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TRILHA PRINCIPAL

Ontologic Model and Architecture for a Context Aware Spatial Data Infrastructure for the 2014 World Cup

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***Abstract* - In large sporting events like the World Cup in 2014, there is an imminent demand for information systems that are able to deliver to the user, useful information such as the location of games, conferences, training or a particular physical structure for their accommodation and feeding, besides showing the best routes to these places. However, the huge volume of information, concerning the events and to the own infrastructure of the World Cup host cities, hamper the search for information that is directly related to a determined user in particular. The Spatial Data Infrastructures aimed at ensuring greater access, availability and exchange of geographic information. This approach, together with the mapping of ontological concepts of the environment where the user is, allow us to provide information relevant to their context. This paper presents a proposed union between these two approaches in order to offer the user an infrastructure that not only consider the simple input of a query, but also be able to refine it and even anticipate information, respecting their environment, interest, individuality and that uses your geographic knowledge as a source of new information.**

***Index Terms* - SDI, Context Information, Ontology, VGI, World Cup.**

I. Introduction

The 2014 World Cup, as well as other world class sport events, such as the Olympic games, bring together millions of people from the most diverse cultures and nationalities. In the countries that host those events, there is a huge effort from the government and private initiative to offer the best infrastructure for them. The required infrastructure contemplates not only building and upgrading sport arenas, training and concentrations centers but also an adequate structure to receive well the thousands of tourists and professionals from different areas that come from all regions of the country and from abroad.

For 2014 World Cup that will be in Brazil, the Brazilian government forecasts investing close to R$47 billion to answer to the physical infrastructure demands [1]. This plan includes upgrading airports, soccer stadiums, telecommunications, security, urban mobility, power and health. It is estimated that this investment will generate and indirect impact of around R$185 billions. [1].

Besides all the necessary infrastructure, there is a demand that is neither smaller nor less important for information systems that use the data concerning the 2014 World Cup to offer added value to the users. Such data and information are not limited to game and training schedule or standings, but also those indirectly connected to the event, such as transportation, housing, communication, etc. Analyzing this information at a class level we can see that there is a fundamental attribute that remains constant: the location, and also that there is an important relationship between these information classes with its relevance for each user in a specific context.

When dealing with location, Geographic Information Systems (GIS) are a good approach for manipulating, analyzing and treating georeferences data.

On the other hand, Spatial Data Infrastructure (SDI) allow for a larger dissemination of the data produces and organized with the help of GISs. SDIs integrate standardized metadata catalogs that have a detailed description of the geographical data and allow for larger access and sharing of spatial data.

Under the user perspective, information can have a larger or smaller value according to the environment it resides. Relevant information for a specific user can be mapped through ontologies that represent general or specific concepts of a domain using classes, what makes it possible to create an architectural model that is context sensitive and where each user can have personalized access according to his or her specific context. That avoids the unnecessary and tiresome effort from the user to obtain information from different domains that are not part of his environment, assuring a fuller user satisfaction.

The term “2014 World Cup” is the expression most widely known in Brazil. Hence, this is how it was used in this paper, replacing the official “FIFA 2014 World Cup”, which is mandatory for service and product marketing, according to FIFA’s web site (http://www.fifa.com). In spite of the fact that

this work can also apply to other World Cup editions, the year when the next edition will happen was informed in order to emphasize the importance and up-to-date content of this study.

This article describes a proposal for a context sensitive SDI that can serve as support for users of geospatial information systems connected to the 2014 World Cup. We also present an ontological model that is used to contextualize the user in the World Cup environment.

The rest of this article is organized as follows. Section 2 describes some related work. Section 3 presents the proposed context sensitive SDI architecture, the geoportal and its components. Some final considerations and future works are described in section 4.

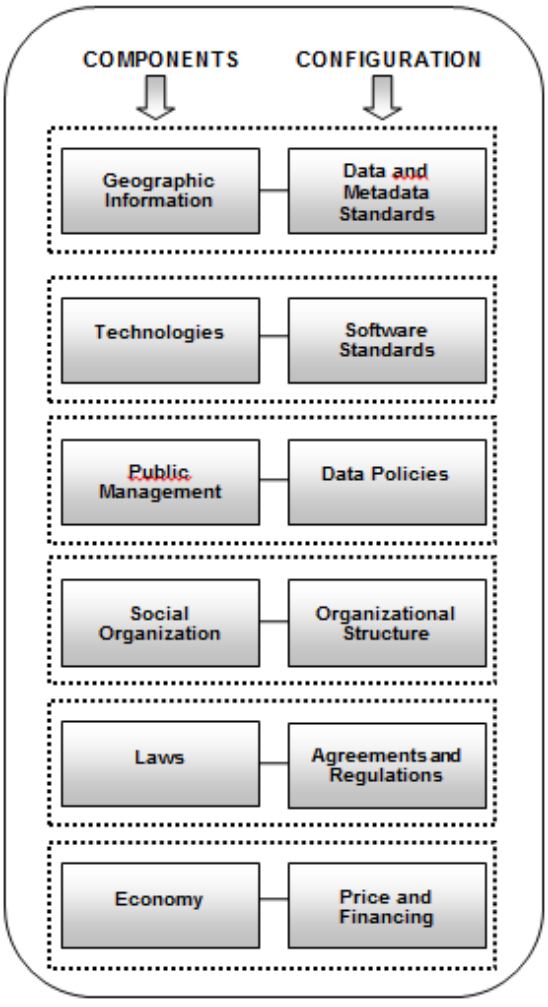

Fig. 1. Components of a SDI (Adapted from [6]).

II. Related Work

The development of a SDI involves technical and non technical elements for interchange, distribution and sharing od patial data, in a progressive process of negotiations and alignments between heterogeneous actors, in a specific context [2]. A SDI is not something that can be delivered as a finished product or artifact. On the contrary, it must be considered as a project under development [2].

SDIs have offered support to several projects, where their use and ease of access to spatial information and the associate services are the main requisites. A SDI stores data from multiple suppliers and distribute them in a transparent way through the network [3].

SDIs can work at different levels: global, national, regional or local [4]. In Brazil, there are many local and regional initiatives for SDIs. At the national level, the Spatial Data National Infrastructure (INDE) is defined as:

"A integrated set of technologies, policies, mechanisms and procedures for coordination and monitoring; standards and agreements necessary to facilitate and order the creation, storage, access, sharing, dissemination and the use of geospatial data originated at the county, district, state of federal level" [5].

INDE is maintaned by the National Cartography Comission (CONCAR) and has many spatial information on the Brazilian territory, documented through metadata, that is, data on data [7]. These metadata follow the MGB profile (Brazilian Geographical Metadata) that is conformant with the ISO 19115:2003 norm and whose catalog is managed by an open source system called Geonetwork.

Figure 1 shows the components and configurations of a SDI. Among the various components of SDIs shown, one of them has as outstanding position because it is the foundation of the whole SDI: geographical information. The Geographical Information include anthropic elements, environmental information, air quality measurements, place names, cultural information, etc.

The geographical information cannot always be captured, as for instance, through Remote Sensoring Imaging. Geogrpahical information supplied voluntarily by the users or Volunteered Geographic Information (VGI) presents itself as a solution with bigger coverage, because it can rely on more that 6 billion sensors: the whole human population spread throughout the globe [8].

A good example of a VGI is Open Street Map (http://www.openstreetmap.org/), that has tens of thousands of sources supplied by citizens with or without geographical information background. There are still no mechanisms that ensure the quality of that information remove errors and create a level of trust. But, on the other hand, volunteering can be shown to be the only solution for the decline in the geographical information supplied by the government worldwide [8].

In the creation of an infrastructure that takes into consideration the user preferences and environment, which is the goal of this work, it is necessary to use mapping elements that are involved in the World Cup using ontology. According to Gruber [9], from the point of view of Computer Science, ontology is "an explicit formal specification of a shared concept". This type of mapping cannot be left behind when

modeling the World Cup domain, allowing for the user to obtain the geographical information that interests him.

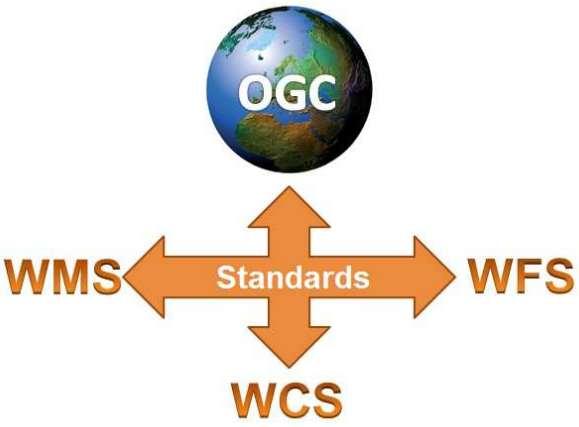

Fig. 2. Major Standards from OGC [15].

According to Kokar [10], ontology based computing has recently shown a tendency to develop a model of computer based context information processes. Nowadays, some languages have been standardized to formalize ontologies. Semantic web languages such as RDF (Resource Description Framework) and OWL (Web Ontology Language), which is based on RDF, support the logic necessary to formalize ontology [10]. OWL is standardized by W3C and has been widely used as a formalization language for ontological concepts [11].

A SDI, besides providing access to data also offer several services, from a simple consultation to a metadata to geoprocessing services, as exhibiting a map and locating entities using only coordinates. In order to ensure that those services are available to a larger number of persons and systems in a distributed and collaborative way, it is necessary to use Web Services. This technology offers not only independent services, but also offers collaborative work where components (Web Services) designed for a given service can be connected to provide a larger service [12].

Having the goal of geoprocessing services interoperability, the Open Geospatial Consortium (OGC) standardized the specifications for Web Services that manipulate data and services on geographical information, known as OWS (OGC Web Service) [13]. This standard allows the connection of several Web Services that together can make a dynamic application [12]. Figure 2 illustrates the main standards from OGC, which are Web Map Services, Web Feature Services and Web Coverage Services.

There are several works that describe problems in huge events such as the Beijing Olympics. One example is the work performed by Weißenberg [14]. In this paper, the author develops a context model to offer context sensitive mobile services to the Beijing Olympics from 2008.

Lamas [16] proposed a context sensitive GIS for mobile devices to help students, professors, employeers and visitors to find events and specific departments in a university. In this work models and architectures were developed to support location services also based on the user environment.

Barth [17] describes techniques used in recommendation systems to deal with user profiles. Differently from the current work that is based on ontologic models, Barth uses free stereotypes to model his recommendation system.

Rodrigues [18] describes the usage of a GIS in public transportation, where a proposal for a User Information System is presented. This system allows the user to receive information and interact with a module that shows georeferenced and contextualized information on public transportation for his geographic environment.

Most of the references works are about context sensitive GIS or recommendation systems that can also be improved and applied to other huge events such as the 2014 World Cup. Nevertheless, none of them use the data, services or metadata available at the SDI or proposes a thematic context aware SDI as a solution for the demand for spatial information that takes into consideration the World Cup environment together with the user preferences.

According to Orshoven [19], a SDI that deals with a specific user community (such as, for instance, tourists and professionals involved with the 2014 World Cup) with thematic data (information on that event) is called a Thematic Thematic Spatial Data Infrastructure (TSDI).

III. MODEL AND ARCHITECTURE FOR CONTEXT AWARE SDI

The thematic SDI proposed in this papers uses a WEB application interface that uses a GPS and, when this device is missing, can ask the user for its current geographic position. Information processing is performed using Web Services according to OGC standards.

Figure 3 illustrates the layered SDI architecture, with its respective components that we describe now [20]:

- Application layer: this layer is composed by the Web application and the GPS location component;
- Web Application: is made of an interface with support to different languages, The user can enroll himself with personal data and preferences. Afterwards, he will be able to authenticate using information on his location and other data that is pertinent to the World Cup environment, such as events or services connected to it. The user can, at any given moment, update his preference list or make a search on other events or services.

  Since the web application is by definition multiplatform, besides computers, notebooks and tablets, other mobile devices such as palms and cell phones that have HTML and Javascript enabled browsers can access the SDI from wherever they may find an Internet connection.
- GPS (Global Positioning System): a global positioning system that supplies geographic

coordinates through a receiving device. In case the computer, notebook or mobile device does not have a GPS, the user can supply the information through the interface.

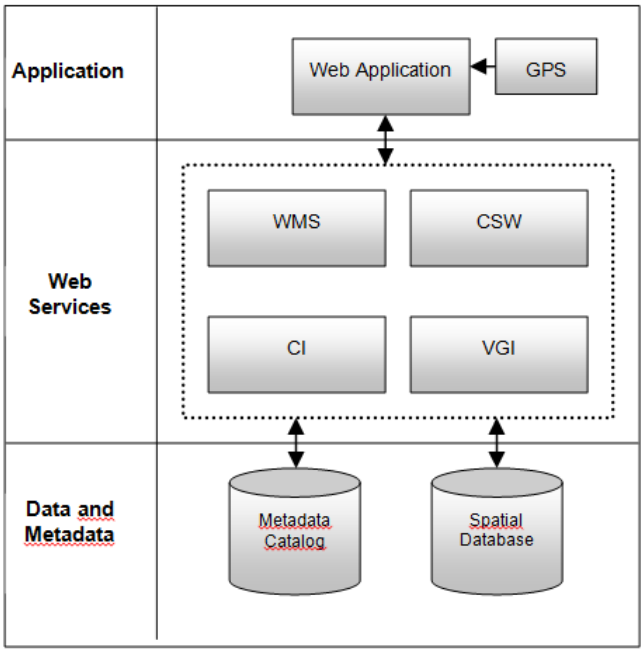

Fig. 3. Context sensitive SDI architecture (Adapted from [20]).

The Web services layers is composed by WMS, CSW e VGI, which are described below:

- WMS (Web Map Service): Web service responsible for the exhibition of cartographic maps.
- CSW (Catalogue Service for the Web): Web service responsible for the search of metadata inside a specific catalog.
- CI (Context Information): based on an ontologic mapping, the Web service provides information that is relevant to the World Cup environment.
- VGI (Volunteered Geographic Information): the user can, at any given time, supply new information on a specific location or about events and services connected to a location. In order to contribute, he has to fill a form online where personal data are collected for his validation and posterior access. After the proper authentication, the user can enter information on events about the World Cup, as well as data on support infrastructure, such as hotels and restaurants, informing their location on a map available at the geoportal. These data will be validated and made available by a technical staff, with the goal of increasing the geographic database on the 2014 World Cup.

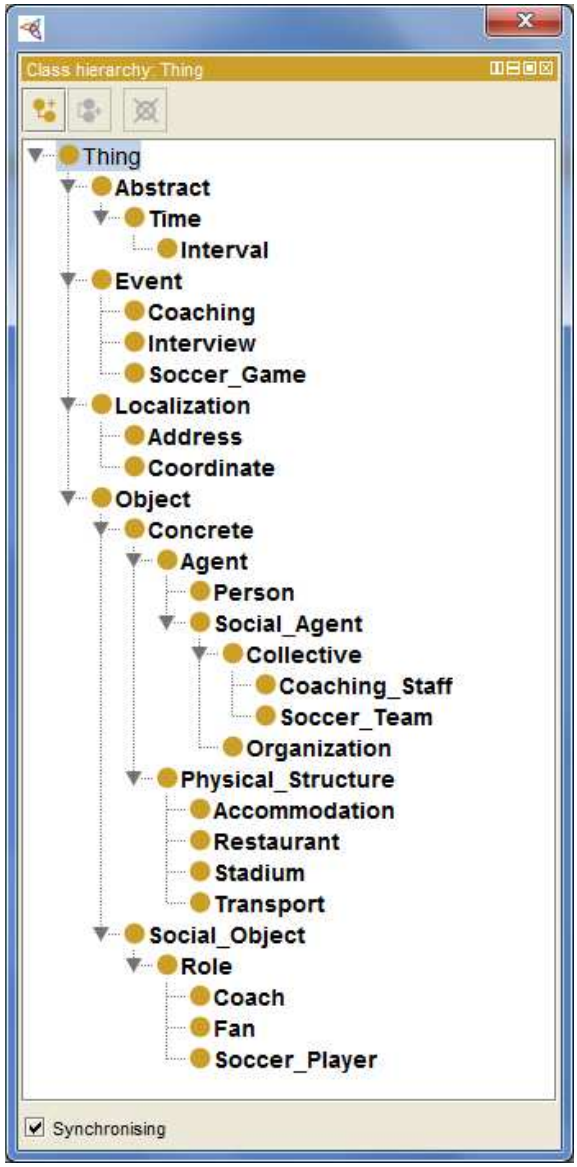

Fig. 4. OntoCopa Context Model (Adapted from [20]).

The Data and Metadata layer is made of the Metadata catalog and the Spatial database, which are described below:

- Metadata Catalog: set of metadata that describe the available data, including the VGI description;
- Spatial Database: data repository that stores spatial information on the locations where there will be events connected to the 2014 World Cup and that also manages data on each user preferences.

A. Context Model

In order to formalize the concepts that are part of the World Cup environment, a domain ontology was created, resulting in a context model that we called OntoCopa. This domain ontology gives the necessary support for the SDI for user requisitions and preferences. To develop this ontology we used the Protégé tool, which offers facilities for ontology edition,

Fig. 5. geoCopa Portal with the host cities indicated in the map.

visualization and use [21]. Based on the work of Oliveira [20], figure 4 shows the refinement of the OntoCopa ontology.

We defined several classes and subclasses for each concept connected fo the World Cup. Each class and its relationships is described in the following topics, using as foundations some of the categories of the DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering) higher level ontology defined by Gangemi [22]

The name of the classes was kept in Portuguese, as this was the real name used inside Protegé. The translation of each name is given beside it.

- Abstract – class that corresponds to the concept of intangible entities. Its single subclass is Time.
- Time – class that represents the changes and the sequence of events in space. The class Interval is its single subclass.
- Interval – Time subclass that corresponds to the difference between the initial and final instants of an event;
- Event – class that represents anything happening in a certain place at a certain time that may or ay not have a participant. Its subclasses are Colective, Soccer_Game and Coaching;
- Interview – subclass of Event that represents the concept of events booked for a certain moment (Time) and place (Localization).
- Soccer_Game – sublass of Event that represents the concept of a match between two teams or countries at a certain moment (Time) and place (Localization).
- Agent – class that includes active objects that perform some action. Its subclasses are Social_Agent and Person;
- Social_Agent – class that represents actors that perform their work in the social environment. Its subclasses are Collective and Organization;
- Collective – class that correspond to the set of social agents. The classes Soccer_Team and Coaching_Staff are its subclass;
- Coaching_Staff – subclass of Collective that represents the staff of a soccer team;
- Soccer_Team – subclass of Collective that represents the set of players from the same club or national team;
- Organization – class that represents the concept of a set of social agents, bonded by their purpose and

common goals;

- Person – class that represents human beings.
- Physical Structure – class that corresponds to structures for accommodation, feeding, transportation and leisure. The classes Accommodation, Stadium, Transport and Restaurant are its subclasses.
- Accommodation Stadium, Transport and Restaurant – subclasses of Physical_Structure that give support for visitors, tourists and professionals involved in the World Cup;
- Social_Object – class that represents objects that play a part in the social world. Its subclass is Role.
- Role – subclass of Social_Object that corresponds to the responsibilities, rights and duties of a certain person in a specific environment. Its subclasses are Soccer_Player, Fan and Coach.
- Soccer_Player – Represents the professionals that play in a specific national team;
- Fan – subclass of Papel formed by the persons that cheer for a soccer team and participate in its events.
- Coach - subclass of Papel corresponding to the role of the professional that coaches the players in a soccer team.

B. *geoCopa Portal*

A SDI has a set of technologies, services, data and spatial metadata. For all these resources to be available for users in an easy and simplified way, they are included in a geoportal. Geoportals are web sites that gather and organize such decentralized geographic resources through a set of web pages [22];

Geoportal geoCopa, shown in figure 5, was developed to become the focal point of all SDI resources for the 2014 World Cup. In its main page we see the map of Brazil with the markings of each stadium and the cities that will host the games of the 2014 World Cup. Each marking is a link that allows the use to access a brief description of each city and each stadium where the games will happen.

The geoPortal makes it clear the problem definition and the solution proposed, as well as the general and specific goals of this work in the menu item “The Project”. In the menu item “The World Cup” we supply information on the event, history of Brazil’s candidacy, choice of host nation, the rules of the competition and history on other editions. Through the portal we also have access to the Geonetwork system through the menu item “Metadata”, which allows us to access the metadata catalog and the geographic maps in the format KML (Keyhole Markup Language) and Shapefile. The viewing, manipulation and generation of new maps can be performed through the menu item “Data visualization”, where we can access a customized version of the I3GEO open source system. With this system we also generate the WMS services of the SDI, integrating its spatial information set with the INDE through a sharing and use interface for these services. Last, but not least, the menu item “Contact” shows information on the project staff.

C. *Metadata Catalog*

Searching and retrieving spatial information is one of the main goals of a SDI. In order to have access to a specific geographic piece of data, we must describe it and catalog that

Fig. 6. Metadata Catalog Manager

description. In this sense, metadata offer more detail about spatial data. They allow spatial information to be retrieved easily in different queries with many terms related to the spatial data, by users and professionals of different domains and interests.

In order to ensure better organization and interoperability among the many sources of geographic data spread through the world, many metadata standards were created, such as ISO19115, CSDGM (Content Standard for Digital Geospatial Metadat*a*) and the Brazilian Geographic Metadata profile (MGB). As mentioned before, this work used as its standard the profile MGB and the Geonetwork system to manage the set of data descriptions, that is, the metadata catalog. This choice was due to a recommendation from INDE on the issue of MGB (whose homologation by CONCAR happened in 2009) about using the Geonetwork open source system because it is adherent to the CSW protocol [7].

Figure 6 shows the main page of the metadata catalog manager, Geonetwork, configured for the World Cup SDI. Besides cataloging metadata, Geonetworks allows us to perform queries on the metadata related to World Cup spatial information such as the location of the host cities, for example. The search can be made by title, site, abstract, key works and even free text that corresponds to any field of a certain metadata.

D. User registration

For each user to receive information on the World Cup according to his preference and to use the context model, it will be necessary to register using an electronic form available at the geoCopa portal at the link “New registration”. In this form, the user will inform the role he thinks is more adequate form him (fan, player, coach, etc). Another important information to be filled is the location and period (in days) whose related information the user intends to know about (events, services and connected infrastructure). He can also inform his favorite team and his language. Besides registering his home address, the user will also have the option to include the place where he will stay during the World Cup. This information will allow the system to deliver information related to his preferences in the World Cup environment mapped according to the context model.

E. Location and Interaction with the Ontology

Even before authentication at the geoPortal, the system will indicate the user location using the API Geolocation [24]. Based on information of the OntoCopa model and pre-registered information, the system will show dialog boxes with information on events and services, as we can see in figure 7. Each entity of the conceptual and logic model designed for this prototype was created according to the proposed OntoCopa ontology. This allows the CI (Context Information) component to perform searches in the context model through the links between the classes of the logical model and present them in the dialog boxes.

All the information stored in the database is georeferenced and are shown marked with an icon in the geoportal that is specific to each event or services, making it easier to identify them and verify the distance to it and the time it would take to their place of occurrence. In order to verify the distance and the travel time the user can choose the option “Trace routes” available at the left menu of the same page. In this option the user may use a selection box that includes all host cities or inform a destination describing it in the textbox below.

A directed search that looks for hotels, restaurants, stadiums or other infrastructures is also available in order to support the users that are visitors from other states or countries.

The users may also voluntarily contribute by marking unknown point and describing them through the menu “Mark Points” and through the button “Contribute”.

IV. CONCLUSION

This paper presented a proposal for a SDI based on an architecture that integrates its technological components with Web services based on an ontology model and with support to VGI that allows for information refinement that allows for bigger interaction between the user and the SDI.

Taking into consideration the environment and the user preferences, the system filters information returning only those data that should be interesting for the user through a Web interface.

With all context information it is possible not only to deliver information that is pertinent for the current user, but also to motivate him to contribute with new geographic information about places and events that he may know about [20]. Hence, the proposed SDI architecture and ontology make it easier to inexperienced users to access and use the spatial information, independently of their nationality or culture and also enriches the spatial database with truthful information through VGI.

Future work may approach the description of the relationships among classes of the OntoCopa ontology, the modeling of the spatial database (according to the context model) and of the Web application, as well as its validation by the user.

The project site is located at the Internet address given by the url: www.ide.ufv.br/geocopa.

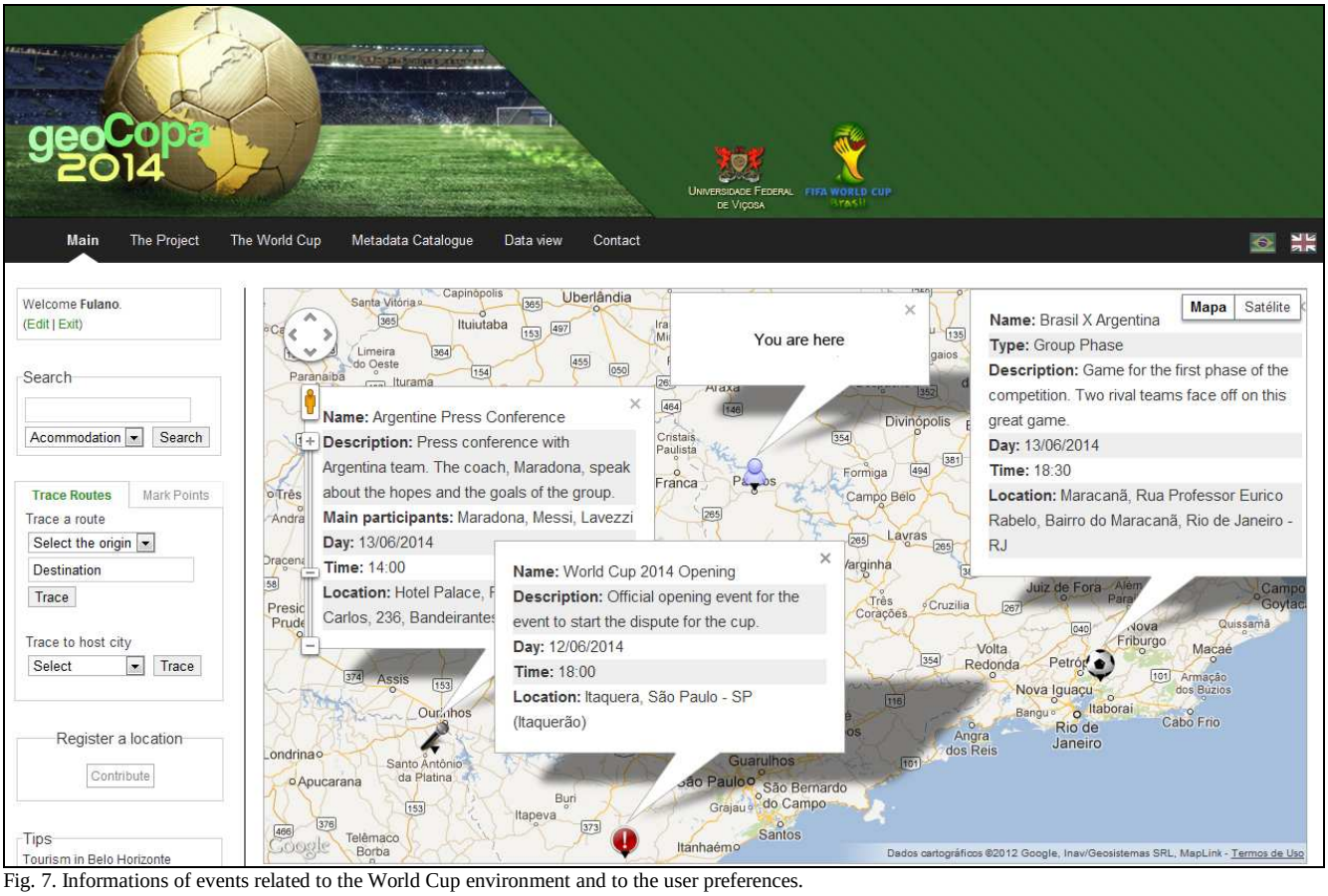

Fig. 7. Informations of events related to the World Cup environment and to the user preferences.

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