CO-401

DEFINITION AND IMPLEMENTATION OF A WEB SPATIAL CONTEXT SERVICE DEDICATED TO SERIOUS GAMES ON SMART PHONES

EDOH-ALOVE É., HUBERT F., BADARD T.
Université Laval, QUÉBEC, CANADA

1. INTRODUCTION

Our work is part of the project GeoEduc3D, funded by the Network of Centres of Excellence GEOIDE. This project aims to provide interactive educational games, based on geospatial technologies and exploring thematic issues which the young audience is sensitive like climate change or sustainable development. Smartphones like iPhone or Android OS are widely used today. They offer a powerful and impressive combination of technical characteristics (i.e. screen size, computing power, touch screen, integrated GPS, accelerometer, access to wireless networks, and so on.) that are interesting to deploy such games in real environments. Their content and the different opportunities of man-machine interaction depend on the current player's position in the world.

Particular attention is thus paid to the spatial context of the player and how it can be used in this type of game, in a multiplayer environment. For example, the position and orientation of a player, with a bricklayer profile, could be used to provide him means to visualize and interact with geo-referenced augmented reality objects like sacks of cement or a trowel. These objects would not be able to see or use by another player with a scout profile. The possibilities for using this context are multiple within this type of applications. However, there is currently no model of spatial context applicable to interactive educational games dedicated to smartphones in a multiplayer environment. In such environment, there is no interoperable remote system for exchanging context data between mobile platforms (sensors and client applications). Furthermore, dissociation between management and application context is rarely done and we can see a lack of access to centralized spatial context data around specific domains of our project: augmented reality (AR), games and mobile.

So, a fundamental question appears: how to make available spatial context information for any application, anywhere, anytime, by taking into account aspects of augmented reality, educational game and mobility? Our main objective is therefore to design and implement a solution dedicated to the acquisition and diffusion of spatial context in a multi-players environment from and for smartphones. To achieve this goal, we focus on web services concepts and technologies. In our situation, a web service offers firstly the ability to centralize all context information of players in a multi-player environment on a remote system using contextual data acquisitions. Secondly these available contextual data from such a web service can be accessed, exchanged and queried by client applications on smartphones. This article presents, in section 2, different definitions of context and a modeling of spatial context by taking into account aspects of augmented reality, gaming, mobility and multi-player environment. Then, we describe in section 3 the architecture of our service-oriented spatial context data management and specific operations defined in our service contract. Conclusion and future works are given in section 4.

2. DEFINITIONS AND MODELING OF SPATIAL CONTEXT

2.1. Definitions: context, context awareness

Several definitions of context have been suggested since the 1990s. One of the most relevant and widely adopted in the literature is given by (Dey, 2000). He said that the context is "any information that can be used to characterize the situation of an entity, an entity can be a person, place or object that is considered appropriate in the interaction between a user and an application (both included)". Here, a "place" refers to geographic areas such as offices, buildings or streets. A "person" may be an individual or a group of geographically dispersed individuals. An "object" refers either a physical object or a software component.

The notion of context awareness (or context sensitivity) was introduced and defined by (Schilit et al., 1994) as the ability for mobile applications to discover and respond to changes in the environment where they are located. For (Dey, 2000), a system is context sensitive if it uses contextual data to provide relevant information and/or services to the user. The relevance depends on the user's task. We therefore consider that a system (or application) is context-aware if it is designed to acquire, store and/or interpret contextual information to provide services and information meeting the needs of any user at anytime and anywhere. A user can be a person, an application or a device.

In the next sections, we focus on different types of context that are closer to our interests: the spatial context and the context in mobility.

2.2. Spatial Context

In the work majority on context-aware applications, spatial context is reduced to the location (location of the user). In the best cases, it can identify locations which are found in the user environment (George et al., 2009). We do not find elsewhere the term "spatial context" in the literature, but we can find the concept of "context of use" which refers to any information characterizing the user, the environment and platform (Petit, 2010). (Li, 2007) defines spatial context (or geographical context) according to three dimensions: the spatial context static (geospatial data stored as buildings, stores), the dynamic spatial context (geo-referenced data from sensors) and the internal spatial context (data available from local equipment such as GPS).

2.3. Context and mobility

With the introduction of mobility, various studies have mainly led to the context modeling and the implementation of context sensitive solutions in several application areas such as tourism (George et al., 2009, Tan et al., 2009; Meng et al. 2005; Filho et al. 2008; Abowd et al., 1997, Li et al. 2006; Schwinger et al., 2008, Repo et al., 2004, Cai et al. , 2006; Cheverst et al. 2000; Lopez-Velasco et al., 2006). Among these works, the TILES (Temporal, Identity, Rental, Environmental and Social) model, proposed by (Tan et al., 2009), classifies contextual information used in mobile context-aware applications related to tourism. 42 context properties have been identified as a result of reviews of related works in such a domain. A typology has been defined and adopted, according to 10 categories of properties of contextual information: position, time, identity, environmental, social, network, business, equipment, physiology and cognition. After investigation and validation of useful properties from a group of users, 5 categories were chosen: Temporal, Identity, Localisation, Environmental and Social.

According to these researches, we consider that the notion of spatial context does not only concern the user position and that the environment can refer to spatial objects (places or people nearby) or not (temperature, noise level). On the other side, mobility has made relevant and meaningful contextual elements such as physical location, device, user‘s environment (all the places near the current position of the user). This implies, for us, that it would not be interesting to consider the spatial context as an isolated category in our project. Indeed, the context model that we propose to define must take into account the spatial aspect, but also other criteria such as user profile – the player in the GeoEduc3D project -, camera, smartphone, temporal aspects, and so on. In the next section, we give a new definition and a model of spatial context.

2.4. Definition and modeling of spatial context (augmented reality, games, mobility)

Our definition of spatial context must provide a complete description of the user’s context properties according specific domains of our project: augmented reality, educational games, multiplayer environment and mobility. In this section, a definition of spatial context by (Li, 2007) with three types of spatial context: static context, dynamic context and internal context. Based on the definition of Li (cf. section 2.2), we suggest a new definition of spatial context as the specific context for our work (see Figure 1).

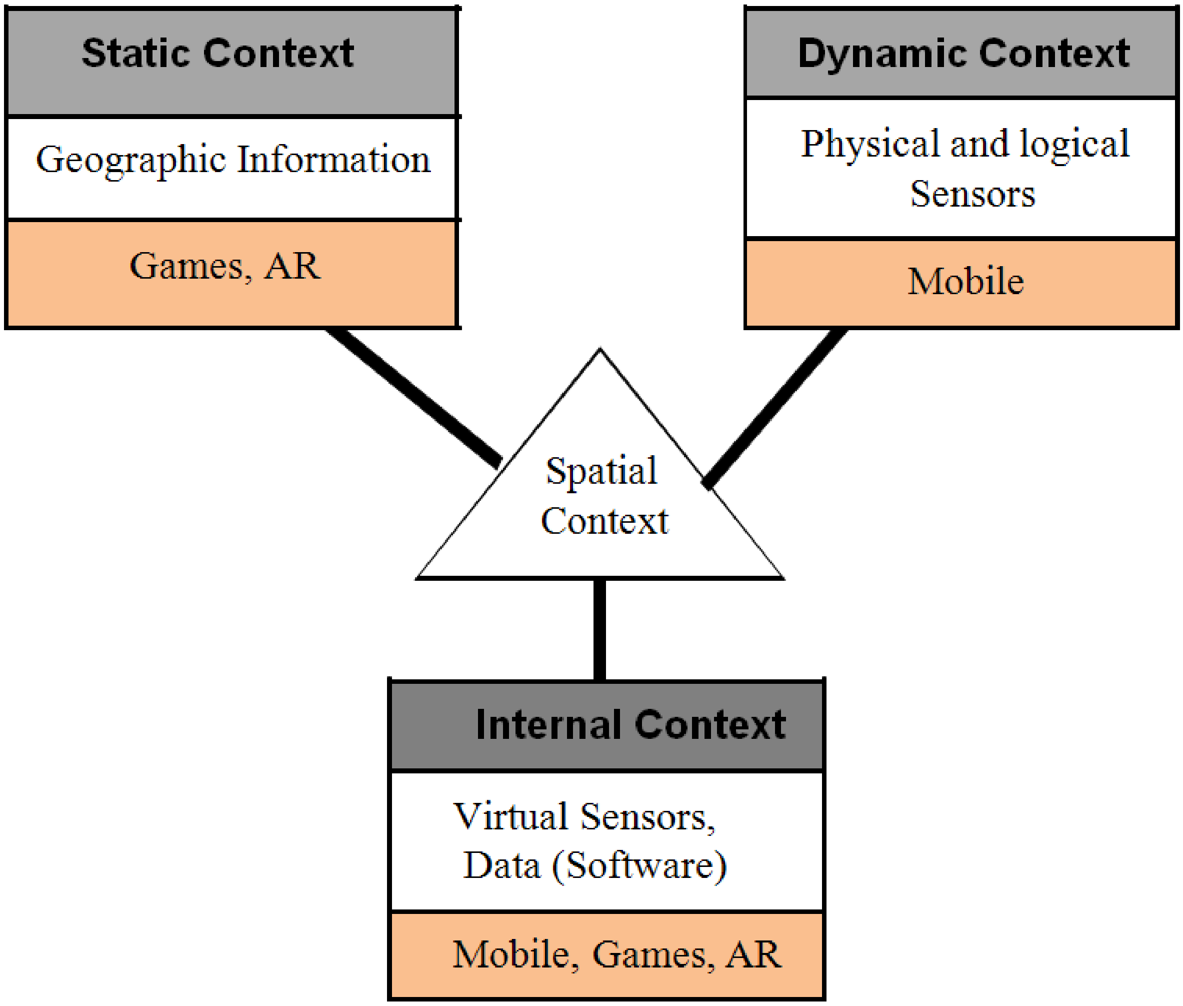

Figure 1. Definition of spatial context (AR, Games, Mobile), adapted from (Li, 2007)

The spatial context is identified by any information, spatial or related, characterizing static, dynamic or internal aspect of an entity which can be a person, place or object considered relevant to the interaction between a user and an application, both included. To better describe the dynamic and internal contexts, different sensors of the environment must be considered as sources of contextual information, according three types of sensors: physical sensors (i.e. temperature sensors, position sensors), virtual sensors (i.e. device performance, user profile) and logical sensors (i.e. information derivation from multiple sources) (Chaari , 2007). Data can be collected explicitly from the user or be provided indirectly by other applications or physical sensors. Specifically, we suggest the following definition for the three different parts of spatial context:

- **Static context**: this context concerns spatial information that may be relevant for describing the user's environment and its interaction with the game application. For example; it could be spatial information to increase the sight of the reality of the user by using AR points of interest (POI) and/or game scene with its geographical boundaries.
- **Dynamic context**: this context refers to all data collected from physical and logical sensors (i.e. temperature and brightness sensors, or accelerometer). For example, we could find information about the current position (GPS) of the players that have different profiles, by allowing them to interact with objects in augmented reality.
- **Internal Context**: this type of context takes into account information from virtual sensors and describes in this case the user profile, the mobile device, the gaming environment, social environment of the user and the network. For example, we have information about the general profile of the player (i.e. names, date of birth, preferences) or his profile in the game (i.e. role in the game). This information could help adapt the interactions between players and between players and the camera.

This spatial context definition implies a multidimensional and multi-scale aspect that we must take into account in its modeling. This does not only focus on the user's position, but also on the mobile device, the physical environment, time and so on. Moreover, it does not just concern a local scale but also a global scale, according to a multi-player environment. We therefore suggest a formal representation of spatial context according to 8 categories of contextual information. As a descriptive model of the spatial context in our specific project, categories are described by various properties and can contain sub-categories. The categories are:

- **Runtime Environment category**: this category takes into account information about the date and time linked with a given context for the current user session. First, it allows to link the different contexts (i.e. context information) received by our system to the concerned player. Secondly it allows associating a time or lifetime to contexts, in order to offer an effective history management. We also distinguish 2 subcategories : – "Temporal aspect" with date and hours properties. – "Current session" with a state property (connected, disconnected, waiting)
- **Player category**: this category takes into account properties containing personal information and professional player like his name, age, preferred language or curriculum. This category is one of the most important because knowing the contextual information related to the overall profile of the player before and during the game will produce a customized content and game interface, and will enrich the interaction between players. We distinguished 3 subcategories : – "Profile" with name, first name, birthday, sex, preferred languages, mood properties – "Education aspect" with programs, fields, levels of study properties – "Game aspect" with player profession, favourite knowledge, scores, available resources and tools properties
- **Location category**: this category contains information about location of the user, the spatial elements in the neighbourhood and so on. This can have a strong impact on the games progress and visual and interactive content available in the latter, because, according to the player positions during the game, objects may appear in augmented reality, actions can only be done in particular location in order to progress in the game, interactions can be proposed between the players and so on. We also distinguish 4 subcategories : – "General location" with state, region, city, district or area properties. – "Punctual location" with current location, movement speed, orientation (accelerometer) or movement direction properties. – "Game location" with geographic boundary of scene, AR points of interests (POI), spatial objects built by user as properties. – "By proximity" with nearby spatial objects, distance between position and nearby objects as properties.
- **Environment category**: This category should be taken into account because during the game, players are constantly interacting with their environment. We refer here to contextual information specific to the ambient environment (temperature, brightness, weather, and so on.) as well as data on traffic conditions or the type of locality (rural, urban, industrial). We also distinguish 2 subcategories : – "General aspect" with temperature, brightness, weather or season properties. – "Spatial aspect" with traffic condition and type of locality properties.
- **Social category**: this category is useful in a multi-player game to know the players which are around (physically or logically) a player or to know which players are as a same team or which players are opponents. It will allow you to select any players whose information, like a position, might be of interest to one or more other players. For example a player could only see on his screen play the players of his team or opponents who are at some distance from him. We also distinguish 2 subcategories : – "General" with current player and nearby players properties. – "Team" with team name and teammate names properties.
- **Network category**: knowing the network status, available resources and their condition is an important information source for everything about the game and its progress because of the fact that some games may require the operation of a game server and/or a wireless connection. The properties are network state and connexion type (GSM, WiFi).
- **Device category**: This category takes into account information such as type of device, sensors available on the device (i.e. accelerometers, GPS, microphone), the possibilities of connection, connection speed, the memory space, the screen size, type of input / output, and so on. We distinguish 2 subcategories : – "Capabilities" with memory space, storage or battery level properties. – "Functionalities" with tactile screen, speech recognition, camera, microphone, GPS, or accelerometers as properties.
- **Game category**: This last category connects us to the game side of applications that will use all this contextual information. In fact, this implies all kinds of contextual information related to the game progress like start time, number of current players or best scores. The identified properties of this category are start time, number of current players, number of allowed players, best scores, team score or game statistics.

3. SPATIAL CONTEXT MANAGEMENT ARCHITECTURE

The system, service-oriented, data management context that we propose aims to acquire, manage and make available data or contextual information in our application framework. These data come from different sensors integrated into mobile devices or external sensors such as weather stations (Benazzouz et al., 2010). Thus, they can be shared between different applications mobile gaming. Figure 2 shows the functional architecture of this system of data management environment with as a web service of spatial context (WSCS - Web Spatial Context Service) as central element. This web service relies on the recommendations of the OWS specification from the Open Geospatial Consortium (OGC) which serves as a reference to the implementation of web services in the geospatial domain. This architecture is as follows:

- **Third party resources**: context data come from various sensors embedded or not in mobile devices in the environment of multiplayer game. These sensors are of different types as mentioned in Section 2: physical sensors, virtual sensors, logical sensors. Other resources can be exploited as other web services context that might be useful. Another key component to this third party is the database that will be directly connected to the Web spatial context service to regularly store contextual data during a phase of play. This database must be able to manage data based on our descriptive model defined in the previous section in order to meet our expectations. Moreover, as technical part, we have selected to use a PostgreSQL database with its PostGIS extension, in order to manage the different contextual data. PostgreSQL is the most powerful open source database management system of the world and PostGIS allows to manage spatial entities in a database according to OGC Simple Feature specifications.

- **Third server**: This server is the key element of our architecture since it corresponds to our web spatial context service. The goal of this service is to make available a wide quantity of data and contextual information to mobile client applications. This web service handles requests from different client applications to store data and to return anytime and anywhere. To store and manage contextual data, we need to use the database resources of the third party resource. This service must also be able to use other resources available to complete the context information stored. As technical side, we implement our web service by using the well-known computing language Java and the open source Apache HTTP server. Thus, Apache Tomcat has been selected to implement our web server because it allows to defines and build Java servlet and JSP through an Apache server.

- **Third customer**: Customers of mobile applications are deployed on different game smart phone (iPhone or Android OS). They use wireless networks (WiFi, 3G) to access our web service. Through this access, requests of acquisition type can be sent to our web spatial context service with new contextual data. These customers can also generate requests to query the web service in order to retrieve contextual data at different levels of detail in the final goal to process such data in the client side and accommodate the user accordingly. As technical information, we choose to implement user interface on client by using the PhoneGap solution (http://www.phonegap.com). The main advantage of this solution is that it can be used on different OS, like Android or iPhone. In fact, PhoneGap is an open source mobile framework based on HTML5, CSS and Javascript languages. So, it can be open through all the current navigators like Safari, Chrome, etc. Moreover, PhoneGap offers possibilities to obtain different smartphone information in a transparent and easy way.

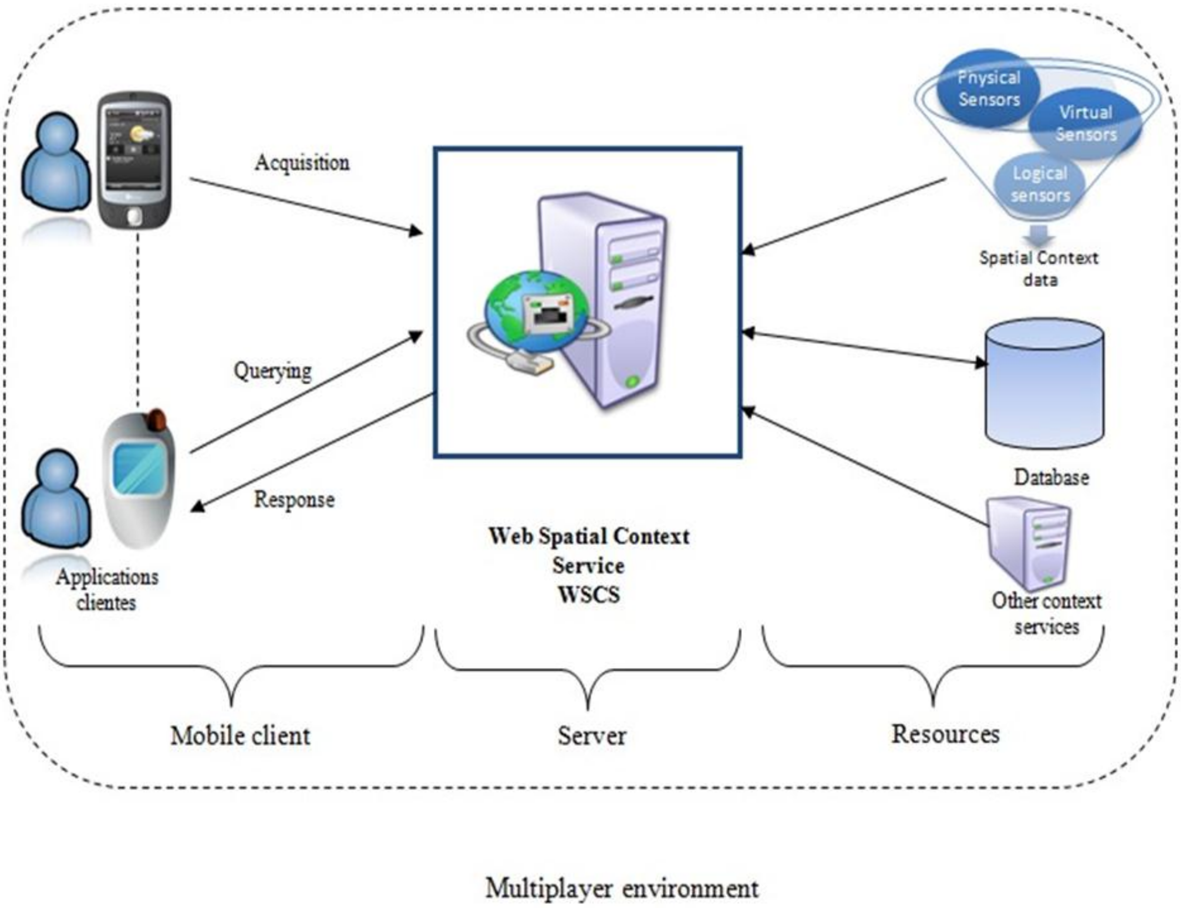

Figure 2. Context spatial management Architecture

To better understand how this system works, let us consider an example of an iPhone device that has multiple physical sensors such as GPS for position, an accelerometer for orientation, a camera for the video stream. As virtual sensors, this iPhone device can show to the user a web form in order to specify a player profile. The frequency of sending requests for acquiring contextual information provided by these sensors are not the same: the profile of the player is sent once at the beginning of the game session, while its position and orientation are provided at regular time intervals. The web spatial context service, by receiving these requests, retrieves the information of interest and stored them in the database, while completing them with other information from sensors or other services context. Due to the fact that this information is made available, any game application can retrieve it through query requests, sent to our WSCS. In order to implement this web spatial context service, we should proceed to the development of its specifications. Besides the definition of a service contract, we are working on the proposal of an exchange format based on XML and a query language for the full effective operation of the service. The service contract that we have determined has the following operations:

- The **getCapabilities** operation describes the service and all the operations available and the parameters required as input parameters and output formats. As input, only the operation name must be given. Data are returned in the XML output format.
- The **describeContextData** operation provides a description of context properties according to a given context data in input. Data are returned in the XML output format.
- The **getContextData** operation retrieves contextual information depending on different parameters provided in input. Category, sensor, date and/or bbox are identified as input of this type request. As output, we must have contextual data in a XML and/or GML format. GML (Geography Markup Language) is a standard markup language from OGC and ISO dedicated to the geospatial data and information.
- The **getContextByUser** operation retrieves context data related to a user. It is based on the previous getContextData operation. As input, it requires a username, coordinates and eventually a buffer.
- The **lockContextData** and transaction operations are used to add, change and/or delete data safely.

4. CONCLUSION AND FUTURE WORKS

The aim of this paper was to present the thoughts and contributions on the design of a Web spatial context service dedicated to gaming applications for interactive and immersive educational and smartphones in the GeoÉduc3D project. After a brief literature review on various notions of context, we suggested a definition of spatial context that determines the context data to be included in our application framework. Another contribution was to develop a descriptive model of spatial context, based on this definition with the identification of 8 major categories. Finally, we suggested an architecture for a spatial context management system with a web spatial context service as key component. A service contract has been defined and briefly described in order to show how our web spatial context service works, through acquisition and research request on stored contextual data.

In continuation of our work, we are therefore looking to implement the prototype of our Web Service Context Space (WSCS) respecting the service contract, the interoperable exchange format and the query language developed. A phase of testing and validation will be performed in a multi-player gaming on smartphones, based on an online game build on the Foursquare API (http://developer.foursquare.com).

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