semantic matching and personalisation processes in the PELS. Given that users are currently only allowed to specify their preferences for sport events and venues, athletes and sports officials are currently not included in the model.

The SOE Ontology is modeled to be consistent with the sport events nomenclature and taxonomy used by the International Olympics Committee (IOC) which has an Olympic sport at the top of the taxonomy, then sports' disciplines and the sports events in the bottom. According to the IOC, a sport is a single or group of disciplines regulated by an international federation (a governing body).

Taking the IOC's model into consideration, the SEO ontology was conceptualized to include all 26 Olympic Sports, and their respective disciplines, and events in the Summer Olympic Games. The sports are modeled as top level concepts, while the disciplines as the subclasses (where applicable) of these top level concepts while the events are instances of the subclasses. In addition, each individual event is qualified by a number of object properties such as *performedWith*, *performedIn* in order to support a richer inference and classification scheme by comparing the values of the specified object properties.

B. Location Information Ontology (LIO)

The Location Information (LIO) domain ontology conceptualizes the notion of location in the proposed framework. Location related information is necessary for adding a location component to the semantically annotated events schedule thereby signifying where the events are taking place which translates into providing a means to model location information for the events described in the SEO domain ontology. Thereby, enabling the personalization system to filter events according to a user's current location. Moreover, users can elicit their preferences through locations (venue of sports events) explicitly – by users choosing which sport event venues they will prefer to visit or receive live

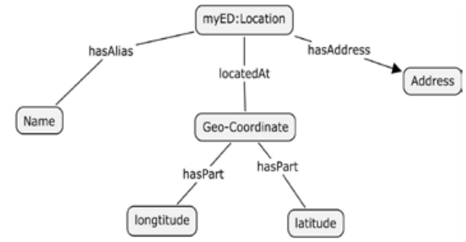

Figure 2. An abridged representation of the Location Information Ontology (LIO).

information from or implicitly – by the system monitoring which event venues the user actually attends and using the information as a form of relevance feedback to augment the user's general preference model. Figure 2 shows an abridged model of the LIO.

The Location concept is has the property *hasAddress* which qualifies the address of the given location. The *locatedAt* property reflects the location's geo-coordinates (in logtutude and latitude) while the *hasAlias* is used to hold the location's well-known name e.g., Aquatics Centre.

C. User Profile Ontology (UPO)

In conceptualizing the User Profile Ontology (UPO), we were inspired by a number of user models especially the General User Model Ontology [11]. However, we have so modeled it such that only concepts relevant to our domain of discourse are retained. Our model logically contains both static and dynamic representations of the User. The static information are those that are less likely to change over time and this is represented by the Person the user is. This sub-model describes the user's unique identifier and other demographic information. The other components comprise the dynamic entities whose instances are updated by the system as the user interacts with it. These components include the user's *locationHistory*, *usageHistory*, and Preferences.

Furthermore, as depicted in Figure 3 the proposed User Profile Ontology is modeled to capture not only the sports events selected by the user in previous instances, but also the location where the user was. For instance, the user selecting an Archery event while at the Aquatic Centre may signal the user's preference for swimming events over archery.

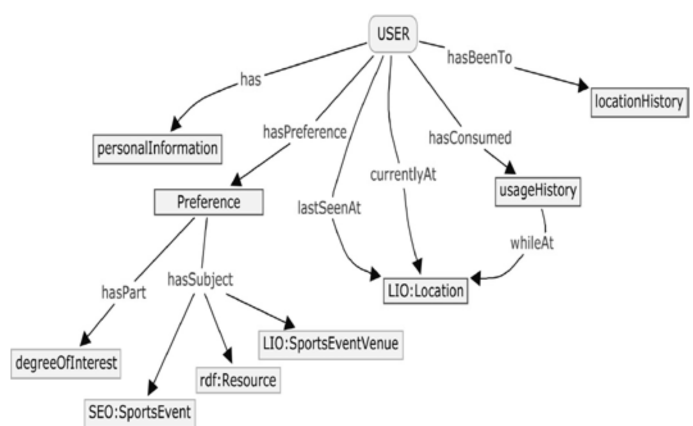

Figure 3 An abridged representation of the User Profile Ontology

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The *Preference* concept is used to specify the user's sports event and venue interests and disinterests respectively. These interests are associated with a *degreeOfInterest* index which is used in a preferences weighting scheme and reflects how much the user prefers a given event over the others. This weighing scheme allows the profiling system to dynamically increase the weights associated with sports events the user continually shows an interest in, while the index of those the user shows disinterests in are gradually attenuated.

V. User Profile Learning

Since user's preferences change over time [8], it is imperative to for the system to learn the user's preferences by monitoring the user's behavior by analyzing the contents they have viewed in the past as stored in the *usageHistory* component of the profile and the sports venues they have been to as stored in the *locationHistory* component of the profile. One approach employed in ensuring that the user's profile stays relevant is by updating the *degreeOfInterest* component for every preference concept in the user's profile by a time-based decay function based on the user's behavior (i.e., sports events venue attendance habit and mobile application usage). The decay function is as follows:

$$doi_{new} = doi_{old} + Rfb \times e^{-\partial x} \times \log\left(\frac{time}{\log length}\right) \qquad (1)$$

The doi_{old} variable stands for the current *degreeOfInterest* component of the preference concept. Rfb is the relevance feedback factor given through an analysis of the content consumption and frequency of visits to a given event venue; the relevance feedback value is taken to be a Boolean value. The $\log\left(\frac{time}{\log length}\right)$ expression reflects the time spent at the given event venue or watching an event content item on the mobile application and the duration of the event or length of the content, operates as the normalizing factor. The $e^{-\partial x}$ factor is used to cushion the personalized non-linear change of the concept's weight according to user *locationHistory* and *usageHistory* data. '*x*' represents the number of consumed content. The more content a user consumes, for example, the more slowly the weights increase. The ∂ factor is a constant, which takes different values in the two opposite scenarios of consumed/non-consumed content. More precisely, in the case of non-consumed content, the changing rate (i.e., the decreasing rate) should be slower, since a non-consumed content does not constitute an explicit indication for non-interest. On the contrary, in case of consumed content the changing rate (i.e., the increasing rate) should be faster, since a consumed content demonstrates a better indication for interest.

VI. Further Work

In moving this work forward, the profile learning algorithm will be improved by integrating a weight spreading algorithm which will update other semantically related preference concepts' weights when one of the neighboring concepts in the user model is updated. In addition, an empirical evaluation of the framework will be carried out using real users and the results will be compared with that of convention DLSE personalization systems. Furthermore, aspects of social and group modeling are areas to be further investigated with respect to this work.

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