CLOUD LARIISA, A CONTEXT-AWARE FRAMEWORK FOR A PUBLIC HEALTH ENVIRONMENT BASED ON CLOUD COMPUTING CONCEPT

RESUMO

***Abstract* – LARIISA is a framework that makes use of context-aware and ontology technologies to support decision-making and governance in the public health sector. It is able to perceive the status of epidemiological emergencies and adapt itself in real time to a risk situation. This paper presents the LARIISA's cloud computing version, a LARIISA's second rendition, whose main aim is to provide a software platform enabling the "facilities-like" offering of healthcare infrastructure, middleware and applications. It will also provide features to facilitate the description, publication, discovery and integration of both public and private healthcare software systems in an open way,**

Keywords – context-aware system; ontology; health governance; Cloud Computing

1. INTRODUCTION

Governance is a general term connoting a series of loosely related trends in public administration and public policy management organizations whose purpose is to leverage the available knowledge (in a community, for example) to improve the administrative performance and the democratization of local decision-making processes. For instance, urban governance aims at promoting a closer relationship of civil society with the public organizations for the improvement of the welfare on big cities [1][2][3]. The concept of governance is also being used by international organizations such as the World Bank and the United Nations.

These organizations are developing projects concerning the practice of governance in developing countries aiming at fostering the participation of the entire society in the public management. This practice calls for an open government, with participation channels; demands strong partnerships with other public institutions and the private sector; and a permanent and virtuous integration of the government with the citizen. Abiding by ethical conduct usually motivates the administration itself and encourages members of civil society to participate in the process of social development.

Among the problems of information management in health area, we can observe how difficult it is for a significant part of the managers to act on decision-making processes along the levels of government. There are different reasons to these difficulties: low level of coverage of the information; the delay between the collection of information and its subsequent analysis; low reliability of gathered information, etc.

To address some of these problems, a framework called LARIISA was conceived that supports decision-making concerning public health governance. It makes use of the concepts like context-aware, ontology and personal tracking to help health managers take more knowledgeable decisions. This paper presents the LARIISA's cloud computing version, a LARIISA's second rendition, whose main aim is to provide a software platform enabling the "facilities-like" offering of healthcare infrastructure, middleware and applications. It will also provide features to facilitate the description, publication, discovery and integration of both public and private healthcare software systems in an open way,

This paper is organized as follows: Section II describes the objectives of the LARIISA´s cloud-computing version. Section III discusses a little bit about the context-aware, ontology and personal tracking concepts. Section IV presents the LARIISA prototype. The Section V shows the new version. Section VI presents related work. Finally, Section VII concludes the paper and discusses future work.

2. PURPOSE OF CLOUD LARIISA

LARIISA is an intelligent platform to support decision-making in public health governance [4][5][6]. It is able to perceive the status of emergency epidemiological and adapt itself in real time to a risk situation. In order to obtain information about the family health, this application uses digital TV and mobile phone applications. While registering the trajectory followed by the mobile device, for example, 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 assess and tackle, if possible, epidemiological problems like new outbreaks of dengue, for example.

Several studies have presented proposals highlighting the importance of health networks and their systemic integration, since no entity or organization alone can provide for the integrality of the healthcare services, because of the interdependence that exists between entities and organizations.

We believe that data integration technologies combined with cloud computing infrastructure can afford unquestionable benefits to the systemic integration in the health sector and particularly for integrating applications of electronic governance in the healthcare sector. Moreover, a solution based on cloud environment will provide scalability and the necessary elasticity for these systems.

The main objective of this project is to provide a software platform that allows the publication and data integration related to public health into an environment of cloud computing. This platform will consist of many different services that will provide the required functionalities for describing, publishing, discovering and integrating open data. We define open data as data having their description defined by a common vocabulary stated through domain ontology.

3. CONTEXT-AWARE SCENARIO

A. *Context-awareness*

Information could be captured that reveals 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 [7]. 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 at assisting users in their day-to-day tasks, context-aware applications have been using elements of ubiquitous systems to obtain user context information. A context, to be represented, needs to be modeled by some technique.

B. *Ontologies*

The traditional information recovery on the web does not reflect data semantics, their relationships and the knowledge 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 [10].

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 [11][12].

C. *Personal Tracking*

There are several applications that use context related data to provide enriched information, for example, the proximity of people or objects, the current temperature, date, annotations, etc. They are often obtained from sensors in mobile devices, from users or from the web. With this associated information, context-aware applications can better suggest actions or new information to aid the decision-making processes [13] [14].

In this paper, we go a further step, 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 [13] (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.

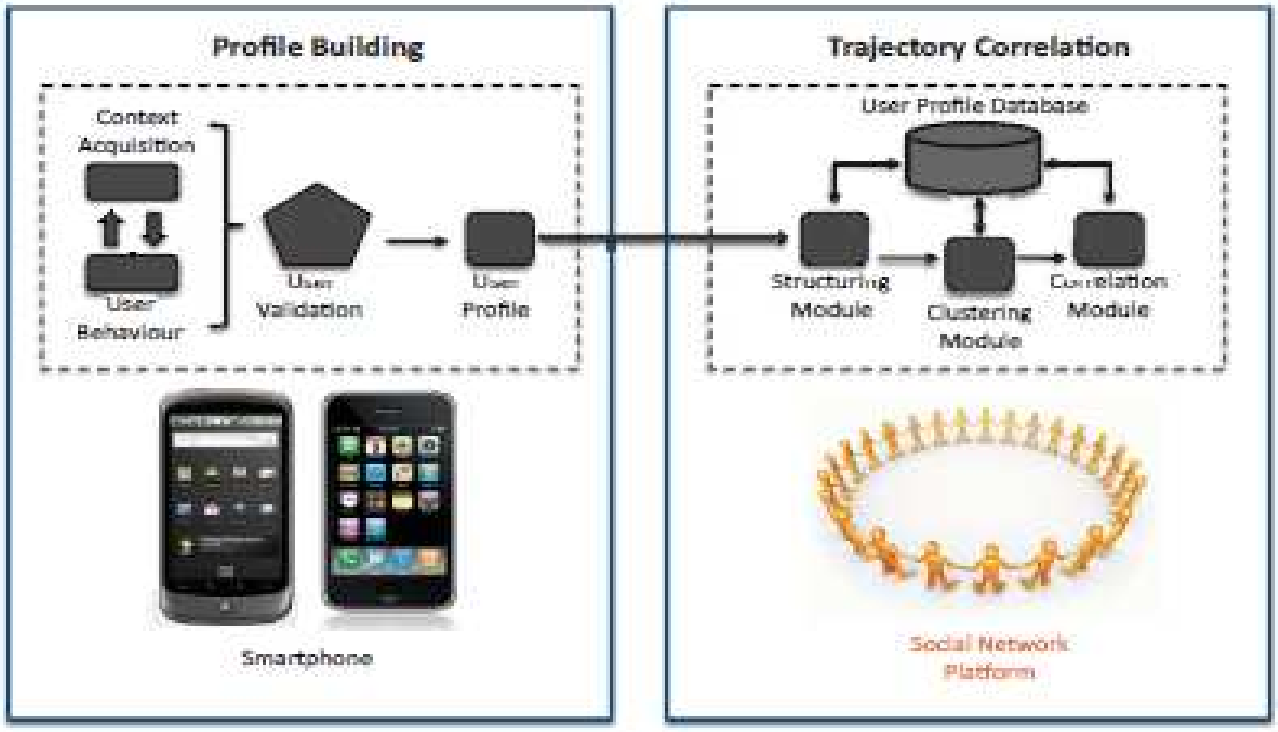

Figure 1: Main components of Captain: A context-aware system based on personal tracking

4. THE LARIISA FRAMEWORK

Figure 2 presents the LARIISA Framework introduced in simplified versions of the local and global health context information models for governance decision-making. These local and global health models are illustrated in figures 3 and 4, respectively. This framework defines the basic architecture for the building of context-aware applications for aiding decision-making in the healthcare sector.

LARIISA posits that a healthcare system can be well represented through five different views: Knowledge Management, Normative, Clinical-Epidemiological, Administrative and Shared Management (MONTEIRO 2009). Therefore, the prototype presented in this paper implements LARIISA´s components, applying them to the scenario of decision-making to the control of dengue epidemics in the Ceará State taking in account these five views.

This platform works with real-time information and comprises inference systems based on ontology models. It is context-oriented, providing higher adaptability to the decision-making applications existing in Brazilian healthcare network. The current healthcare network is divided into five levels: Primary Care Network (also known as Family Health); specialized Ambulatory Care Network; Hospital Network; Urgency and Emergency; Mental Health.

Since LARIISA proposes to integrate the five levels above, it tends to grow very complex and its architecture is planned to accommodate this growth. The present project makes use of LARIISA´s context-oriented capabilities, particularly the applications aimed at the Primary Care Network, and, more specifically, the infant-morten health area.

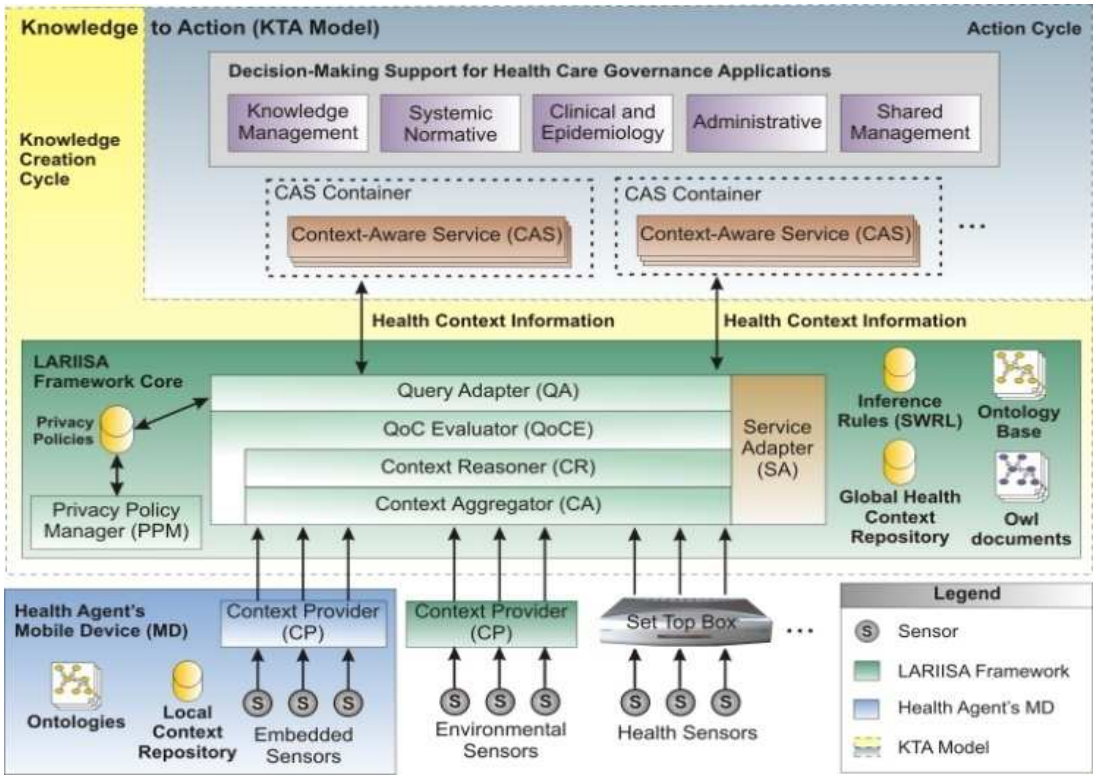

Figure 2: Lariisa Framework

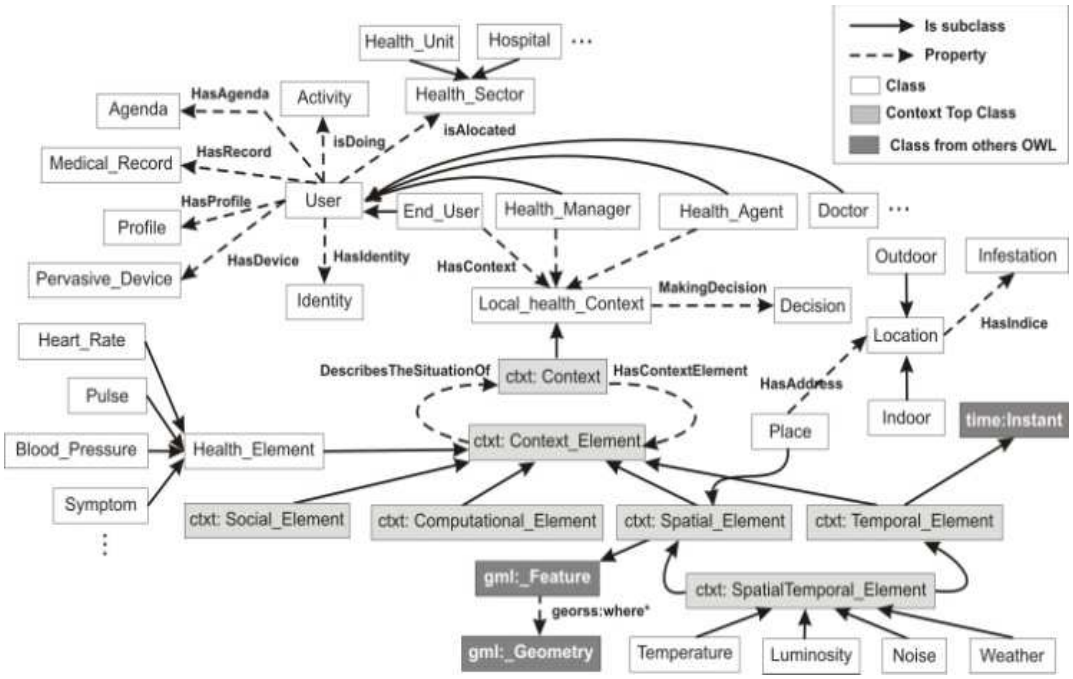

Figure 3: Lariisa local health context model

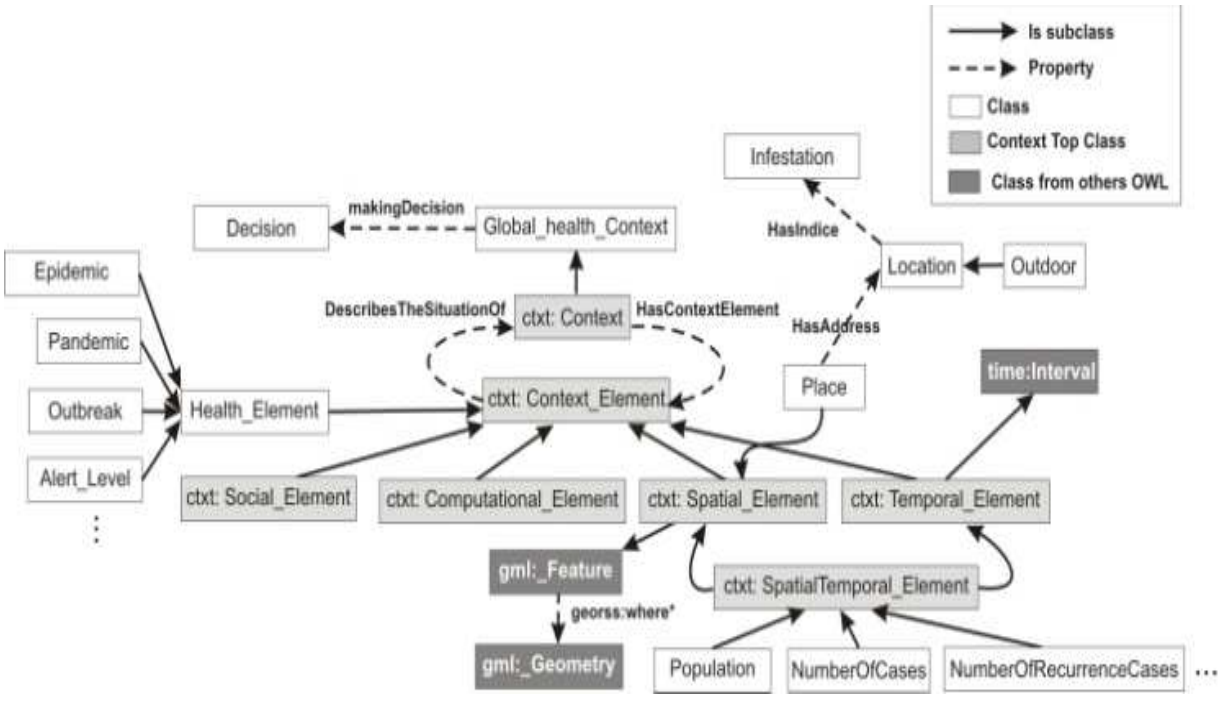

Figure 4: Lariisa Global health context model:

5. LARIISA´S CLOUD COMPUTING VERSION

Figure 5 presents the LARIISA scenario that uses personal tracking technology. The LARIISA Framework (figures 2, 3 and 4) will play a very important function in collecting and treating information related to health. LARIISA will be used as a software platform containing many services oriented to the publishing of open data, which will allow its future integration with data from other data sources.

Another objective of this platform is to allow the building of mash-up applications, which will be able to make use of others services provided by the platform, particularly services that enable the integration of data from different sources. Additionally, there will be oriented services for data visualization and decision support. Altogether, in order to address the different tasks proposed by LARIISA, we have to answer questions from different domains. For didactical purposes, we listed these concerns below.

. Data Base Issues

P_DB1. What are the consequences of using the cloud computing technology in the process of data integration? Which opportunities and challenges will be brought about with it? The understanding of these questions is very important to formulate the right solution.

P_DB2. How a process should be specified to publish governmental open data through the framework of the W3C Linked Data? Particularly, we will detail this process for the case of the public health information system;

P_DB3. How the publication and integration of government data in a cloud environment should be handled? In this problem, we will analyze the requirements of the applications to be developed in cloud environment, trying to identify which integration services are necessary to support these applications. Moreover, we will investigate how publishing services should be orchestrated to support the process presented in problem P_DB1.

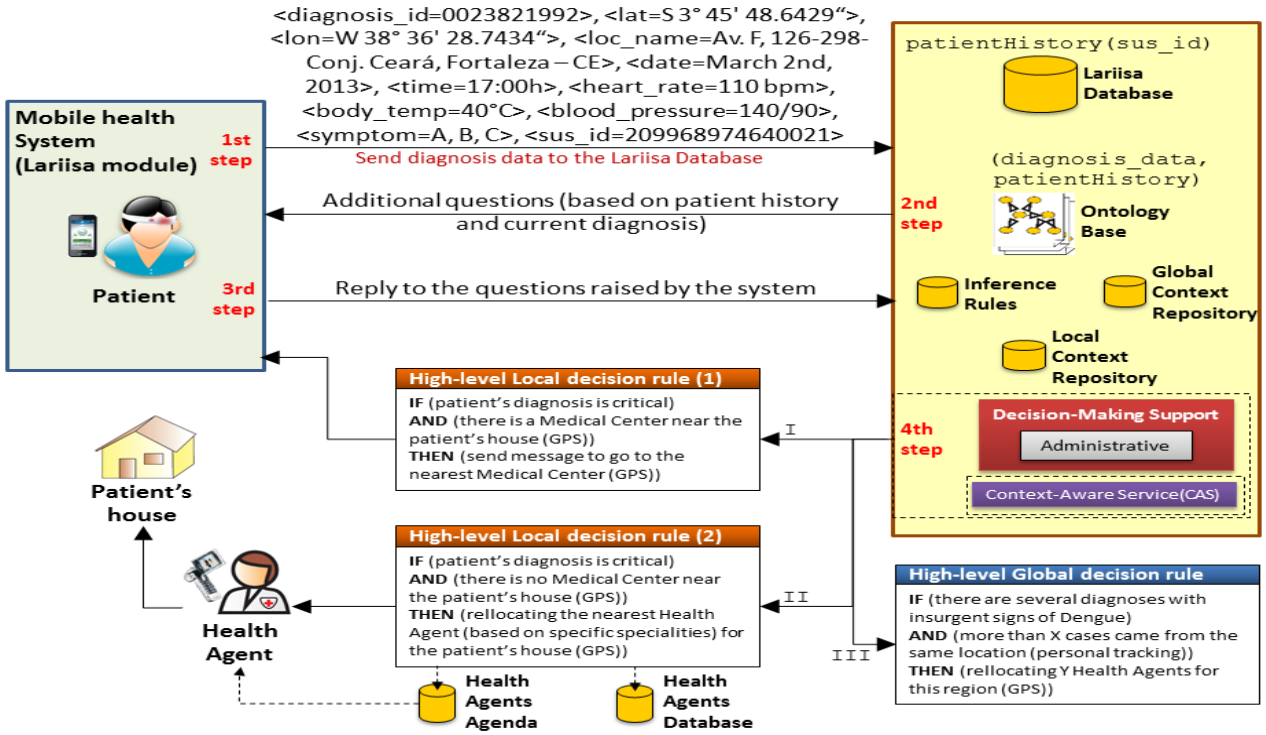

Fig. 5. Lariisa´s Personal Tracking Scenario

1 *Cloud Computing Issues*

P_CC1. How a cloud architecture of applications or services should be specified for publication and integration of the governmental data? This problem should deal with the level of service that applications will be made available by the clouds and the interface of this level with the level of the data storage service.

P_CC2. How the databases of governmental applications should be mapped to the data model supported by cloud infrastructure? The mapping should take into account the heterogeneity of the data models of existing sources.

P_CC3. How government data should be published, particularly healthcare based data, concerning security and access control? The definition of a protocol for this should consider the dissemination of data within the parameters of health ethics. This problem should define the security model of the data sent to the cloud.

P_CC4. How can we calculate the budget to meet both processing and data volume requirements given a fixed SLA?

6. RELATED WORKS

Existing processes for patients' vital data collection require a great deal of labor work to collect, input and analyze the information. These processes are usually slow and error-prone, introducing a latency that prevents real-time data accessibility. This scenario restrains the clinical diagnostics and monitoring capabilities. In [15] is proposed a solution to automate this process by using sensors attached to existing medical equipment that are inter-connected to exchange service. The proposal is based on the concepts of utility computing and wireless sensor networks. The information becomes available in the cloud from where it can be processed by expert systems and/or distributed to medical staff. The proof-of-concept design applies commodity computing integrated to legacy medical devices, ensuring cost-effectiveness and simple integration.

In [16] Online personal health record (PHR) enables patients to manage their own medical records in a centralized way, which greatly facilitates the storage, access and sharing of personal health data. It proposes a novel framework for access control to PHRs within cloud computing environment. To enable fine-grained and scalable access control for PHRs, we leverage attribute based encryption (ABE) techniques to encrypt each patient’s PHR data. To reduce the key distribution complexity, we divide the system into multiple security domains, where each domain manages only a subset of the users. In this way, each patient has full control over her own privacy, and the key management complexity is reduced dramatically. Our proposed scheme is also flexible, in that it supports efficient and on-demand revocation of user access rights, and break-glass access under emergency scenarios.

7. CONCLUSION

The decision-making process in health governance systems is a constant challenge, whether in urban scenario, where human resources and infrastructure available do not accompany the growing demand, or in rural areas, where management is aggravated due to precariousness of contingent communication, etc.

The LARIISA project is a rich environment for developing context-aware decision-making applications, aimed at fostering governance public health systems. This paper presented the LARIISA 2.0 version, a computational model named Cloud LARIISA. The main objective of Cloud LARIISA is to provide a software platform that allows publishing services and integrating data related to public health in a cloud computing environment. This platform is composed of several services that will provide the functionality needed to describe, publish, discover, and integrate data openly.

Although the contextual knowledge and the real-time information are key ingredients for the intelligent governance of health systems, in practice, these are not always available at the time health managers need them, resulting in making decisions “in the dark” or even the refraining to take actions.

A direct consequence is the inefficient usage of resources applied and / or lack of treatment / control of health problem (e.g., an epidemic). The situation becomes even more complex when the health governance decisions seek for synergy with the reality of the "last mile" in the health system: the families. The decentralization promoted by this new health paradigm focused on families, naturally, makes the decision-making process and the application of knowledge in health area even harder.

A cornerstone for the establishment of governance is to adopt information technology as a mechanism to allow the publication and distribution of information to all segments of society. Economic factors have led to an increase in the infrastructure and facilities for providing computing as a service, in an elastic way, i.e., through cloud computing, where companies and individuals can rent computing capacity and storage, rather than making large capital investments required for the construction and the provision of installing large-scale computing.

These services are typically hosted in data centers, using shared hardware for processing and storage. Of course, cloud computing emerges as an appropriated response to the needs of handling large volumes of data that need to be processed, integrated and available for users and applications. This way, cloud computing is the ideal candidate to support the applications development for electronic govern.

Promoting electronic governance has as main agenda to provide citizens with a transparent view of the information generated and managed by public agencies. Thus, the first step in this direction is to provide methods and techniques to publish and integrate different data sources from these agencies in order to provide a unique insight to its users.

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