Analysis of Interoperability in Public Health Systems*

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Abstract

Health information systems (HIS) are constantly evolving in both complexity and data volume. Nevertheless, not every HIS share the same data standard or are otherwise able to communicate with one another. The need for communication among these systems has resulted in a worldwide effort to develop interoperability standards for healthcare systems. Brazil also has adopted measures to foster interoperability in public health services, notably with the issue of the ordinance 2.073 of August 31, 2011 by the Ministry of Health, which regulates the adoption of international standards. This article presents an analysis of the different types of interoperability in public health systems, using GISSA, an intelligent system to support decision making in maternal and child health, to showcase them. A prototype was implemented that addresses the problem of interoperability from a structural viewpoint, by aggregating new services to the GISSA legacy version and also from a semantic viewpoint, by enabling the coexistence, in one system, of the two main electronic health record standards, i.e, FHIR and OpenEHR.

keywords: Interoperability, Health Information Systems and GISSA.

Contents

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1 Introduction

The vast diversity of data and information provided to the Public Administration brings major challenges to cooperation and to formalization of processes at a national level. The exaggerated dissemination of information, triggered by the availability of information technologies (networks, computers, the web and information systems), has been bringing increasing difficulties for the integration of information sources from both government and private instances.

In the health sector, medical entities generate a dense volume of information on a daily basis in diverse formats and from different sources of information. To make matters worse, it is common for entities to adopt different information systems (IS) to handle and store their data. One of the priorities highlighted by these institutions is directly linked to the integration of these ISs with their internal and external partners, ensuring the exchange of information. This integration of ISs is a fundamental feature of the concept of systems interoperability, object of this work. The complexity of medical activity requires interoperable health information systems (HIS), a worldwide trend.

Countries such as Canada, France, the United Kingdom, the United States, Australia, New Zealand, among others, are taking measures to enable interoperability in public services. The Brazilian government, sensitive to this trend, has been trying to set standards to mitigate integration problems between HIS. Interoperability has become a clear concern in Brazil since Ministry of Health's ordinance No. 2,073 of August 31, 2011. One of the chapters of this ordinance addresses the definition and adoption of the OpenEHR health information interoperability standard, including the definition of details and main attributes of the services, their components, activities, and policies required.

To the Institute of Electrical and Electronics Engineers (IEEE)1, interoperability is the ability of a system or product to work with other systems or products without any special effort on the part of a customer. According to IEEE, the application of interoperability is possible only through the rigorous use of established norms and standards. Therefore, interoperability is directly related to cooperation, defined by specific rules, standards and policies that enable the integrated exchange of information about different types of problems related to different contexts. Thus, there are several types of interoperability (technical, semantic, organizational, political and human, inter-community, legal and international).

This paper analyzes the types of interoperability in public health systems. In addition to the interoperability stratification, an architecture that solves interoperability problems in the aggregation of new services in legacy health systems is presented. As proof of concept for the architecture presented the framework GISSA (Intelligent Governance in Health System) was used, an intelligent decision-making system in maternal and child health. The types of interoperability addressed in GISSA permeate the semantic levels, Health Information Standards, and aggregation of new services.

This paper's organization is presented hereafter. Section two presents related works that use HIS and interoperability concepts. Section three describes the definition of interoperability in the literature. Section four details GISSA and its components. Section five addresses the main contribution of this article: health system interoperability. Finally, section six presents the conclusion of this paper.

2 RELATED WORKS

In [5], a research is described whose purpose is to deepen the identified issues that are related to the problem of semantic interoperability on the patient information record in the openEHR standard. The results express that the use of specific tools may be relevant in the search for semantic interoperability between systems and that the informality in the definition of the terms that will be used in information system vocabularies can prevent a clear understanding of the desired meaning.

The architecture proposed by [2] enabled the creation of a software called SmartBeat, whose purpose was the development and evaluation of an intelligent system for the management of heart failure in senior people. The results ensure interoperability between the SmartBeat system and the e-Prescription (software service for electronic prescription).

In [6], an architecture for developing a SOA-based EHR system is described, taking into account interoperability between legacy systems. The results indicate that in the literature there is a deficiency precisely in the definition of an interoperable architecture for specific systems, and a deployment architecture was defined.

Unlike related works presented here, this paper presents types of interoperability and an in-depth study to interoperate ontology services, health information representation standards, and system functionality. This paper seeks a joint solution for these three types of interoperability aiming to solve them in a single way.

3 Interoperability

In Computer Science, interoperability is the ability of a system to share, communicate, and exchange applications and information with other systems that have disparate structures and data [3] [10][11].

For [4], interoperability is defined as the quality capable of making one system or process use the information and / or functions of another system or process by adhering to common standards. In [8] 's view, interoperability is understood as a continuous process centered on ensuring that systems or processes exchange information.

Taking into account the extent of the term interoperability and its meaning, [8] strengthens the term by proposing an interoperability categorization to address different occurrences. [8] defines the types of interoperability as:

- **Technical interoperability**: it is the standardization of communication, transportation, storage and representation of information;
- **Semantic interoperability**: is about the meaning of the information generated by different systems and with different data;
- **Organizational interoperability**: it is the relationship with the organizational context, seeks understanding between processes and information that are intrinsic in corporate architecture;
- **Political and human interoperability**: is about the way information is disseminated or accessible within the organization;
- **Intercommunity Interoperability**: it is about how to approach access to information originated in different sources, by organizations, specialists and communities of different nature.

When it comes to the types of interoperability (concept, application and context), there are different types of issues related to typifications. In this aspect, [11] indicates that the problems linked to each type can present syntactic, semantic and structural differences as they are related to sources of information manipulated by the system.

Para atenuar os problemas oriundos dos tipos de interoperabilidades, [11] sugere que o grau de cooperação entre sistemas deve ser categorizado em pelo menos três níveis de acordo de cooperação estabelecida:

- **Technical Cooperation:** this type of cooperation seeks to promote technological interoperability to the context;
- **Content Cooperation:** this type of cooperation seeks to promote semantic interoperability to the context;
- **Organizational Cooperation:** this type of cooperation is related to organizational and intercommunity interoperability;

After referring to the levels of cooperation suggested by [10], [1] supplements by adding the policy issues that aim to establish discussion groups to standardize key guidelines and fundamental policies.

In this sense, in Brazil interoperability is as an important theme that has been generating concern in medical systems. This theme is discussed in Ministry of Health's ordinance No. 2,073 of 2011, which in one of its chapters brings a political approach to foster the initiative for standardization and use of interoperability in health information systems. A suggestion of this ordinance is the application of ontologies and terminologies to address HIS interoperability issues.

4 GISSA

The GISSA project is a framework that emerged from the LARIISA platform [9]. It is an intelligent governance system to support decision-making in health environments, focusing on the Ministry of Health's Cegonha Network project, whose goal is to preserve the health of both mother and child, especially in the early years [7], being implemented by [removed for double-blind review] and supported by Studies and Projects Funding (Financiamento de Estudos e Projetos - FINEP in brazilian Portuguese). The GISSA framework is made up of a series of components that make it possible to collect, integrate and view information relevant to decision-making procedures [12]. GISSSA includes all health actors (patient, health agent, nurse, doctor, hospital manager, health department, mayor, governor, etc.), generating panels and alerts related to maternal and child health issues from information contained in SUS databases in real time.

The GISSA proof of concept was held in the city of Tauá and has been currently expanded to other municipalities in the state Ceará. GISSA gets its data from the source systems. Robots take information from SUS transactional databases (eg SINASC, SIM, eSUS-AB) and pass it on to analytical databases, which in turn are used by the GISSA framework and its components. The GISSA Framework has the potential to add functionality and services through REST technology. GISSA uses the Atlantic web framework (AWF), a framework tailored to the needs of GISSA since it enables building declaratively - and therefore with high productivity - key functionalities for healthcare decision makers, namely: dashboards , indicators, reports and alerts. Figure 1 shows the formalization of GISSA architecture, its components, connections, and data flow.

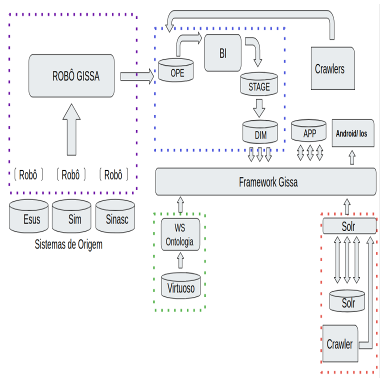

Figure 1: GISSA Architecture

5 GISSA INTEROPERABILITY

As stated in the Introduction, this paper analyzes the types of interoperability in public health systems, stratifying these types into independent models, highlighting semantic aspects, standardized Electronic Health Records (RES) and aggregating new services in legacy health systems. An architecture that solves interoperability problems in the aggregation of these new services in the GISSA framework is presented as proof of concept.

- **GISSA semantic interoperability**;
- **RES interoperability**;
- **Interoperability in aggregating new services**;

5.1 GISSA semantic interoperability

Figure 2 shows the ontological view of GISSA. It is a portal where ontologies and data are interconnected to face application development challenges, where there is a need to semantically integrate heterogeneous data sources. The main goal of the portal is to provide an ontological layer that connects data semantically and allows integrated access to data sources. Accessing this layer through the portal can occur through different types of search interfaces, so that the portal can meet different access demands and types of users. The platform also provides the pay-as-you-go semantic integration service, which ensures sufficient flexibility and extensibility for new data sources to be added to the portal. As it stands, the portal publishes two SUS databases available on the GISSA platform.

5.2 RES interoperability

What is sought in GISSA is interoperability between systems with different standards, ie semantic interoperability that corresponds to the ability of different systems to consume data with different standards, such as FHIR and OpenEHR. To this end, a gateway using micro-services technology is being implemented. Therefore, the implementation of a Hub capable of integrating the multiple existing systems in the public and private health sectors allows, despite the different data formats, medical professionals and health centers to consume information

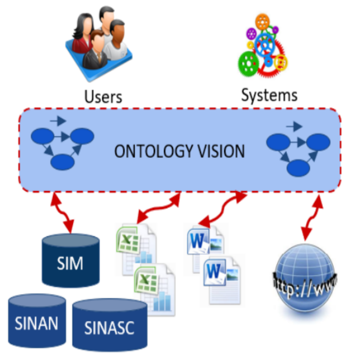

Figure 2: Ontology Vision

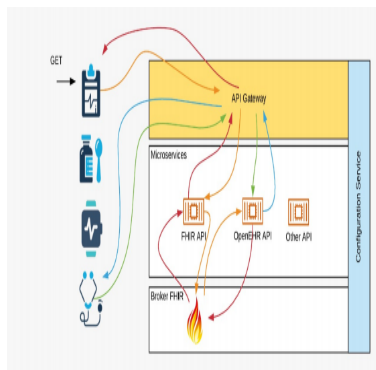

Figure 3: microservices

in a smooth and transparent manner. Structurally, this architecture comprises the Richardson Maturity Model, reaching the four implementation levels of an API RESTful, HATEOAS (Hypermedia as the Engine of Application State). Figure 3 shows the RES interoperability picture.

5.3 Interoperability in aggregating new services

To build our analysis on the interoperability found in GISSA, four steps were proposed:

- **5.3.1 Selecting GISSA application data**: the information used in GISSA is selected from the DATA-SUS systems (eSUS-AB, SIM and SINASC, etc., which are the source systems). This information is obtained through authorization from the heads of each municipality. GISSA is a data protected product that keeps your information confidential. To populate GISSA information it is necessary to perform a periodic load through robots installed on the machines of the municipalities that have the databases.
- **5.3.2 Extracting data**: the information obtained through the robots is stored in the Operacional database (a database with raw and untreated information). The Operational database passes the information to BI, which in its turn creates the information execution

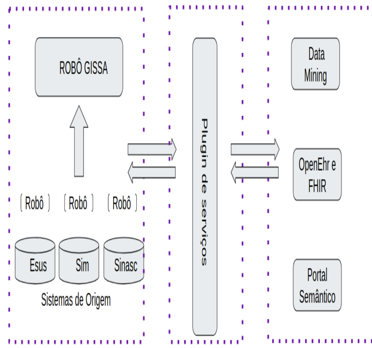

Figure 4: Interoperable Architecture

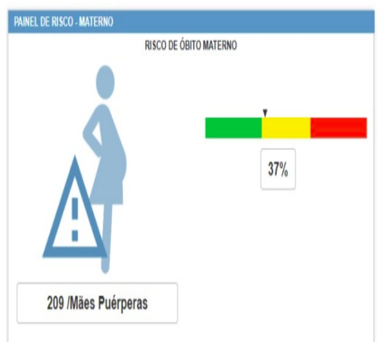

Figure 5: Maternal death dashboard generated by interoperable architecture

routines that will be refined into the Staging and Dimensional databases. The latter will handle the information, leaving it in the proper format for display on system screens.

- **5.3.3 Interoperating data**: Interoperability in GISSA happens through an abstraction layer that integrates types of data and services, enabling communication between the systems involved. This abstraction layer is responsible for making requests in the database and feeding the applications that use this information. Figure 4 shows the interoperable architecture.

  The interoperable mechanism is validated by integrating, using data mining algorithms, dashboard (figure 5).

- **5.3.4 Identifying interoperability**: the identification of interoperability is based on the application of the previous steps, using the concepts presented in the Interoperability section (section 3). In Gissa, interoprability was identified at the service aggregation level, health information representation standard (FHIR and OpenHER) and ontology.

6 CONCLUSION

Adding new services in legacy environments is not always an easy task, especially if the implemented system is not well documented. Although the GISSA framework was used as proof of concept of the proposed interoperability in the aggregation of new services, the methodology adopted in this paper can be used in other similar environments. In addition, the proposed architecture allows dealing with different levels of information, offering a layer of abstraction in which new data can be integrated.

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