Clariisa, a Context-Aware Framework Based on Geolocation for a Health Care Governance System

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***Abstract* — Context-awareness has been successfully included in the mobile device applications due mainly to the presence of numerous sensors and the access to several communication networks. Therefore, this paper presents a context-aware framework based on geolocation for a health care governance system. While enabling remote health diagnosis of a patient using his/her own mobile device, the proposed system enriches the patient's health data with geolocation before sending it to the Lariisa framework, an intelligent platform to support decision-making in public health governance. In order to collect information about a patient's health status, the proposed application uses mobile devices equipped with medical sensors. While remotely registering a patient's health diagnosis using a mobile device, the system allows the creation of an enriched description of the user context (e.g. weather, location, and date). The main contributions related to our framework include patient health diagnosis provided remotely, support for decision-making health systems, and context information for context-aware health systems.**

Keywords - context-aware; geolocation; diagnosis; decision-making; health; framework

I. Introduction

Mobile devices, such as smartphones, nowadays, are not simple call-making devices anymore. They have already become real information centers [1]. With all the embedded features like GPS, accelerometer, Internet connection, digital camera, among others, a user easily creates and publishes personal multimedia content. For instance, any user can quickly take a picture and put it in his/her web-based photo album [2]. In addition, multimedia content can be enriched and organized with context information collected by smartphones, such as date, geographical position and current weather.

There are several applications that use context related data to provide enriched information, such as the proximity of people or objects in the photo, the current temperature, date, annotations, etc. They are often obtained from sensors embedded in mobile devices, from users or from the web. With this associated information, context-aware applications can better suggest actions or new information to support the decision-making process [2] [4]. Taking it into consideration, we propose a context-aware framework that remotely collects vital signs with enriched data from users to send it to a decision-making health care governance system [3]. Thus, the use of a mobile device equipped with medical sensors is needful.

With the advent of mobile devices (e.g. smartphones) packed with medical sensors [5] [6] [7], our proposal becomes an innovative way to remotely collect vital signs from patients to provide a health diagnosis to the patients. To evaluate the system usability and its contribution in the society, the proposed system was applied in a challenging scenario of a context-aware health care governance system [3].

Taking into account the Lariisa Framework [3] and Captain Project [2], this paper goes a step forward and proposes Clariisa, a context-aware framework based on geolocation for a health care governance system.

The organization of this paper is presented as follows. Section 2 presents related work. Section 3 describes the Lariisa framework. Section 4 introduces an overview about context-awareness, personal tracking and geolocation, and the Captain. Section 5 presents the proposed scenario. Section 6 describes implementation aspects of the scenario proposed, and finally section 5 concludes this paper and discusses future work.

II. Related Work

Some efforts towards context acquisition framework implemented in the Android platform are proposed to reduce the complexity of the development of mobile spatial and context-aware applications. In such applications, location is the key information to improve the interaction between user and services, combining location with other context information, such as weather, user's activity, temperature, among others [8].

In addition, telemedicine is the use of advanced communication technologies within the context of clinical health that delivers care across distance [9]. As such, it facilitates the delivery of telehealth care for the direct benefit of patients [10]. On this paper, telehealth care will be explored in order to provide a remote health diagnosis to patients as well support an intelligent decision-making health care governance system.

III. LARIISA

Lariisa Framework takes into account local and global health context information models for governance decision making. Lariisa defines the basic architecture for building context-aware applications and supporting decision-making in the health care area. Lariisa was specified taking into account specific requirements of five governance fields: Knowledge Management, Systemic Normative, Clinical and Epidemiological, Administrative and Shared Management [3]. Therefore, the system proposed in this paper provides a context-aware diagnosis based on geolocation to Lariisa, applying it to the scenario of decision-making for local and global contexts [22].

Lariisa framework works with real-time information and comprises inference systems based on ontology models. It is context-oriented, providing 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. The proposed system makes use of Lariisa´s context-oriented capabilities, particularly the applications aimed at the Primary Care Network, and, more specifically, the infant-marten health area.

LARIISA is centered on the concept of health context information. Based on Dey's definition of context [15], we consider health context as any information that can be used to characterize the situation of an entity in a health system. Lariisa is able to perceive the status of emergency epidemiological and adapt itself in real time to a risk situation.

IV. CONTEXT-AWARENESS

The interaction between humans and computers in socio-technical systems takes place in a certain context referring to the physical and social situation in which computational devices and environments are embedded [14].

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 [15]. Context is this type of information, which characterizes a situation and can be used by decision-making processes. Applications that use this type of information are named context-aware applications [16]. 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 [17].

Aiming in assisting users in their day-to-day tasks, context-aware applications have been using elements of ubiquitous systems to obtain user 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. Geolocation (GPS Coordinates)

We propose the use of context information related to the user location while registering his/her remote health diagnosis. The user location is registered by using the GPS sensor of the device, as presented in figure 2. The GPS coordinates and description of the patient context are added to the patient health diagnosis, helping the decision-making process of Lariisa. The ability to track, trace and control anything from anywhere on the planet has been mankind's unfulfilled desire [13].

B. Captain: A Context-Aware system based on Personal Tracking

The main purpose of Captain is to map the trajectory of a mobile user, adding contextual information related to each user position. The mobile application proposed on the Captain project performs the yacht tracking, associating contextual information with each position.

While registering the trajectory followed by the mobile device, it allows users to create multimedia documents (e.g. photo, audio, video), which are connected to an enriched description of the user context (e.g. weather, location, date). Finally, all this data and documents are combined to produce a new content, which is published on the Web [2].

V. CLARIISA

Figure 1 presents an overview of the proposed system, which is divided in three main parts: *Data Acquisition*, *Data Processing* and *Publishing*. *Data Acquisition* concerns the sensor application, information (e.g. User ID and symptoms) added by the user, and the acquired data. After that, all acquired data will be processed in the *Data Processing* step. In this part, the system uses the raw data in order to capture all necessary diagnosis data. When the user health diagnosis context is properly collected and inferred, the *Publishing* part initiates its process. Finally, a new content is formerly produced and can be stored in the Lariisa database, taking into account the association of context information.

Identifying which user is sending health status enriched data to the Lariisa Database is crucial for the proposed framework. Without this identification, it is not possible to determine who is sending health vital signs to the system. To overcome this challenge, a unique identification (ID) number needs to be informed by the user at the moment he/she starts a new health diagnosis from his/her mobile device. The unique ID chosen is the SUS ID, an identification number assigned to every Brazilian citizen as part of the national registry of users – for the consolidation of the *Sistema Único de Saúde* (SUS) of Brazil [18]. In this context, the unique ID can be used to register a new health diagnosis and also query information from other databases such as SUS database, public hospital databases, etc.

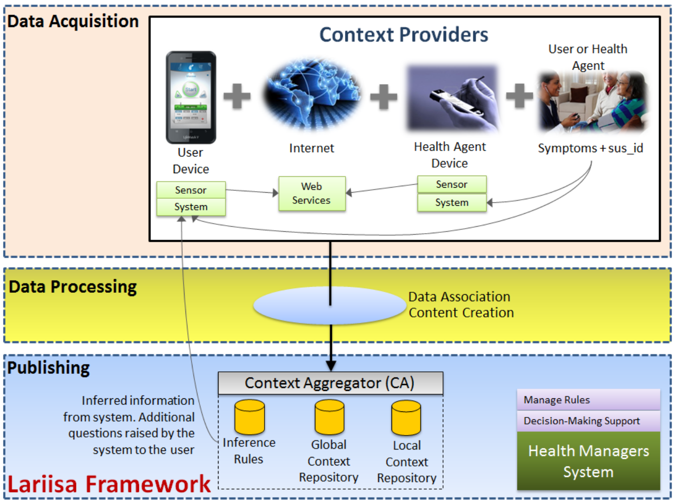

Fig. 1. Clariisa Architecture

While a user is registering the health status data, the sensors acquire context information, such as position, direction, date, and weather. The collected data is manipulated by the second part in order to acquire all required data to be sent to Lariisa.

One of the main features of context-aware systems is the location [1]. The proposed system also relies in this feature. GPS collects the geographic location of a taken health diagnosis to add this information in the metadata (Figures 2 and 3). This action is important to help the content generation as well as to acquire new information (e.g., location name and weather) of a diagnosis that is being taken. These three parts (Data Acquisition, Data Processing and Publishing) of the proposed system are detailed in the next section.

The proposed architecture considers both mobile devices: user devices (e.g. a patient smartphone) and health agent devices. In this paper we focus on user devices and its contribution for the Lariisa framework. In addition, a personal tracking scenario for health agents is discussed in [20].

VI. Implementation Aspects

We take into consideration the use of the LifeWatch V phone, a fully featured android-based phone [6]. Even this device has a variety of health sensors (blood glucose, body fat, stress test, etc.), our proposal is limited to the body temperature, blood pressure and heart rate sensors. 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. In order to minimize these dependencies, we propose some design decisions.

A. Data Acquisition

The *Data Acquisition* uses sensors available in mobile devices to get information about localization, time, heart rate, blood pressure, body temperature, local weather, etc. In addition, SUS ID and symptoms informed by the user when the application is started are also considered as *Data Acquisition*.

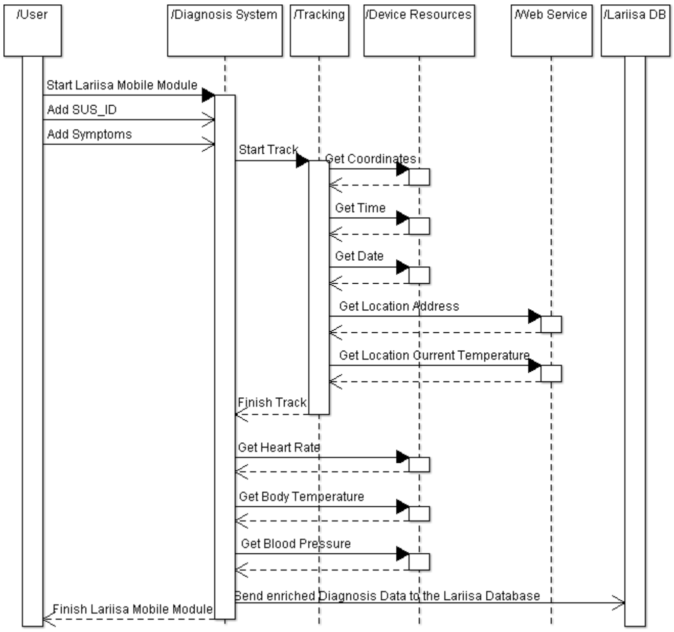

Fig. 2. Sequence Diagram of Data Acquisition

According to figure 2, the user starts the data acquisition process in the mobile device. After starting the application, the *Data Acquisition* process starts to collect all data needed to send the patient's enriched health data to the Lariisa Database. Before starting the acquisition of location, time and health, the user must inform his/her SUS ID and symptoms to the system. These data (SUS ID and symptoms) are added to the other data acquired, including health data gathered by the sensors and data gathered from the Internet via Web Services. Location name and weather can be obtained from the Internet, both using the position information acquired by the GPS. If Internet connection is not available at the moment diagnosis system is started, all data will be cached and further it will be sent to the Lariisa Database. In order to improve the *Data Acquisition* process, SUS ID information is stored on the system. Therefore, the user does not need to send the ID at the next time he/she uses the system.

In order to improve the data processing step, it is important to organize the acquired data into the metadata. Therefore, the system uses tags to arrange the information in the metadata.

B. Data Processing

The *Data Processing* part is responsible to increase the robustness of the system by offering more than a context-aware data collector. It associates and organizes the information in order to provide a comprehensive structure to be published (registered) on the Lariisa Database.

Making use of the acquired data organized by tags, the data processing part is started. It has to organize the data in order to facilitate the content generation for later registering on the Lariisa Database. The key idea is to use the context information of the remote health diagnosis data for decision-making support, considering both local and global contexts (see section II). The system provides enriched health diagnosis based on the information acquired by the mobile application. For example, if a user starts a remote health diagnosis, the system will generate a new diagnosis with the coordinates S 3° 45' 48.6429", W 38° 36' 28.7434" at 17:00 on 03/02/2013. Besides that, the mobile application captures health data from medical sensors (body temperature, blood pressure, heart rate, etc.), and the user is requested to add his/her health symptoms and SUS ID. According to Figure 3, all data acquired are grouped to be later published on the Lariisa Database.

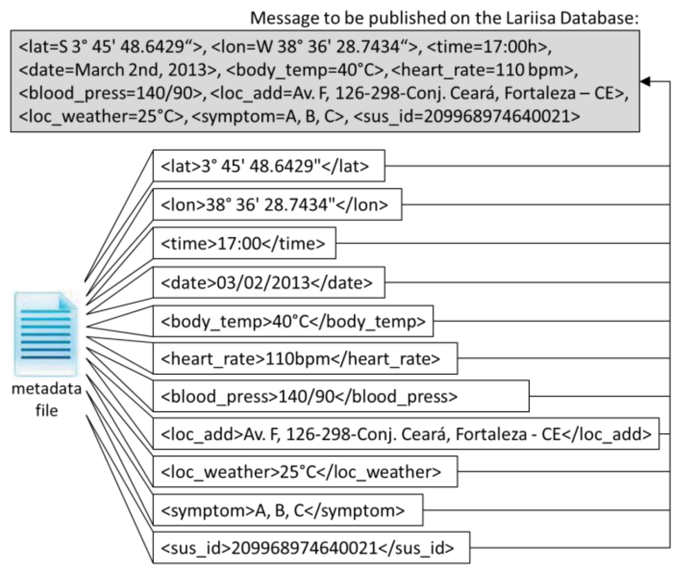

Fig. 3. Data Processing

If the mobile device due to an absence of connection does not acquire the information of location name and weather, our system interface has to be able to obtain this information based on context information. The specialized web services provide the weather status for present and future times. To solve this problem, we propose a mechanism to capture this information using a HTML parser in order to get the location name and for the past time. This parser reads the web page *DailyHistory* of the *WeatherUnderground* and obtains the weather status related to the context information provided by the acquired data [1]. When the application generates the content to register all health status data, the third step of the proposed system can be started.

C. Publishing

The last part of the system is responsible for registering the content on the Lariisa Database. An important part of the architecture proposed in Figure 1 is the use of Context Aggregator Layer (CA) to receive health status context information from context providers. This layer is also responsible for running context aggregation operations in order to have useful high-level context represented by the Local Health Context Ontology [3]. Moreover, health managers could view the content of diagnoses organized by day, by place, or by patient (e.g. filtering diagnoses results by SUS ID).

After publishing the patient's health status data on the Lariisa Database, the framework is then able to raise additional questions to the user. These additional questions are raised by the system based on inferred information that was previously analyzed by the system using ontologies concepts [19]. After a patient replies the questions raised by Lariisa, .As shown in figure 4, three steps are required before the system make a decision (4th step) considering both local and global contexts. These four steps are described as follows:

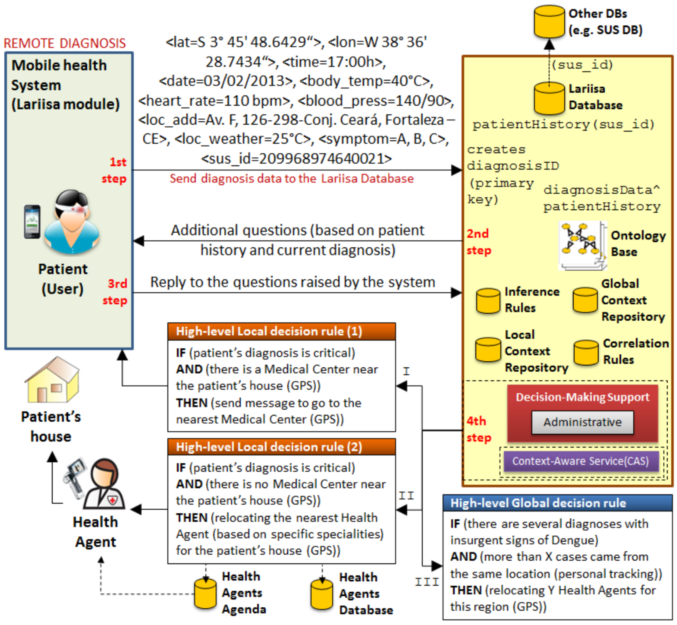

Fig. 4. Personal Tracking Scenario (Clariisa)

- **1st Step:** User starts diagnosis application on the mobile device, and the system (after Data Acquisition and Data Processing processes) registers the enriched patient health status to the Lariisa Database. A "diagnosis ID" is created as the primary key of the data stored on the database.
- **2nd Step**: Lariisa Framework analyzes the enriched patient health status considering both current health data and patient history. Next, it makes inferences and correlations and raises additional questions to the user.
- **3rd Step:** User replies to the questions raised by the system, providing more contextual information related to his/her health status. The answers to the questions are very important because the system increases the accuracy in the patient health diagnosis.
- **4th Step:** Based on all contextual information provided by the user, Lariisa Framework is now able to make a

consistent decision considering either local or global contexts.

All these steps can be viewed on figure 4, including examples of high-level local and global decision rules.

For instance, a user is registering a new diagnosis using the proposed system. At this moment, the user is at the office and the diagnosis result is critical based on the context provided to the context-aware health care system (Lariisa). Lariisa is then able to make a decision and send a message to the user, suggesting him/her to go to the nearest health center (based on GPS coordinates). On the other hand, if many cases of an insurgent disease came from the same region (based on GPS coordinates), then the Lariisa is able to relocating health agents to that region, or alert public health system to purchase more drugs and avoid lack of drugs in an epidemiological real case.

D. Prototype

As a proof of concept, a prototype is being developed. It will permit to register user geolocation at the moment a health diagnosis is being taken via mobile device. Additionally, the mobile application also collects health data through medical sensors. We designed a mechanism to capture health diagnosis data and register contextual information in order to associate them with the current position. The mobile application stores all information and data related to the geolocation in a predefined folder. The *Data Acquisition* process is developed in the Android platform, since the LifeWatch V uses this Operational System. Besides that, we developed our own local parser to get the information of each tag and to infer about context information using the HTML parser. It is important to note that some of Data Processing features were also implemented in the mobile phone, such as the inference mechanism to get the weather status and location name.

The *Data Processing* step is implemented as a desktop application to offer an interface of creation and publication of health status content. It implements the module to get the context information that was not acquired by the mobile application, using the HTML parser. We tried to develop a robustness and intuitive user interface to improve the usability.

VII. CONCLUSION

Adding geolocation data in remote health diagnoses of patients become an innovative way of providing context information for context-aware health care systems.

Lariisa [3] is an intelligent system for decision-making in a public health management environment. In [21] the authors propose a data integration platform for the Lariisa. The aim of this proposed platform is to enable the integration of a large variety of health information databases with different governance issues involved, enabling interoperability among these multiple sources of data. Making use of this platform, the framework on this paper will be able to correlate information stored in different databases of private or public companies. It would permit the system to find additional information of a specific patient (e.g. via SUS ID) to collect more health information related to a specific patient, thereafter taking a decision more accurately.

As future work, we will focus on improving usability of the developed application. Besides that, we plan to study the content combination of different users in order to create reference among their trajectories, personal data and contextual information. Finally, we have the intention to integrate the proposed system and the personal tracking scenario for health agents [20]. Our proposed approach can bring great advances into the process of high-level local and global decisions rules within the context of Lariisa. Information collected by health agent devices can also be correlated with the health diagnoses enriched data collected by user devices to generate a new metadata for the context-aware heal care system. The remote health diagnosis proposed on this paper also works for reduction in numbers of hospital admissions.

The framework presented on this paper has the purpose of joining Continua Health Alliance [23], a non-profit, open industry organization of healthcare and technology companies.

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