Integrating Mobile Devices In a Brazilian Health Governance Framework

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Abstract -This work presents a proposal for integrating Context Providers to the LARIISA - a project that makes use of intelligent systems for helping decision-making in the area of public health governance. The context providers gather information about concerned communities and will allow the implementation of ontologies reflecting different levels of public health governance (e.g. state-wide, locality-wide, etc.) mirroring LARIISA's Local and Global models.To connect LARIISA and context providers, we proposethe LISA - LARIISA Integration System- a highly expansible system that aims at facilitating the inclusion and exclusion of context providers, even if they have not originally been conceived for the LARIISA interface.

Index terms –eHealth, governance, systems integration

I. INTRODUCTION

Public health managers lack efficient monitoring mechanisms enabling them to undertake more promptly actions when facing endemics (e.g., dengue, viral illness, etc.) or even to see them through regular preventive healthcare programs, e.g., the Family Health Program [1].

Faced with this kind of challenge, many advocate the use of innovative clinical approaches including encouraging greater involvement of the patient and systematic monitoring of their condition, rather than simply treating acute problems.The information technology, thanks to its ability to remotely monitor and interact with patients and caregivers, presents appealing qualities for this role. In fact, the Information and Communications Technology (ICT) has been improving the public health conditions in both urban and rural areas.

Since First World Telecom Development Conference (WTDC),back in 1994, new applications have mushroomed that aim to improve health services access and quality. In 2005, the World Health Assembly acknowledged e-healthas a safe and efficient way of using ICT in the healthcare sector, and even advised itsStateMembers to develop plans with this regard (eHealth Master Plan) [2].

Thewidespread use of mobile deviceshas nowspawned a new research and development area dubbed m-health. It involves applying mobile devices (cell phones, PDAs, smarthphones, biomedical monitoring devices, etc.) to support medical and public health practice. In 2006, ITUestablished a study group to deal specifically with this subject [3].

It is in this context that appears the LARA [4]and the RIISO [5] projects. While LARA makes use of*context aware*technologies to create a ubiquitous environment that adapts itself to the user profile, RIISO proposes a governance framework to support decision-making in healthcare systems. It advocates that every sound decision in healthcare should consider information from fivedomains: Knowledge Management, Regulations, Epidemiology, Administration and Shared Management.

Acknowledging the complementary characteristics of LARA and RIISO, the LARIISA project was proposed to consolidate both projects in one combined endeavor aiming at designing a framework to support governance in healthcare systems while taking account of context related issues. Thus, LARIISA is an e-health application to improve decision-making in the health sector, most notably, in rural areas, where insufficient infrastructure and information as well as a shortage of human and budgetary resources take their toll on health services' quality.

The specific purpose of this paper is to investigate LARIISA'sm-Health component, by addressing the problem of integrating mobile devices and Digital TV settop boxes - responsible forproviding context related information- with LARIISA framework.To this end, it introduces the LISA, the LARIISA Integration System Architecture.

II. LARIISA PROJECT

LARIISAis a project that makes use of intelligent systems for helping decision-making in the area of public health governance. It advocates using mobile devices, embedded systems and also the set-top box appliance of the Brazilian System of Digital Television- SBTVD as context providers and, in its first version, using the Ceara Digital Belt [6] as the communication infrastructure. It is alsodesigned to provide health managers with an intelligent governanceframework that will support them in making decisions concerning the Basic Attention network from the Brazilian Unified Health System- Sistema Único de Saúde (SUS).

a. LARIISA's Objectives

The LARIISA Project aims at researching and developing a framework that uses information primarily collected from and sent to the households which. Once processed by knowledge management mechanisms, this information will guide health managers in the decision making process. With this purpose, LARIISA will capture real-time informationfrom digital TV settop boxes and mobile devices that will provide health authorities with further elements to make more knowledgeable decisions.

LARIISA will run atop the Ceara Digital Belt in addition to other existing communication links, like WiMax, WiFi e GPRS and will be based on inference systems that will reason on ontologies tailored to model context information.A LARIISA's proof of concept (PoC) is being implemented that presents the following characteristics:

•Embedded Hardware and software: Specification and implementation of social, economic, environmental and biometrical context providers that will run in mobile and medical devices as well in TV settop boxes.

•Software Engineering: modeling and development of a SOA-based system that offers some services to support health managers with decision-making at the primary care level.

•Ontology-Based Knowledge ManagementSystem (OBKMS): An OBKMS will be created and maintained to provide support to LARIISA´s decision-making applications.

•e-Health applications: Intelligent applications will help the decision-making in areas such as epidemiology and clinics for the maternal-infantile health;

•socio-economic viability analysisof the decision-making process leveraged with real-time and quality information andtaking account of the acceptability by the user.

•Interactive Content: Development of interactive content to be conveyed to the user via Digital TV.

At the end of this PoC, we expect to have the following scenario implemented:

"context information will be captured by smartphones operated by health workers (health agents, inspectors, auditors, etc.), by biometrical data collecting devices or even by settop boxes operated by users - who will interact with TV programs. Context informationwill be transmitted to LARIISA's "smart components"(i.e., inference mechanisms, ontologies, knowledge management database) through the Ceara's Digital Belt, wimax, GPRS, etc. Inturn, these components will hand over information to governance-aid applicationsrunning in situation rooms to provide health managers at their different levels (state governors, mayors, hospitals, community health centers, etc) with appropriate recommendations, priorities, policies, etc."

In such a scenario we can envisage, for example, the health agents's timetable being dynamically scheduled (in other words, a context aware timetable) or health managers making decisions based on real-time information thus enabling more proactiveactions.

In this same scenario, context providers will be used by health agents to gather information from different sources: socio-economical (revenue, educational level), environmental (temperature, humidity, etc.) and medical (height, blood pressure, heart pace, etc).With this information, one can detect some illnesses upfront (e.g. high pressure, cardiac dysrhytmia) and redirect efforts to the diagnosed illness without the need for the patient to go to a community health center. To summarize, LARIISA can collect information from different sources, or context providers: from settop boxes – the Brazilian DTV standard sets forth theGINGA middleware, which provides for the needed interactivity[7] -, from smartphones, which can, for example, be used by health agents to collect information directly from the population, and from specific environmental and biomedical sensing devices.

III. THE LISAIntegrationArchitecture

This paper introduces LISA (LARIISA Integration System Architecture), a solution to integrate the context providers to the LARIISA framework. LISA was designed to address some system integration issues, privileging expansibility, flexibilityand facility to connect/disconnect context providers even if they

have notoriginally been conceived for interfacing with LARIISA.A prototype has been implemented that permits to gather information from the "Ficha A" (a form querying socio-economical conditions of a family) and send it to the LARIISA database using the Digital Belt facility.

The LISA's main objectiveis to enable the connection of context providers to LARIISA, regardless of software or hardware platform. It ascertains that context information be delivered without changes in their protocol, formator any further prerequisite, considering the difficulties, if possible at all, of operating changes in legacy systems.

a. The challenges of systems integration

When integrating systems, one must cope with some recurring issues, namely:

•Communication infrastructure is not realiable and, more often than not, slow. So, integration solutions may not ignore that the data exchanged between two or more applications will traverse routers, switches, links, etc. all of them prone to failures and adding transmission delays.

•Incompatible applications: integration systems must take in account that distinctapplications are not necessarily compatible to one another (different operational systems, programming languages, databases, etc.)

•Applications invariably change: integration solutions should, therefore, minimize coupling with the application, so that changes operated on one of them do not significantly impact on the system as a whole.

b.System Integration Technologies

Apparently, there aremany different technologies that enable systems integration, but, when it comes to principles, they boil down to just a few[8]:

•File Transfer: One application writes to a file that will be read by another application. In that case, applications should agree on the name, format and location of the file, on the file creation interval, on the responsible for deleting the file and so on.

•Shared Databases: applications interact by storing shared data in a common database.

•Remote Procedure Calls (RPC): RPC is a synchronous communication strategywhere each application exposes some of its procedures so that they can be invoked remotely. Approaches may be object oriented (RMI or CORBA) or not (SOAP, xml-rpc, or REST).

•Messaging: each application connect to a common messaging system and exchange message objects. Messaging is usually asynchronous though it may also be synchronous.

c. Criteria for evaluating integration solutions

We should consider the following criteria before we can choose the best integration solution:

•Coupling: System integration should minimize the dependency among systems, so that changes performed on one specific system do not interfere with the others;

•Invasiveness: System integration requires coding in both the systems and the integration platform and this "invasiveness" should be kept to a bare minimum.

•Technology: Every integration solution needs specialized software/hardware. The right integration choice should take account of the costs to deploy and to maintain the choosen technology as well as its planned obsolescence – i.e. the deliberate deprecation some industries impose on their products in order to reduce ongoing support costs.

•Time delay: The chosen solution should minimize the time spent on exchanging data between systems.

IV.LARIISA ARCHITECTURE ENHANCED WITH LISA

LISA's main objective is to define a way to regulate the access of the context providers, offering them a single interface to LARIISA (Figure 1):
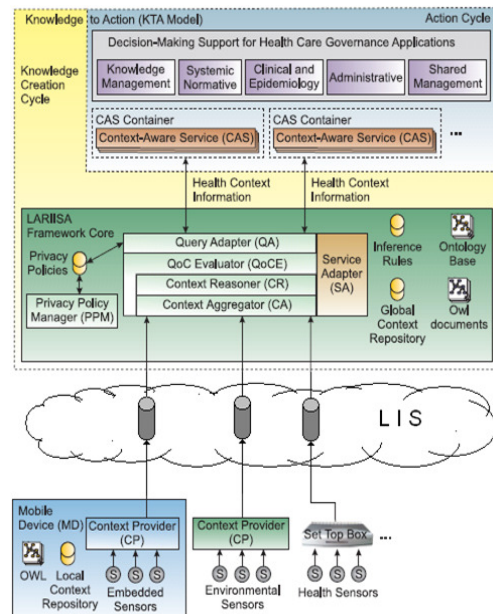

FIGURE 1. LARIISA AND LISA

a. Evaluating the system integration technologies

Upon adoption of the file transfer-based integration model, context providers are supposed to write to a file to be read by the LARIISA Context-Aware Service (CAS). Considering that context providers are geographically dispersed and probably running atop heterogenous platforms, this strategy seems very cumbersome, forcing LARIISA to read a number of different formats – and this number may augment indefinitely.

Shared databaseswould hardly be a judicious choice, since context providers are not known a priori. Including new contextmetadata (and context presents a very accommodating nature) would require adjustments in the database. In addition to being error-prone, this strategy is far from scalable.

Remote Procedure Callwould not be a good choice either for, due to its synchronous and blocking characteristic, it would strongly impacton LARIISA's overall performance. One could argue that it is no longer accurate to say that RPC applications are necessarily bound to synchronous interactions, considering that it is now possible to simulate degrees of asynchronicity (e.g., DCE threads). However, such choice would make application development more difficult since complex programming must be done to handle multiple simultaneous calls.

Due to all the above"misdemeanors" of the alternative solutions, Messaging has been appointed the integration model that best suits LARIISA's requirements.Being loosely coupled (minimizes dependency among applications), minimally invasive, mostly asynchronous (again, one could point out that messaging can be synchronous as well – but we just don't look for this feature in it) and reliable, Messaging brings together all characteristics needed by LARIISA in one single solution.

b. Integrating context providers with LARIISA

Context providers are responsible for collecting raw health related context data from different sources like mobile devices used by health agents, from set top boxes, from environmental sensors (temperature, humidity, pluviometry, etc.), from medical devices (ECG, EEG, pulse, etc.) and so on. Collected data will be sent to the Context Aggregator (CA) module from LARIISA.

LARIISA is designed to be compliant with international e-Health standards, like the ones listed in the Interoperability Decree, issued by the Ministry of Health in Brazil in 2011 [9]. Thus, it will adhere to standards like DICOM [10] (the Digital Imaging and Communications in Medicine standard for distributing and viewing any kind of medical image regardless of the origin - radiology, dermatology, pathology, endoscopy etc.), HL7 [11](regulates the interoperability among systems), etc. As for the integration platform solution, we decided for the Open eHealth Integration Platform (IPF), which provides comprehensive support for message processing and connecting information systems in the healthcare sector [12].

Context providers connect to the integration bus through specific webservices so that applications running on smartphones, set top boxes, medical equipments, etc. need adapters to collectdata coded in different protocols, encapsulate the data in HL7 messages and forward them to the final system through appropriate channels (point-to-point or publish-subscribe). Figure 2 depicts LISA's architecture for two contextproviders, namely, settop boxes and mobile devices:
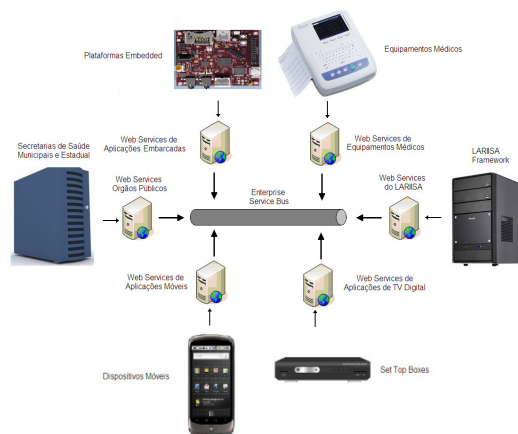

FIGURE 2. LISA´S ARCHITECTURE

V.IMPLEMENTEDPROTOTYPE

For the validation of LARIISA´sarchitecture it is necessary to a pilot project in a small town situated outside of the metropolitan region of Fortaleza/CE. The town of Tauá/CE was elected for the development of the Pilot Project.

This work presents the following contributions to the pilot project in Tauá

Introduction of the Component LARIISA PROCESS INTEGRATOR SYSTEM ARCHITECTURE (LISA), with the objective to make the integration of context provider to LARIISA so as to make the data in real time for decision-making,throughcontext provider available (settop box, mobile devices and biometricand environmental sensors). LISA should transmit information between LARIISA and context providers running different

operational platform, programming languages, data format, etc.

LISA-MCP is a built-in application in mobile device, operated by a health agent that realize the data collection of the families and the offers through the internet,for the database system, making efficient analysis of the data by LARIISA and providing information on global context and location for the intervention of administrators for any detected problem.In Tauá the data on the data bank legacy, called SIAB (The Primary Healthcare Information System) [13]should be passed on to the data bank of LARIISA and updated in continuous flow by LISA-MCP's.

The prototype was implemented in open platforms, and the hardware platform chosen was the "Nexus One"Google´s smarthphone - [14], with Operating System Android [15].

The context´s data, related to the family are collected by the Health Agent through smartphone with the LISA-MCP. The use of smartphone allows data collection of the family and combines information from geographic context (position of the GPS) and social (photographs) that is not present in the "Ficha A" and should be used in LARIISA.

LISA-MCP presents several screens that must be completed by the Health Agent. On the firstscreen of LISA-MCP, the Health Agent inserts address of the family, collects the GPS position of the residence and accesses the register screen of the family.

From the record of the family screen, the Health Agent performs the register of familymembers, inserting general information, pre-existing diseases and the individual photo. From "New Register" button it is possible to enter the information from all the members of a family. The "Move" button refers to the additional information about housing and sanitation, and other information of interest about the family. The *housing and sanitation*screen allows the collection of information on the hydro-sanitary conditionsof the family to provide context information enabling different analysis by the system managers. The "*Other Information*" screen gathering information on **where** and **how** the family has access to medical services and additional information of social and economic interest.

Once the data has been collected by the Health Agent, it is passed on to the webservice that will convert it to LARIISA´s standards, protocols and integration tools.

The adopted integration platform for the LARIISA is theOpen eHealth. Although not mandatory, it is strongly recommended the adoption ofDICOM protocolfor the transfer of

images and clinical data, HL7 protocol as a standard format for the exchange of messages, in addition to both Brazilian and ISO standards concerning the development of information systems for healthcare.

VI.LISA´s PoC Scenario

Figure 3 shows the scenario for LISA´s proof of concept in Tauá:
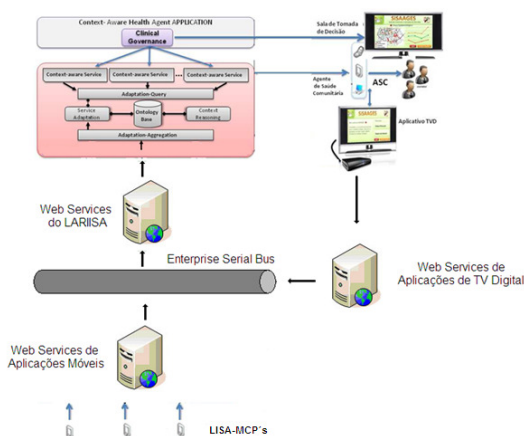

FIGURE3. SET FOR THE IMPLEMENTATION OF LARIISA PLUS FROM LISA

Context of Global Health describes the information at a high level, from local health context which is used for making decisions about health governance. The information in the context of the family is collected by the health agent, through the registration of the "Ficha A" in LISA-MCP.The data is sent by LISA to LARIISA, which evaluates a few parameters, like thenumber of occurrences of dengue fever, the geographical location and the period of study of dengue cases. Considering the information, LARIISA could, for example, advise concerned health managers to create emergency room in the region for the treatment of dengue.Figure 4 shows the decision-making processspecifiedin both ECA (Event-Condition-Action) [16] and SWRL[17] rules.

Dengue fever outbreak decision-making process specified with the *ECA model*:

IF ((numberOfDengueRecurrenceCases(region Y, period Z) > X) THEN {Alert: to create an ER in the region Y}

The equivalent *SWRL Ru*le:

Global_Health_Context(?ghc)   ^   Location(?Y)   ^ time:Interval(?Z)
^ hasContextElement(?ghc, ?Y)
^ hasContextElement(?ghc,?Z)
^   NumberOfRecurrenceCases(?W)   ^ hasContextElement(?ghc,?W)
^ swrlb:greaterThan(?W,X)
_ MakingDecision(?ghc,"Alert: to create an ER in the region Y")

FIGURE4. CREATION OF EMERGENCY ROOM FOR DENGUE CONTROL

VII. CONCLUSION

We presented here, in this paper, the specification and implementation of an integration architecture that allows the interconnection of heterogeneous equipments for the collection of data, taking into account aspects of reliability, versatility, scalability and uniformity of access, so that the inclusion, removal and upgrade of devices and data be possible with minimum intervention.

The suggested integration environment attends the requirements needed for the interconnection of the context providers to the database of LARIISA and their subsequent use in the context of a system of decision-making in public health.

The implemented prototype improves the "Ficha A" by adding information about geographic (e.g. GPS coordinates of dwellings) and social (e.g. photos of people and of relevant health conditions, etc) that can be of use to healthcare decision-makers.

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