Understanding Individual's Behaviors in Urban Environments

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***Abstract*—UrbanContext is an urban computing context abstraction model that follows an individual centered approach and validates the use of the Theory of Roles to understand the behavior of the individual within a social environment. The roles defined in UrbanContext allow the interpretation of the states of the individual, facilitating its interaction with the environment and offering services without damaging its privacy. In this paper, we mainly describe a real evaluation scenario for UrbanContext at the UBI platform in Oulu (Finland).**

Keywords–Urban Computing; Urban Context; Models; Theory of Roles; Smart Cities.

I. INTRODUCTION

Several projects have focused their works on improving cities, with the objective of making them more intelligent and ubiquitous. The ubiquitous city [1][2] is defined as a city with high technological interaction that has as goal to offer services and information at any place and time to its inhabitants.

These urban environments become spaces where persons, places and technologies converge. These three aspects form the so called triad [3] in urban computing. People become dynamic individuals and the main subject of study, if we want to offer people-centric services within an urban environment.

To model the context in the urban environment we face a big complexity due to the great number of variables involved in such spaces. This complexity demands techniques that allow the modeling and the representation of the individuals' behaviors in the cities.

Our contribution to face this problem is UrbanContext, a model for urban computing systems that uses the Theory of Roles [4] to manage context. UrbanContext facilitates the interpretation of the states of the individual, the development of adapted services and the generation of positive relationships. We propose a validation scenario in an adapted real environment, and evaluate our roles model approach.

The paper is organized as follows: The first section is an introduction about the context and the theory of roles in urban computing. The second section presents the roles model used in UrbanContext and describes the dynamic of the component. The third section presents an evaluation scenario for UrbanContext at Oulu (Finland), and finally, we conclude and present some future work.

II. THE CONTEXT AND THE THEORY OF ROLES

To model the urban environments it is necessary to consider the context. Schilit and Theimer [5] introduced the term *"context aware"*, and they consider the *"context"* as the location, identities of nearby people or objects, and the changes happening to these objects. Later, this definition was complemented in [6], where it was stated that the important aspects of context were: where you are, who you are, and what resources are near you.

One of the broader definitions was made by Dey [7], who defined *"context"* as any information that can be used to characterize the situation of an entity. These definitions were widely discussed and subsequently improved by Dourish [8], who indicated that to understand and model the context it was also necessary to involve social issues. Based on the latter idea, in UrbanContext we need a user-oriented approach that allows the identification of the individual's behavior and interaction within the urban environment.

The Academic Community has done big efforts to understand the different points of view present in urban environments. A representative example from the beginnings could be the project "Familiar Strangers" presented by Paulos in Intel Research [9], while recently we could mention the project "Urban Computing Middleware" funded by the South Korean Government [10], that tries to identify people, present in an environment, sharing the same likes in order to provide them with common services.

One of the challenges found in urban environments is the need to generate interacting spaces that allow to establish strong relationships among individuals. To achieve that it is necessary to understand the roles that people play in an urban environment in order to satisfy their real needs [11].

To face all these challenges, we use the Theory of Roles proposed by Erving Goffman [4]. This theory considers an individual who determines its behavior according to the role he/she plays in a certain situation. The individual's behaviors are influenced by the interactions he/she experiences, and is constantly changing the roles played within the social environment.

Therefore, the objectives of the UrbanContext, are to improve the interaction of the individual within the urban context, to identify its needs in every interaction and to provide services for it.

III. ROLES MODEL IN AN URBAN ENVIRONMENT

Understanding human behavior generates technical challenges for managing and classifying data with the required quality [12]. These challenges are related also with the issues to understand how the individual socially interacts, and how this interaction can be powered.

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The individual interacts in physical and social environments that influence directly its behaviors, so we need to understand what he/she is doing, and what he/she really wants to do in specific physical places to estimate past behaviors in order to predict future ones. The roles model used in UrbanContext focuses on those challenges, and characterizes several individual states, defining if the user wants to be disconnected from the system or if it wants to play a certain role in a particular spatial or temporal scenario within the urban environment.

A. The Management of the Context in the UrbanContext Model

As we said before, we have created UrbanContext [13], which is a general-purpose model with a set of components, used for the design of urban computing platforms that applies the Theory of Roles to manage the individual's context in urban environments.

UrbanContext was designed from the result of previous projects and experiments developed in controlled and open environments of urban interaction. Our previous experiences have been performed gradually and were restricted to three major projects [14][15][16] (See Figure 1).

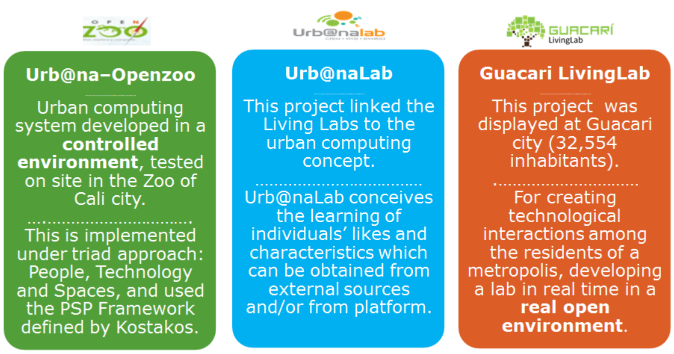

Figure 1. Previous Projects Developed in Urban Computing.

Openzoo [14] was the first project, and it was developed in an urban tourist controlled environment. Here, we worked along with anthropologists and sociologists analyzing a group of 400 individuals. After that, we had seven work sessions with focus groups of 45 users of different categories in a zoo. This allowed an ethnographic analysis of the individuals, the identification of their perception about the urban environment and the availability of technological resources.

Based on this first experience, we developed Urb@naLab [15], an urban computing platform that mixes the living lab concept in its design to allow the creation of collaborative spaces where the individual could participate actively in the co-creation of services. This originated a third project called Guacarí LivingLab [16], an Urb@naLab adaptation on an open real environment. LivingLab was considered as an ideal space to experiment, where we carried out three sessions with control groups of 45 people to observe and measure the interaction among individuals.

These previous experiments allowed us to identify the constant needs when designing urban computing platforms and led us to propose Goffman's Theory of Roles [4] to model the context of the individual. In order to describe it, we outlined our proposal with five components that we consider relevant to develop urban platforms (See Figure 2): interface, roles, semantic, cloud and services. The components of the UrbanContext model can be described as:

Interface Component, is the main external interaction point, uses several devices and technologies present in urban environments like mobile devices, augmented reality, etc.

Roles Component, is in charge of understanding human behaviors for modelling human states. This component allows the system to manage context information, to identify user interactions and to provide personalized services.

Semantic Component, is in charge of classifying all the information obtained, in order to be processed afterwards by algorithms to introduce a semantic level for reasoning.

Cloud Component stores all the data obtained from the individual and the urban atmosphere.

Service Component provides a set of adapted services to the individual needs.

In UrbanContext, the management of the context and the roles assumed by the individual are modeled through the Roles Component. The Roles Component is composed of four sub-components: urban agent, urban atmosphere, context and context management. Next, we describe the main aim of all those sub-components:

Urban Agent SubComponent, which is focused on the characterization of the user. It should collect all the information of the user directly from its interaction, as well as from different social sources he/she is related to.

Urban Atmosphere SubComponent, that allows filtering through all the data about the place, the environment, as well as the persons attending the space.

Context SubComponent, which is associated with the identification of the contexts in which the individual participates within the urban atmosphere. It considers that the individual can be in three different contexts: personal, social and global. This sub-component collects and identifies the roles of the individuals within every selected context.

Context Management SubComponent, that focuses on the semantic processing of all the data collected by the other components. It also achieves discovering services, establishes the logic of the individual's behaviors in the atmosphere and builds effective relationships.

B. Roles Component Flow

In UrbanContext we use a multi-tier approach to manage the context, which is divided in three main parts: global, social and personal. Thus, the Roles Component provides:

The ***global context*** is fixed to an individual in an open space of the urban atmosphere. This context manages what people share through a set of services around a public place: a concert, the meeting in a square or a spontaneous congregation.

The ***social context*** corresponds to what is obtained from socializing with other individuals; for example, friends, acquaintances and people the individual gets in contact with.

The ***personal context*** is based on the individual's own world, the one that is only available to it. In this space, the user is represented as a big bubble with some needs, fears, concerns, ideas and tastes.

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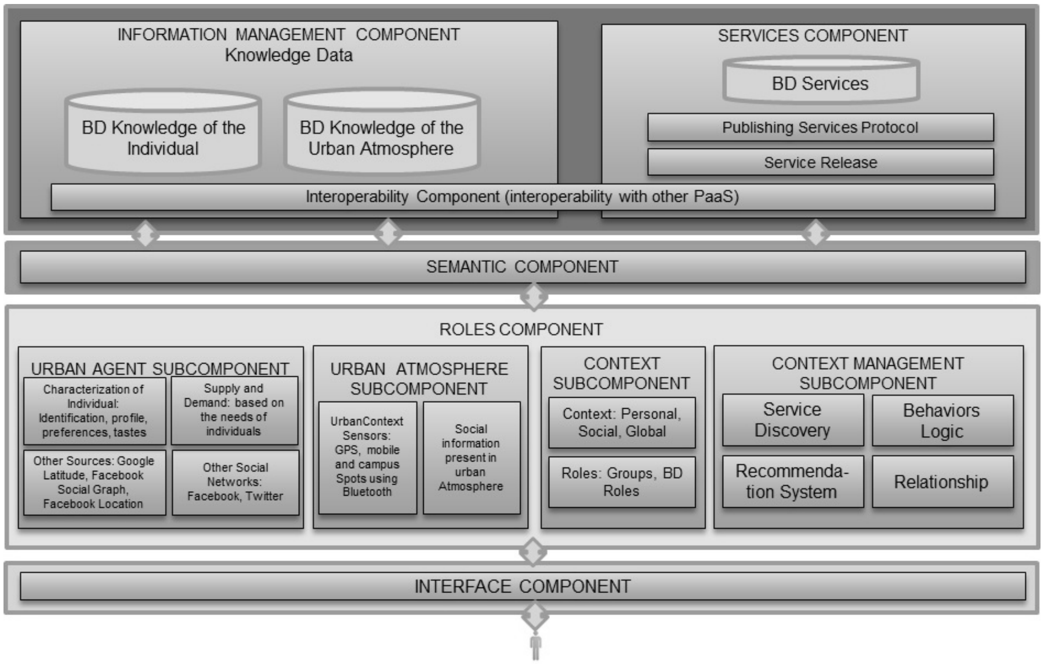

Figure 2. UrbanContext Model.

At this level of abstraction, we use a second ranking that allows to offer customization. For this approach, we used the Theory of Roles, which considers individuals always playing roles according to their situation. By applying this concept in UrbanContext, we establish that for every context an individual can play different roles that we can structure hierarchically as:

Role Groups: Personal, Family, Professional or Academic, Social and Rest of the World Roles.

Role Categories: Within each Role Group we have created several categories that identify the role the individual is playing, i.e., father, uncle, teacher, friend, or just himself.

Individuals can release public information and needs according to the role and the context they are at a certain moment. This information is fed into a knowledge base that identifies the role of individuals in an urban environment to be able to provide the right services adapted to their needs.

IV. EVALUATION PROCESS OF URBANCONTEXT

The evaluation process of the UrbanContext model considers three main steps. The first one identifies ***who is the individual***, the second one identifies ***what role is playing the individual*** and the third one predicts ***which services are relevant for the individual.***

The evaluation of the UrbanContext takes place at Oulu (Finland), where citizens have available a smart city platform, ***Open UBI(quitous) Oulu*** [17], which is accessible through displays scattered over the city. The UBI platform offers services like games, transport information, event information, maps, etc. (See Figure 3).

As the interaction with the UBI platform is done through smart displays and not with mobile devices, and taking into account that to identify the individual's roles it is necessary that participants are available online, we have designed a mobile application in Android to support all these issues.

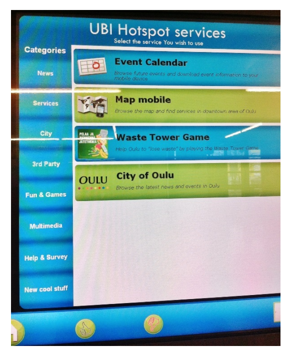

Figure 3. UBI Platform Interface.

The development of this application has taken into account technical and sociological factors. The application shall be able to consider different scenarios. For example, in many cases we need different services for a person when he/she is 20 years old, than when he/she is 35 years old.

The Android application can be freely downloaded by the participants in the evaluation. The application identifies the individuals and their devices. The application also stores a set of individuals' interaction records during a certain amount of time. Finally, the mobile application also includes an algorithm to manage the knowledge needed for the predicting future services (See Figure 4).

Concerning the three evaluation steps described above, they are performed as described next:

Individual and urban atmosphere information: the information is obtained through *UrbanContext Application*, uploading the Urban Agent SubComponent (name, age, sex, etc), and the Urban Atmosphere SubComponent (location in real time, place, etc).

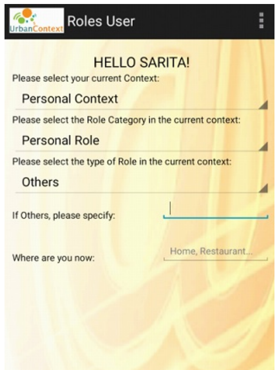

Figure 4. UrbanContext Android Application.

In Oulu, there exists demographic repositories with data coming from the users of the UBI platform. These data are combined with the data coming from the *UrbanContext Application* to obtain context enriched individual information.

Individuals' Roles: the individuals' roles are also captured through *UrbanContext Application*. The application was designed to start using a predetermined roles repository, which were obtained according by a previous study introduced in [18]. Using this predefined set of roles, an individual can choose at any time the role he/she plays from the default list or add new roles to the knowledge base.

Regarding the use of the mobile application, the user provides information about the actual context and the role it is playing when logging in for the first time. After that, the application enters a hibernation mode, appearing as an active icon on the screen of the mobile device. In hibernation mode, the user may at any time change its role by a simple touch. The application will use data mining algorithms to predict individual services based on the roles played by the individual.

Services prediction: the database obtained by the roles model, and the user interaction with the mobile device, allows to predict different services for resting or working time. For instance, if the user is resting at home at 6pm, the application can suggest a social network, but if the user is working at 9am, other work related services can be suggested instead.

While the knowledge roles' database is initially tuned by the user, the next times it adapts progressively to each user, and by means of data mining techniques (supervised classification techniques through decision trees), it is able to suggest the recommended services.

V. Conclusion and Future Work

In this paper, we present UrbanContext, a model for urban platforms that follows an individual centered approach. We consider the Theory of Roles to understand the individual's behavior within a social environment. We also define an evaluation environment in a real scenario to validate UrbanContext.

We can conclude that UrbanContext, and its roles model proposal, aim to understand the interpretation of the states of the individual, as well as its interaction with the environment. We consider that the urban atmosphere and the individuals' context directly influence the individuals' needs.

We have also realized, through the characterization of the individual and the urban atmosphere, that the roles model provides a knowledge base that facilitates the interaction and promotes positive relationships.

As future work, we plan to evaluate the UrbanContext model, at the UBI platform in Oulu (Finland), by means of our new Android mobile application. We also plan to collect enough data to measure the level of interaction of the individuals, in order to provide the adequate services according to the roles that individuals are playing at a certain time.

References

[1] J. Hwang, "u-city: The next paradigm of urban development," Handbook of Research on Urban Informatics: The Practice and Promise of the Real-Time City, 2009, pp. 367–378.

[2] M. Foth, "From social butterfly to engaged citizen," Urban Informatics, Social Media, Ubiquitous Computing, and Mobile Technology to Support Citizen Engagement, 2011, p. Chapter 17.

[3] M. Foth, J. H.-j. Choi, and C. Satchell, "Urban informatics," in Proceedings of the ACM 2011 Conference on Computer Supported Cooperative Work, ser. CSCW '11. NY, USA: ACM, 2011, pp. 1–8.

[4] E. Goffman, The presentation of self in everyday life, ser. Doubleday anchor books. Doubleday, 1959.

[5] B. Schilit and M. Theimer, "Disseminating active map information to mobile hosts," Network, IEEE, vol. 8, no. 5, Sept 1994, pp. 22–32.

[6] B. Schilit, N. Adams, and R. Want, "Context-aware computing applications," in Mobile Computing Systems and Applications, 1994. WMCSA 1994. First Workshop on, Dec 1994, pp. 85–90.

[7] A. K. Dey, "Understanding and using context," Personal Ubiquitous Comput., vol. 5, no. 1, Jan. 2001, pp. 4–7.

[8] P. Dourish, "What we talk about when we talk about context," Personal Ubiquitous Comput., vol. 8, no. 1, Feb. 2004, pp. 19–30.

[9] E. Paulos and E. Goodman, "The familiar stranger: Anxiety, comfort, and play in public places," in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ser. CHI '04. NY, USA: ACM, 2004, pp. 223–230.

[10] J. Lertlakkhanakul, S. Hwang, and J. Choi, "Developing spatial information framework for urban computing environment: A socio-spatial computing framework for smart urban environment," in Management and Service Science, 2009. MASS '09, Sept 2009, pp. 1–5.

[11] T. Kindberg, M. Chalmers, and E. Paulos, "Guest editors' introduction: Urban computing," Pervasive Computing, IEEE, vol. 6, no. 3, July 2007, pp. 18–20.

[12] N. Oliver, "Urban computing and smart cities: Opportunities and challenges in modelling large-scale aggregated human behavior," in Human Behavior Understanding, ser. Lecture Notes in Computer Science, A. Salah and B. Lepri, Eds. Springer Berlin Heidelberg, 2011, vol. 7065, pp. 16–17.

[13] C. L. Zuniga-Canon and J. Burguillo, "Urbancontext: A management model for pervasive environments in user-oriented urban computing," Computer Science, vol. 15, no. 1, 2014, pp. 75–88.

[14] C. L. Zuñiga and et al., "Design of service-oriented pervasive system for urban computing in cali zoo (openzoo)," World Academy of Science, Engineering and Technology, vol. 4, no. 3, 2010, pp. 990 – 995.

[15] C. Zuniga and et al., "Software platform for services in colombian cities using the living labs approach," in GLOBECOM Workshops (GC Wkshps), 2011 IEEE, Dec 2011, pp. 1258–1262.

[16] "CO-T1199: Wireless Networks and Digital Inclusion Services in the Municipality of Guacarí, Sponsored by the IDB (Interamerican Development Bank) and the Italian Trust Fund of Information and Communication Technology for Development," 2011, URL: http://www.iadb.org/en/projects/project-description-title,1303.html?id=CO-T1199 [accessed: June, 2015].

[17] "UBI, Open Ubiquitous Oulu-Finland," URL: http://www.ubioulu.fi/en/ [accessed: June, 2015].

[18] C. Zúñiga-Cañón and J. Burguillo, "Applying data mining in urban environments using the roles model approach," in Advances in Artificial Intelligence – IBERAMIA 2014, ser. Lecture Notes in Computer Science, A. L. Bazzan and K. Pichara, Eds. Springer International Publishing, 2014, vol. 8864, pp. 698–709.