An architecture and an ontology-based context model for GIS health monitoring and alerting: Case of tuberculosis in Morocco

Mohammed ZOUITEN,
Computer science department, Faculty of sciences Dhar El Mehraz, University Sidi Mohammed Ben Abdelah Fez Morocco

Mostafa HARTI,
Computer science department, Faculty of sciences Dhar El Mehraz, University Sidi Mohammed Ben Abdelah Fez Morocco

Chakib NEJJARI,
Epidemiology department, Faculty of Medicine, Fez Morocco

Abstract
Disease data sharing is important for the collaborative preparation, response, and recovery stages of disease control. Disease phenomena are strongly associated with spatial and temporal factors. Web-based Geographical Information Systems (GIS) provide a real-time and dynamic way to represent disease information on maps. However, data heterogeneities and integration and interoperability and cartographical representation are still major challenges in the health geographic fields especially for contagious diseases. These challenges cause barriers in extensively sharing health data and restrain the effectiveness in understanding and responding to disease outbreaks. To overcome this challenge in disease data mapping and sharing, new care models have been defined in order to succeed the dynamic of contagious diseases. These models pose several technology-oriented challenges for GIS-based continuous care, requiring assistance services based on collaboration among different stakeholders: health operators, patient relatives, as well as social community members. This work describe an ontology-based context model and a related context management middleware providing a reusable and extensible application framework to accompany patients as soon as possible and awareness population about contagious diseases after localizing the first case.

Key words:
Ontology, GIS, Health Monitoring

1 - Introduction

In this project, we develop service oriented architecture for on line disease mapping that is distributed, loosely coupled, and interoperable. An implementation of this architecture has been applied to infectious disease studies. We have shown that the development of standard health services and spatial data infrastructure can enhance the efficiency and effectiveness of public health surveillance.

1-1 Back ground

In the last decades, developed countries have experienced an increase average life-length and, consequently, the impact of some diseases on population. Obviously, efficiency and effectiveness of health services cannot be guaranteed by technology efforts by themselves. New models of care have been proposed, which define guidelines for awareness.

1-2 Relationship humans-environments

Currently, such factors as booming population and environmental pollution and rapid urbanization and permanent contact in many countries and global warning all influence the conditions for disease outbreaks. Disease studies have revealed strong spatial aspects of disease diffusion. Thus, mapping spatial aspects of diseases could help people to understand some puzzles of disease outbreak. Unlike the raw disease data and disease maps offer a visual means of identifying cause and effect relationship existing between humans and their environment. Disease maps can enable health practitioners and the general public to visually communicate about disease distribution.

1-3 GIS application in health domain

Geographical Information Systems (GIS) has strong capabilities in mapping and analyzing not only spatial data, but also non-spatial data, and can integrate many kinds of data to greatly enhance disease surveillance. It can render disease data along with other kinds of data like environmental data, representing distribution contagious disease with various cartographical styles.
Meanwhile, the rapid development of the internet influences the popularity of web-based GIS, which itself shows great potential for sharing of disease information trough distributed networks.

1-4 GIS and decision making

Distributing and sharing disease maps via the web could help decision makers across health jurisdictions and authorities collaborate in preventing, controlling and responding to a specific disease outbreak and it's time factor analyzing. By comparing the thematic maps at

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different time intervals, the spatial-temporal change of disease could be projected, including temporal cluster shit and vector transmission rates and mobility of susceptible populations.

2- Related work

There are a number of research projects related to telemedicine. Here we will focus on works proposing context-aware systems to support assistance of patients outside hospital. Most attempts have focused and such as health status monitoring and alert (e.g. medicine taking, training activities, etc.), patient behavior and daily activities modeling. Our reference scenarios include telemonitoring and immediate accounting of cases for predicting risk.

In the world, tuberculosis is a contagious and infectious disease common in the world and which is real public health problem. The traditional location is pulmonary (80 % to 90% of cases) and infected saliva droplets are the usual source of contamination when the patient coughs or sneezes. It mainly affects people aged over 65 years and young people aged between 20 and 40 years [1]

In Morocco, tuberculosis in 2010 has affected nearly 28 000 people, an incidence of about 82 new cases per 100 000 inhabitants. Almost half were cases of smear-positive pulmonary tuberculosis (PTB+). Beyond the particular health and social context mentioned above, control of diseases like tuberculosis. In Morocco it is facing several problems: severe under-reporting of cases, although it is a notifiable disease, with where the underestimation of the seriousness of problem; the large number of lost sight treated in hospital or in service of TB. One main objective of this work is to identify vulnerable populations and areas at risk of tuberculosis in morocco in order to optimize the surveillance and prevention in relation to populations and medical human resources and TB patients. The aim is to understand the geographic distribution and dynamic of this pandemic of cases and characterize risk factors and human environmental impact that may explain this distribution to identify sensitive areas. [1]

3- Method

Today around the world and particularly in Morocco geographic location is always static long as the location is relative in the best cases: as shown in the farm standard used in the retrospective study of patients with tuberculosis collected within the concerned services. University Hospital Hassan II of fez, during a period of 3 years (January 2007 – December 2009) where data collection was done from medical records. [1]

3-1 Risk calculation

The concept of risk was first used in environmental management of natural hazards (floods, earthquakes, etc) before being applied health (risk of catching disease). Traditionally the concept of risk R is the combination of the probability P that the disease occurs at a given location and the vulnerability V is the expression of a certain context, condition conductive. Let Nc: number of cases per region, Np: number of people attended. The vulnerability is given by the classical relationship V=Nc X Np

The calculation of risk in an area frequented will be: R = PXV

3-2 Ontology based disease modeling

In this section, we will describe the main concepts of the ontology-based disease modeling approach for patient assistance and awareness scenario. In fez, no geographical parameter is taken into account according to a standard sheet UHC Hassan II of fez which explains the continued growth and lack of control over this pandemic on area not declared in advance to continuity of paths of travel and the sampling points. As a solution, we offered through our GIS integration parameters address (es) and frequented places in the farm. This is the only way to start a novelty in the field of GIS for health. This method involves creating layers containing places frequented roads with means of transport for a patient and the hospitals visited to the overlay in order to calculate the risk according to formula mentioned above : R= P . V to optimize control programs nationally. The results will help decision makers to respond properly and timely questions: Where? How? When?

As already mentioned, we extend an ontology-based context model representing main general concepts and relations for context representation. Our work moves from the widely accepted definition of context, provided in [3]:"Context is any information that can be used to characterize the situation of an entity." Therefore, an entity is a patient, place, computational entity, or object which is considered relevant for determining the behavior of an application.

The context of an entity is composed of one or more context items. A context item describes a specific characteristic of the entity context considering relation between elements of this entity (contagious disease). Items are classified into five general categories: location, physical data, activity, instrumental context, social context [2]

In this application scenario, context includes data items describing patient geographical localization and disease context. Context reasoning is used mainly for awareness and management and fight.

Hereafter we describe the following ontologies: Patient personal domain ontology, home ontology and the awareness ontology. This tatter ontology represent care networks resources coming from different organizations (health teams, social community members, etc.).

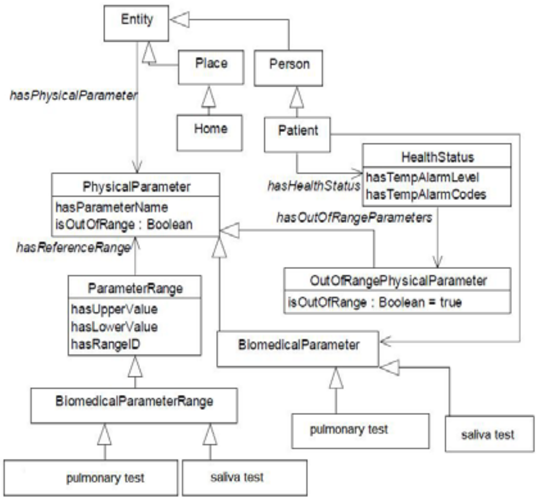

Figure 1 patient personal domain ontology

In the patient personal domain, relevant context items include patient metadata: biomedical parameter values and location and activities.[3]
These data can be used by the system to automatically infer the patient health status and detect possible awareness area.
The context model has been written in OWL (web Ontology Language)[4] . OWL fragments are hereafter represented by means of UML class diagrams. UML classes represent OWL classes, attributes represent OWL data-type properties and associations among classes are used for OWL Object Properties representation.
Figure 1 illustrates a fragment of the context ontology specialized for the patient personal domain. A specialization of biomedical parameter class is added for each specific biomedical parameter which is monitored (tests and positions) but model can be easily extended to include further levels and used for other diseases like cancer for example.

3-3 Disease mapping architecture

To overcome in particular the heterogeneous data integration and service interoperability challenges to disease mapping, we propose the disease architecture illustrated in figure 2. The architecture contains four tiers: a data storage tier and an ontology engine tier and a standard health services tier and maps and animation tier.[3]

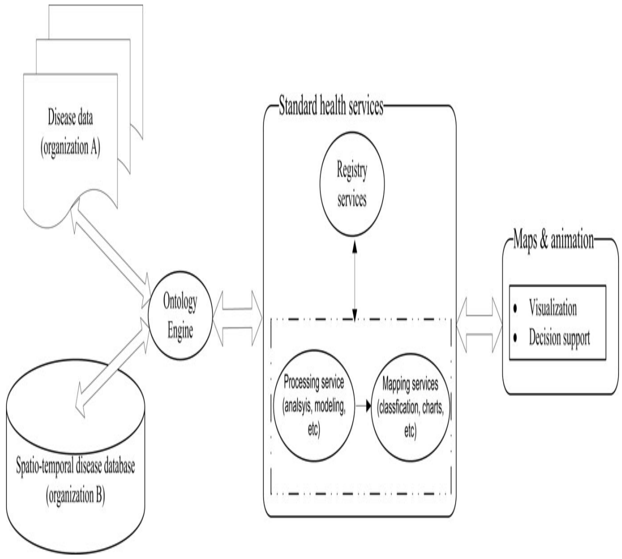

Figure 2 Disease mapping architecture

3-4 OGC services for disease mapping

The OGC web map services (WMS), Styled Layer Descriptor (SLD), and web map context (WMC) are implemented for the disease mapping and sharing in this study. WMS publishes its ability to produce maps rather than its ability to access specific data holding, and generates spatially referenced maps dynamically.
SLD allows user-defined symbolization in producing maps, which make it possible to integrate maps from different WMS in the same style. WMC uses eXtensible Markup Language (XML) based context documents including information about the servers providing layers in the overall map, the bounding box, and map projection shared by all the maps, and these provide sufficient operational metadata for clients to reproduce the maps [5].

4- Results

What makes SOA different? There have been several attempts to present SOA as either a new form of distributed systems architecture, as an extension of object orientation, or as the next-generation EAI. Let's take a closer look at these analogies.The W3C Architecture group defines SOA as a form of distributed systems architecture, typically characterized by the properties shown in the figure 3
This study deals with the visualization of infectious disease spatiotemporal outbreaks and propagation. The implemented framework implemented mapping and collaboration frame work, all WMS services could be registered in the health portal for user access. Through the health portal, users could obtain disease maps from the desired WMS that distributes over the internet, and share

the acquired WMS maps with others through WMC like illustrated in figure 4

Property	Description
Logical view	The service is an abstracted, logical view of actual programs, databases, business processes, and so on, defined in terms of what it does, typically carrying out a business-level operation. Service is defined as a business-meaningful action.
Message orientation	The service is formally defined in terms of the messages exchanged between provider and consumer, and not the properties of the provider and consumer themselves. The internal structure of implementation is deliberately abstracted away. Service interface is separated from the service implementation.
Description orientation	A service is described by machine-processable metadata/service definition.
Granularity	Services tend to use a small number of operations with relatively large and complex messages (payloads).
Network orientation	Services tend to be oriented toward use over a network, although this is not an absolute requirement.
Platform neutral	Messages are sent in a platform-neutral, standardized format delivered through the interfaces. XML is the most obvious format that meets this constraint.

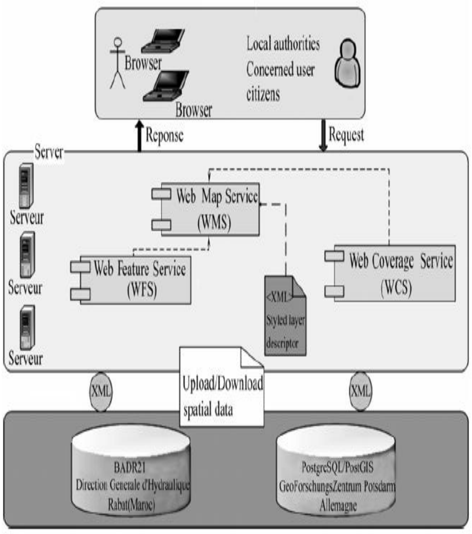

Figure 4 Architecture of system

By proposing an OGC compliant architecture to implement Web-based health services, we contend that the issues of reusability, integration and interoperability of services are well handled in this project. Moreover, the services could be enriched on the continuous development of OGC specifications. Other OGC standard services for example, Web Processing Service (WPS) for processing functions and Web Catalog Service (WCAS) are implemented in our health application.

Data heterogeneity problems always occur in the data collection process of different health organization. This case study accomplished a low-level integration by converting the data from both sides to a common schema. It solves schematic and syntactical heterogeneity issues, but does little to address semantic heterogeneity.

Building a standard ontology for spatiotemporal disease data would enable the concept-based sharing of disease data, solving the semantic heterogeneity problems (cognition and data meaning).

We currently integrating health model with the OGC geospatial data model in generating standard ontology to support better sharing and integration of disease data.

5- Conclusion

Recent disease outbreaks have demonstrated the need for GIS and mapping-related applications in public health. Like the world health organization, and American Centers for Diseases Control, and health Canada are all proactively engaged in mapping viral pandemics and applying GIS models to global and national health policy; in this research, we designed and implemented a service oriented on line disease mapping architecture which is loosely coupled and interoperable in morocco. We have proposed an architecture which supports reusability of health disease data mapping and analysis functions to lower the cost of building huge independent disease surveillance system. It also enables cross-border map visualization, analysis, and sharing disease information through interactive maps or animation in a collaborative manner with multiple partners via distributed network. If a real disease out breaks occurs, this distributed disease mapping architecture can support public education, and disease surveillance, and health care planning, and emergency coordination, and spatial epidemiology, and vaccine distribution, and policy administrative at different administrative levels. If the disease data can be updated frequently, health practitioners could obtain real-time disease maps processed in accordance with different statistical methods and under different spatiotemporal conditions in order to standard both the current situation and the movement of disease. More effective collaboration with the support of disease maps over the internet can secure a faster response to emergency situations. More extensive implementation of standards-based spatial data infrastructure (SDI) in each country could enable effective collaborative decision making and awareness planning. The development of SDI would further support this online disease mapping architecture for decision and policy making. To improve the effectiveness and efficiency of this architecture for disease applications, and further research will concentrate on development of geospatial disease ontology to facilitate data integration and construction of interoperable distributed disease services.

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Mohammed ZOUITEN is a student in the Department of Computer Science at Faculty of Sciences Dhar El Mehraz of Fez; University Sidi Mohammed Ben Abdelah. Supervised by Professor Mostafa HARTI: Professor at the Faculty of Sciences Dhar El Mehraz of Fez ; University Sidi Mohammed Ben Abdelah and Professor Chakib NEJJARI Professor Epidemiologist at the Faculty of Medecine of fez in the same university.His research interests are: GIS for health, modelization object oriented and Ontology Engineering.