A Context-aware Application for Public Health Scenario based on Ontology and Personal Tracking

Mauro Oliveira, Luiz O. M. Andrade, Reinaldo Braga, Franciano Antunes, Marcos Santos, Leonardo M. Gardini

***Abstract*— This work presents a context-aware application based on ontology and personal tracking technologies. It integrates the epidemiological field of LARIISA project, an intelligent platform to support decision making in public health governance. LARIISA is able to perceive the status of emergency epidemiological and adapt itself in real time to a risk situation. In order to obtaining information about the family health, this application uses digital TV and mobile phone applications due mainly to the presence of numerous devices at home and the access to several communication networks. While registering the trajectory followed by the mobile device, it allows health agents to create multimedia documents (e.g. photo, audio, video), which are connected to an enriched description of the user context (e.g. weather, location and date). In this context, we intend to use the features proposed by a personal tracking-based application to verify and troubleshoot an epidemiological problem or detect new outbreaks of dengue, for example.**

Keywords— context-aware; ontology; personal tracking; public health.

I. INTRODUCTION

The Information Technology and Communication (ITC), as well as the expansion and advancement of the Internet through its ability to remote monitoring and interaction with patients, can significantly help doctors and health workers in developing actions more agile. This is possible with remote monitoring systems, installed in homes and can be used to collect and transmit information about the health of family members.

This information would be sent to health professionals, in order to provide improvements to the coordination of actions and effectiveness of the detection /treatment remote of diseases. This scenario fit into the context-aware applications [1] that exploit the dynamic context of its users, by capturing the user's context implicitly, either by sensors or ontological associations based on predetermined rules.

This paper specifies a context-aware application based on ontology and personal tracking technologies. It integrates the epidemiological field of LARIISA project [2][3], an intelligent platform to support decision making in public health governance. This application combines the SISA [4], a health context-aware application based on ontology, and a personal tracking-based system, called CAPTAIN [5] to enable the intelligence governance in decision making in healthcare environments, subsidized by the information captured in the context of families. While registering the trajectory followed by the mobile device, it allows health agents to create multimedia documents (e.g. photo, audio, video), which are connected to an enriched description of the user context (e.g. weather, location and date).

In order to obtaining information about the family health, this application uses digital TV and mobile phone applications due mainly to the presence of numerous devices at home and the access to several communication networks [6][7].

This paper is organized as follows: Section II describes the context-aware, ontology and personal tracking concepts. Section III shows the specification and prototyping of the proposed application. Section IV presents related work. Finally, Section V concludes the paper and discusses future work.

II. CONTEXT-AWARE SCENARIO

A. Context-awareness

Information could be captured revealing where the user is or what the user is doing, and then this information could be used to offer personalized services and information. Context is this type of information, which characterizes a situation and can be used by decision-making applications. Applications that use this type of information are named context-aware applications [1]. Therefore, a context model defines types, names, properties and attributes of the entities involved in context-aware applications, such as users, and other mobile devices. The model attempts to predict representation, search, exchange and interoperability of context information among applications. A well designed model is the key to any context-aware system [8].

Aiming in assisting users in their day-to-day tasks, context-aware applications have been using elements of ubiquitous systems to obtain users context information. A simple example is the use of sensors that detect the presence of people and automatically trigger lighting to an environment, according to the people location and time.

A context, to be represented, needs to be modeled by some technique.

B. Ontologies

The traditional information recovery on the web does not reflect the data semantic, their relationships and the knowledge that they represent. To have a sustainable growth, it is needed to adequately manage this huge mass of information. Semantic Web helps computing devices to understand the meaning of information stored/transmitted over the Internet [9].

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Building a semantic web application needs the creation and implementation of technology standards to establish semantic concepts that make possible sharing information between two or more systems. It is necessary to create mechanisms that describe data and represent the encoding of shared meanings. One of these mechanisms is defined using ontologies.

Using ontologies, especially in the Computer Science area, makes possible the communication between different people and computer systems that participate in the same knowledge field - but not necessarily share the same form of conception about the elements of this domain.

An important reason to use ontologies is the guarantee of reliability surrounding vocabulary concepts or languages that are used in certain environments. Thus, using formal representation acquired with this application, it becomes possible automation of consistency verification, generating environments more reliable.

C. *Personal Tracking*

There are several applications that use context data to provide enriched information. This information might be proximity of people or objects in the photo, current temperature, date and annotations. They are often obtained from sensors of mobile devices, from users or from the web. With this information associated, context-aware applications can better suggest actions or new information to support the decision making processes [10][11].

In this paper, we go a step forward proposing the use of context information to enable the intelligence governance in decision making in healthcare environments, subsidized by the information captured in the context of families. First of all, the user trajectory is registered by using the GPS sensor of the device, as presented in [5] (Figure 1).

While registering the trajectory, the user can make notes and multimedia contents, such as: photos, audio or video. In addition, context information can be associated with each multimedia created, as geographic position, date, and temperature.

These data can be easily stored and enriched in the database of LARIISA. In short, the personal tracking-based system works in three steps: i) collecting context and user-added data; ii) processing and organizing them in the database; iii) recommending the actions in the decision making processes.

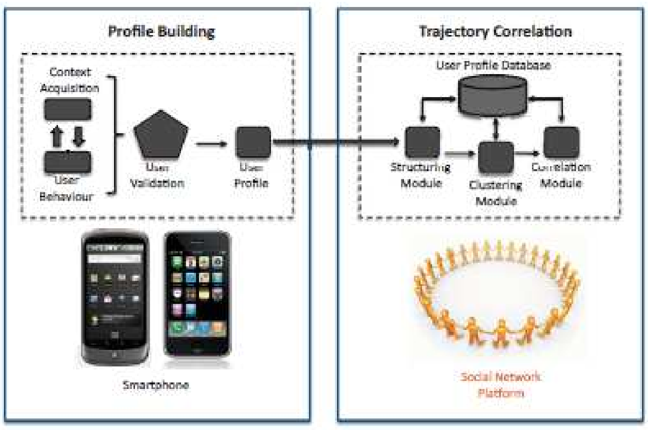

Fig. 1. Main components of Captain: A context-aware system based on personal tracking.

How could the Lariisa project be improved using the Captain architecture? To answer this question, this paper proposes the use of new mobile devices packed with medical sensors [20].

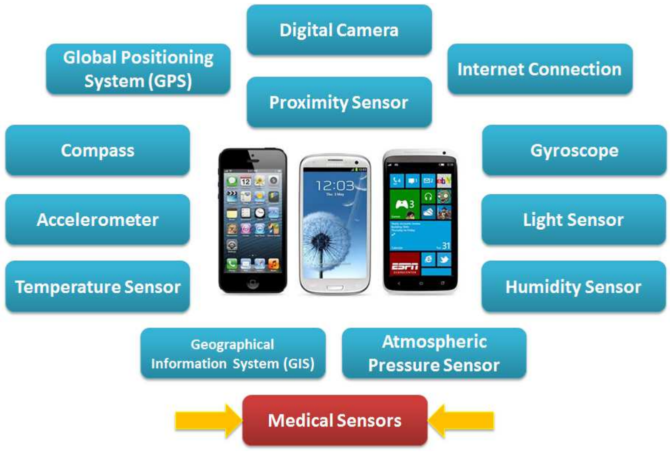

Fig. 2. Mobile device sensors

III. SISA, A LARIISA APPLICATION

A. *LARIISA Project*

The LARIISA [2][12][13] aims to research and the development of a platform able to provide intelligence governance in decision making in health information collected from / sent priority of residencies handled by efficient mechanisms knowledge management. Characterized by real-time information systems and inference based on a model of ontologies, the platform is oriented context, which gives applications greater adaptability of decision making to the reality in question, in this case, the area of health.

For this purpose, the LARIISA provides a series of goals, among them are the construction of Applications in Health, which among other objectives, to support decision making and analysis and creation of ontologies in the field of epidemiology based on information real-time and increased quality of information captured by various sources, including their own citizens through applications DITV, considering this is the only communications equipment present in over 98% of Brazilian homes [7].

B. *SISA Application*

SISA [3] is an acronym for Health System Adapted-to-context Health Management, in Portuguese, component-based framework LARIISA. This system supports decision making and focuses on the idea of improving the quality of services provided by health workers in cases of fighting epidemiological crises, especially dengue. To meet the needs of the key players in the system architecture of the SISA is divided into three main modules (Figure 3);

- **Mobile Module**: This module is expected to be the system interface used by health workers. It is available via the use of mobile devices (mobile phone, PDA, tablet, etc.). The registering process is based on the personal tracking-based application proposed in [5]; consultation schedule of visits to be conducted in the residences; receive notifications of urgency, and act as a provider of context because it allows entering date observed in site visits;

- **DITV Module:** This module is a Context Provider used to capture information from families. An interactive application, linked to the campaigns against dengue is showed in [3]. This application enables the filling of information (epidemiological data) which will be used by the Web module;
- **WEB Module:** This module is an interface web for the SISA users.

The SISA DITV technology uses an interactive application that enables citizens to indicate symptoms of family members; for instance, these symptoms can characterize cases of suspected dengue.

The data captured by the interactive application is sent to the remote module SISA, which will be aggregated, enriched with knowledge captured and saved in a database.

In addition, these data will be exported following a semantic representation that is based on ontologies for application of inference rules associated.

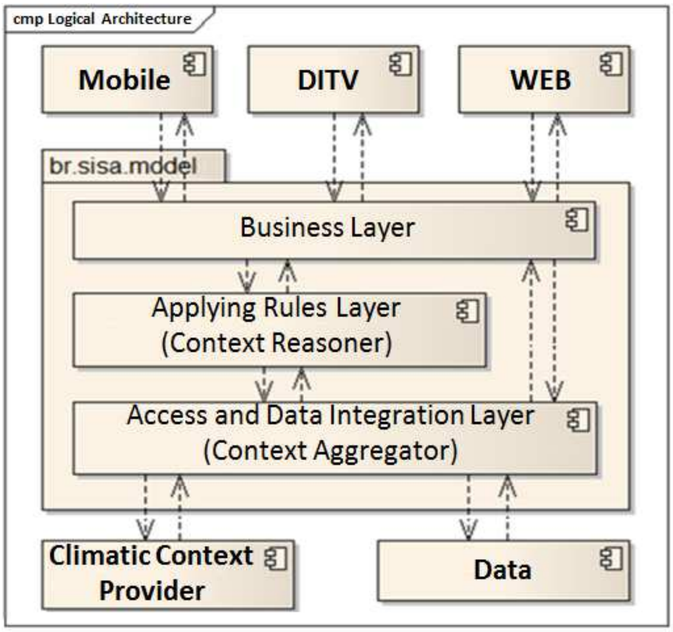

Fig. 3. SISA Logical Architecture

The resulting decisions are forwarded to the levels of performance, being the primary Agent Community Health - ACH, since it maintains direct contact with the community. At the governance level of health, the SISA adds on an epidemiological map observed of the region suspected dengue. In case of a negative finding (e.g., after a visit from a health worker), the system removes the epidemiological map marking, and a positive case confirmed by the ACH, the system dials confirmation of dengue cases and their respective classification levels of care.

If there are many cases identified in a given region, the system is able to generate alerts decision-making to combat on-site (e.g., sending health workers to the site), for the acquisition of drugs, among other management operations (i.e, creation of an emergency unit to combat the epidemic).

C. Prototype Specification

The Mobile Module provides context responsible for data collection informed by health workers, this module has two basic components implemented with WAP and JAVA ME (JME). The access to WAP-based component occurs via HTTP, through the use of any mobile device (mobile phone, PDA, tablet etc.). The component JAVA ME is used to enable the receipt of notifications of urgency, it also depends on the Internet to facilitate the integration, via *Remote Method Invocation*[1] (RMI), the web module. The figure 4 illustrates the initial results of the respective modules.

The DITV module consists of an application of Interactive Digital TV, created in GINGA-NCL, which will be transmitted via data carousel, along with audio and video campaign to combat dengue[2].

The Web Module uses current web development technologies: Java, Java Server Faces (JSF), Rich Faces, Jfree Chart, Entities, Hibernate / JPA, database PostGres. To implement the inference engine was used with JBoss Drools rules written in the format DRL. Below is shown the business rule that assesses the climate context to aid decision making of "Citizen" in this context and based SISA can direct the agent to the nearest health site.

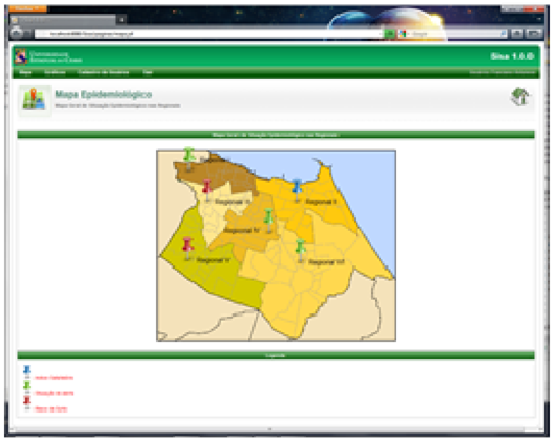

Fig. 4. Web module displaying epidemiological map of Fortaleza / CE for managers

IV. CONTEXT-AWARE APPLICATION SCENARIOS

The scenarios below demonstrate a real integration of the Captain into the Lariisa framework. Making use of Data Acquisition and Data Processing parts of Captain [5], all data (heath data acquired by medical sensors, location name and weather acquired by GPS mechanisms and Internet, date and user notes) were grouped together to form the sentences as follows.

1. Heart rate is 120 bpm and blood pressure is 140/90. These were taken at 4.14° S, 40.58° W (Reriutaba) on March 2nd, 2013 at 17:00h. The weather was rainy and cold. I am not feeling good.
2. Heart rate is 120 bpm and blood pressure is 140/90. These were taken at 4.14° S, 40.58° W (Reriutaba) on March 2nd, 2013 at 17:00h. The weather was rainy and cold. The patient was not feeling good and I took him to the nearest health center.

[1] RMI is a feature of Java technology that enables communication between objects, located in distributed applications, running on different virtual machines.

[2] The video used in the application was obtained in DATASUS site, which provides and authorizes the use of educational videos dengue campaign.

3. Heart rate is 120 bpm, body temperature is 40° and blood pressure is 140/90. These were taken at 4.14° S, 40.58° W (Reriutaba) on March 2nd, 2013 at 17:00h. The weather was sunny. I saw a dengue fever mosquito within my house and I am afraid I got dengue.
4. The photo IMG001 was taken at 4.13° S, 40.47° W (Reriutaba) on March 2nd, 2013 at 17:00h. The weather was sunny. Input from system: Dengue habitat.

It is important to notice that all messages above are received and stored in the Lariisa database.

As shown in Figure 5, the GPS coordinates now have an important role within the context of Lariisa for decision-making. It demonstrates a real scenario of decision-making process after correlating personal tracking and health information.

For instance, Lariisa receives the message n° 3 (above) from a patient's mobile device, indicating that he/she has a fever (due mainly to the body temperature). After receiving message n° 4 from a health agent mobile device, Lariisa framework through inference rules determines that the patient has 80-90% likelihood of contracting Dengue fever (based on the GPS coordinates – there is a Dengue habitat near the patient's house). This inferred information triggered off a health agent visit to the patient's house (Figure 5).

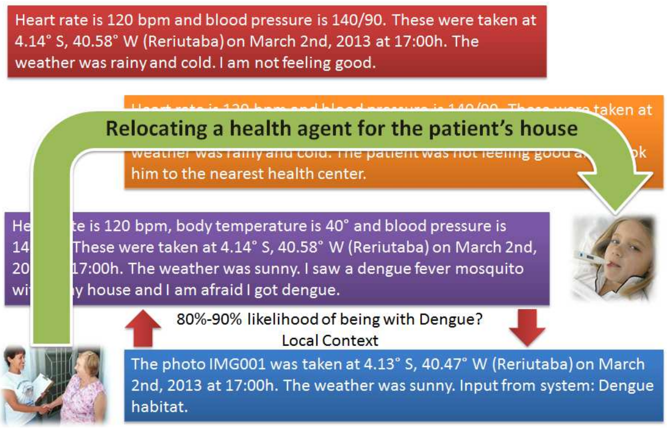

Fig. 5. Context-aware applications scenario

V. Related Work

Context-aware services have been developed based detection technologies and adaptation to the context, with the goal of improving the quality of systems of public health care. While it is clear that there are solutions that propose the use of context-sensitive technologies to the health care system (e.g. Healthcare Systems) [14][15][16], to our knowledge is still incipient existence of approaches to support decision-making context-sensitive to the governance of public health systems.

In [14], the authors present a Context-Aware Integrating System Services (CASIS) that allows building applications capable of high-level decision-making adaptation based on information collected by the system. In [16], the authors propose a system for context management based on ontologies (Context Management System - CMS), which enables you to define contextual terms of use in medical areas. In turn, in [15] the authors describe an architecture for context-sensitive health systems focused on the ability to monitor patients remotely. However, the prototype described in this article is based on semantic mechanisms of knowledge management and inference based on OWL-DL and SWRL rules, which seek to provide mechanisms to aid decision making at local and global levels.

The main difference of this prototype compared to existing work is that it considers specific requirements for decision-making context-sensitive systems in health governance. Furthermore, this prototype was specified using the model as a basis KTA [17] (see [2] the framework LARIISA), reducing the gap between the processes of creation / transfer of knowledge and actions of maintenance of public health.

Another innovative aspect of this prototype compared to existing platforms is that its architecture is designed on the Brazilian Digital TV model [7] and middleware GINGA, with the communication infrastructure of the Digital Belt base [19].

VI. Conclusion

This paper proposed a context-aware application based on ontology and personal tracking technologies as a part of LARIISA project, an intelligent platform to support decision making in public health governance. In order to obtaining information about the family health, this application uses digital TV and mobile phone applications due mainly to the presence of numerous devices at home and the access to several communication networks.

The LARIISA application uses simple devices for interfacing (cell smartphone, etc.) between the agent and the endemic LARIISA. The use of technology DITV exploring the most of its features, such as ubiquity, so as to maximize its use aggregating service like t-health, can enrich the system with context-sensitive computing. The development of context-aware applications is typically challenging and applies them to DITV technology becomes an even greater challenge.

The SISA, described above (section III) demonstrated its viability and relevance in combating dengue, and may contribute in national policies such as the National Plan to Combat Dengue (PNCD) [18]. Furthermore, we expect the use of SISA on a much larger scope for diseases like dengue, considering that the activities to combat dengue are similar to those used to combat other epidemics. As future work, patient's personal tracking scenario will be explored.

Finally, it is also important to mention that context-aware systems have some dependencies that may not be satisfied in some situations. The Internet connection, for example, can be limited or even not available at certain moments. Another problem is related to the mobile device battery. For example, all these features (GPS, Bluetooth, Internet access, etc.) are necessary to the context data acquisition, but they spend too much electric power. In order to minimize these dependencies, we reuse the functions proposed in [5] that have impact in trajectory and context gathering mechanisms.

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