SISA – A Context-aware Application for Epidemiological Dengue Crisis

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Abstract. This work presents a context-aware application for health management (SISA, in Portuguese). It integrates the LARIISA project, an intelligent platform to support decision making in public health governance. The SISA uses context-aware computingas main concept and the Ginga, the middleware for the brazilian digital TV system, for obtaining information about the family health. The SISA is able to perceive the status of emergency epidemiological and adapt itself in real time to a risk situation. This way, the system is able,for example, direct the health care agent to verify and troubleshoot an epidemiological problem or detect new outbreaks of dengue. The epidemiological map visualized by the health managers can contribute to decision-making in a fast and efficient manner.

Keywords: Context-aware application, decision making system, management framework**.**

1. INTRODUCTION

The combat against dengue has particular importance for public health because the disease can affect a large number of people in a short period of time, whereas its transmission vector, Aedesaegypti, complete their development cycle or 0 in 7 days, depending on the climatic conditions. Dengue is often expressed in the form of epidemics, which may lead to a large number of deaths. According to the Ministry of Health, dengue is now undoubtedly the object of greatest public health campaign in Brazil.From 1980 to 2005, the World Health Organization (WHO) reported approximately four million cases of dengue only in Brazil. In 2011, only the State of Ceará - Brazil were confirmed 58 deaths from dengue [1], when a record number since records began 20 years ago. A study by Brandeis University, USA, showed that dengue cost about two billion dollars a year for the Americas [2], divided between spending on treatment (hospital costs) and combating mosquitoes.Costs for the treatment of dengue can be minimized with a system of efficient decision making in real time. In this sense, the current studies and international experiences have shown that in an effective care network, 65% to 75% of dengue cases can be solved even in primary care [3].

The Information Technology and Communication (ICT), 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 agents 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 [5].

This scenario fits into the context-aware applications [6] 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. A context-aware system is able to adapt dynamically, providing a personalized service to the user.

This paper specifies SISA, a pilot project in the state of Ceará, whose purpose is to enable the intelligence governance in decision making in healthcare environments, subsidized by the information captured in the context of families. Thus, we used the model of Brazilian Digital TV and Digital Belt Ceará State, serving as proof of concept to the field of epidemiological project LARIISA - Laboratory of Intelligent Networks and Integrated Health [5] .

In this sense, the SISA can contribute directly to the National Program Dengue Control - PNCD [7] as well as being a complement to integrate with domain epidemiological project LARIISA, giving managers more agile and personalized responses, compared to the current epidemiological situation.

2. SISA, A PROOF OF CONCEPT OF THE LARIISA PROJECT

The LARIISA [8] aims to research and development of a platform able to provide intelligence governance in decision making in health information collected from / sent priority of residencies throughout the state of Ceará, 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, supports decision making and analysis and creation of ontologies in the field of epidemiology based on real-time information and increased quality of information captured by various sources, including their own citizens through applications TVDi, considering this is the only communications equipment present in over 98% of Brazilian homes [9], and development in this area is that the SISA works.

SISA 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 agents 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:

- **TV Module:** Provider Context used to capture information from families. That is an interactive application, linked to the campaigns against dengue. This application enables the filling of information (epidemiological data) which will be used by the Web module;
- **Mobile Module:** This module is expected to be the interface used by health agents in the system. It allows, through the use of mobile devices (mobile phone, PDA, tablet, etc.)., Consultation schedule of visits to be conducted in the homes; receive notifications of urgency, and act as a provider of context because it allows entering data observed in site visits;
- **Web Module**: This module consists into a web system that makes possible to the manager, health secretary or governor a brief overview of the actual situation of the epidemiological context. After logging into the system, the user can consult the epidemiological maps and all the statistical data that help on decision-making. For example, when SISA encounters a high number of dengue cases, it will recommend, if it´s necessary, the raising or the relocation of more Agent Community Health (ACH) to a determinate zone and/or or may start acquiring inputs needed to combat the disease and treatment.

The SISA DTV technology uses an interactive application that enables citizens to indicate symptoms of family members; 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.

The resulting decisions are forwarded to the performance levels, being the first one the Agent Community Health - ACH, since it maintains direct contact with the community. At the governance level of health, the SISA adds a mark on an epidemiological map at the region suspected of dengue. In case of a negative result (i.e, after a visit from a health agent), the system removes the mark of the epidemiological map, and in a positive case, after being confirmed by the ACH, the system prints a 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 (i.e ,sending health agents to the site), for the acquisition of drugs, among other management operations (i.e, creation of an emergency unit to combat the epidemic).

3. SISA ARCHITECTURE

The architecture of the SISA (Figure 1) is based on a client-server model divided into three layers (Vision, Model and Data).

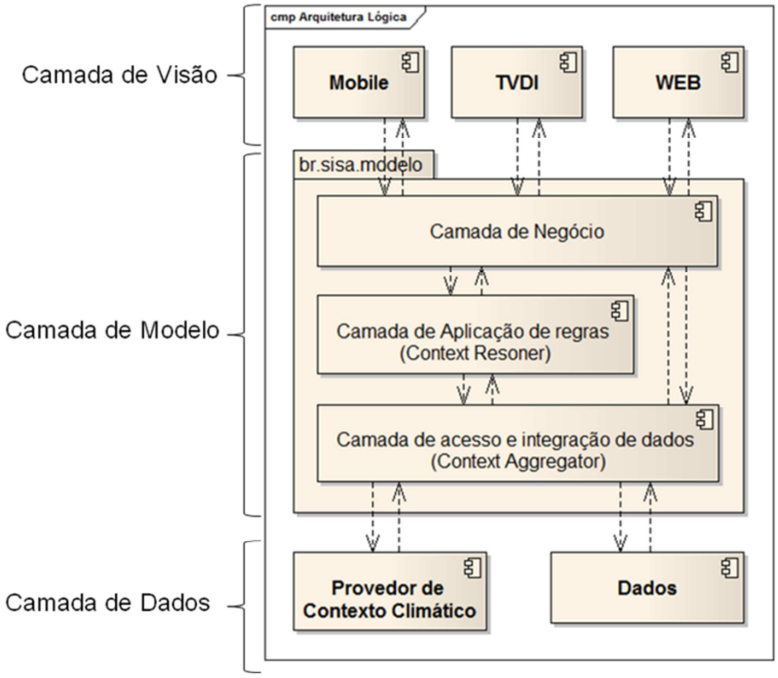

Figure 1. Logical Architecture SISA

The TV 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[1].

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

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, it 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

```
Rule
  "Deslocar Agente mais próximo a localidade do usuário com potencial foco de dengue"

when
  $u:UsuarioFinal(
  contextoLocal.elementoDoContexto.elementoEspacial.clima.SkyConditions == ' raining')
  UsuarioFinal( contextoGlobalDeSaude.elementoDoContexto.elementoEspacial.elementoEs
  pacialTemporal.indiceInfestacaoPredial >= 1)
  UsuarioFinal( contextoGlobalDeSaude.elementoDoContexto.elementoEspacial.elementoEs
  pacialTemporal.indiceInfestacaoPredial <= 3.9)$m:Mensagem()

  $s:ServicoEnvioDeMensagem()
  $agenteSaudeMaisProximo: AgenteSaude()

then

  $agenteSaudeMaisProximo
  $m.setConteudo(
  "Visitar Endereco ("+ contextoLocal.elementoDoContexto.elementoEspacial.endereco+"),
  local com chuva e IIP alta!" );
  $s.enviarSms($m, $agenteSaudeMaisProximo.getNumeroCelular())

end

rule

        "Deslocar Agente mais próximo a localidade do usuário com potencial foco de
        dengue"when

        $u:UsuarioFinal(
        contextoLocal.elementoDoContexto.elementoEspacial.clima.SkyConditions == '
        raining')UsuarioFinal( contextoGlobalDeSaude.elementoDoContexto.elementoEspacial
        .elementoEspacialTemporal.indiceInfestacaoPredial >= 1)

         UsuarioFinal( contextoGlobalDeSaude.elementoDoContexto.elementoEspacial.eleme
        ntoEspacialTemporal.indiceInfestacaoPredial <= 3.9)
        $m:Mensagem()
        $s:ServicoEnvioDeMensagem()
        $agenteSaudeMaisProximo: AgenteSaude()

then
        $agenteSaudeMaisProximo
        $m.setConteudo(
        "Visitar Endereco
        ("+ contextoLocal.elementoDoContexto.elementoEspacial.endereco+"), local com
        chuva e IIP alta!" );
        $s.enviarSms($m, $agenteSaudeMaisProximo.getNumeroCelular())

end
```

The **Module Mobile** provides context responsible for data collection informed by health agents. 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*[2](RMI), the web module. Below the figure 2, 3 and 4 illustrates the initial results of the respective modules.

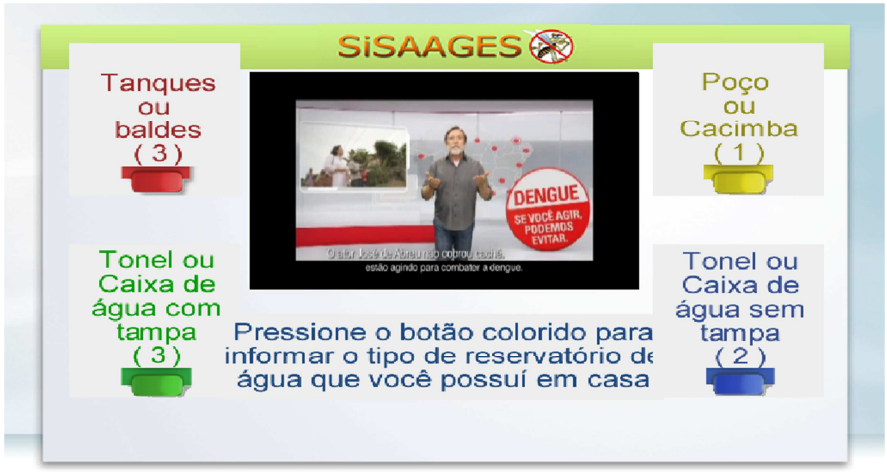

Figure 2. TV module capturing context of citizen

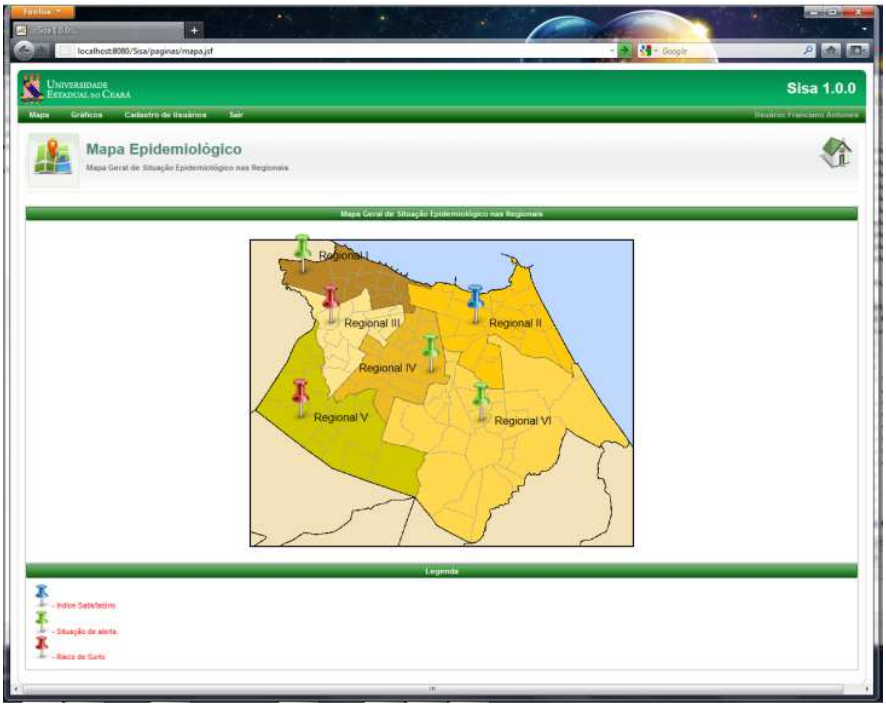

Figure3. Web module displaying epidemiological map of Fortaleza / CE for managers

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

SISA uses technology TVD, through an interactive application that enables citizens to indicate symptoms of the members of your family that can characterize cases of suspected dengue.

Considering the communication infrastructure of Digital Belt, the data captured by the interactive application is sent to the remote module of SISA, which will be aggregated, enriched and saved to a conventional database, and are exported following a semantic representation based on ontologies for the application of inference rules associated. The resulting decisions are then forwarded to the performance levels, and the Community Health Agent - ACH acts as the primary actor, since the health agent maintains direct contact with the community.

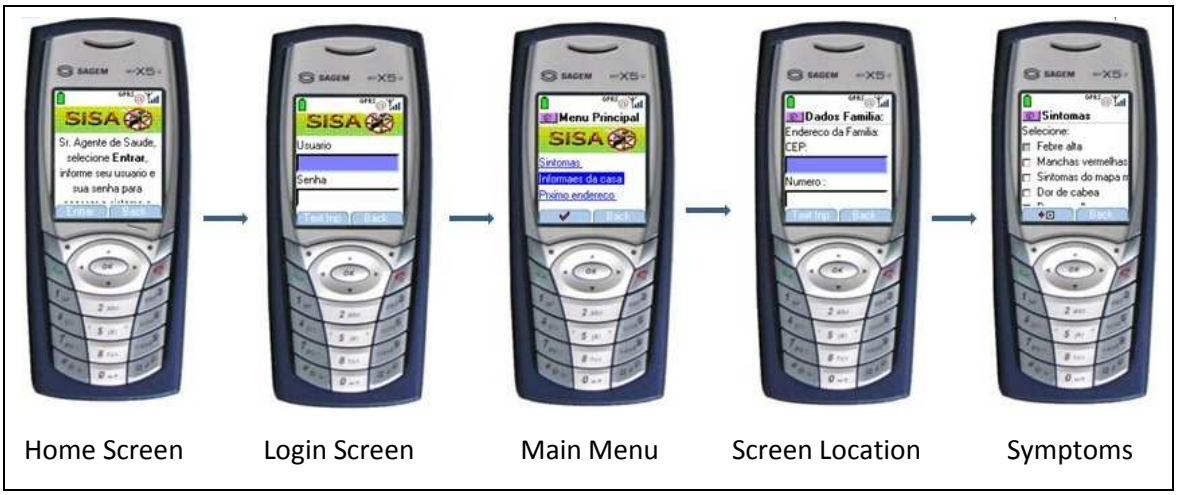

Figure 4. Interface do Module Mobile.

4. 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-aware technologies to the health care system (e.g. Healthcare Systems) [10] [11] [12], to our knowledge is still incipient existence of approaches to support decision-making context-aware to the governance of public health systems.

In [10], 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 [12], the autors 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 [11] the authors describe an architecture for context-aware 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-aware systems in health governance. Furthermore, this prototype was specified using the model as a basis KTA [15] (see [14] 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 [13] and middleware Ginga, with the communication infrastructure of the Digital Belt base [16].

CONCLUSION

The SISA uses simple devices (cellphone, smathphone, etc.) for interfacing between the agent and the LARIISA framework. The use of technology DTV exploring the most of its features can enrich the system with context-aware computing. The development of context-aware applications are typically challenging and apply them to DTV technology becomes an even greater innovation.

At the governance level of health, the SISA adds a epidemiological map of the region observed with suspected dengue identified. In case of a negative finding (e.g. after a visit from a health worker), the system draws the map marker and epidemiological in a positive case, this is confirmed by ACH, the system dials the case of confirmation dengue and its corresponding risk rating. 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 purchase of medicines, among other operations management (e.g. creation of an emergency unit to combat the epidemic).

The SISA demonstrated its viability and relevance in combating dengue, and may contribute in national policies such as the National Plan to Combat Dengue (PNCD) [7]. 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.

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