Model for the interoperability between health service providers (IPS), based on the electronic clinical information standard (HL7) and architecture to design and develop distributed systems (SOA)

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Abstract. This study addresses the need to exchange clinical records, efficiently and uniform among health institutions (IPS Spanish acronym for Instituciones Prestadoras de Salud), which is generated in clinical care users from using the Hospital Information Systems (HIS). From defining a model for interoperability, with reference to the regulations governing the General System of Social Security in Health in Colombia (SGSSS Spanish acronym for Sistema General de Seguridad Social en Salud), the standards to facilitate electronic exchange of clinical information Health Level Seven (HL7) and service oriented architecture (SOA). The model it was designed in two dimensions, on the one hand horizontally would facilitate electronic exchange of clinical information between IPS and on the other side vertically was projected was obtained as they settled components for the exchange of healthcare and administrative records the SGSSS different actors, in this case with the health Promotion Companies (EPS Spanish acronym for Empresas Promotoras de Salud) and the Territorial Entities through health secretaries.

1. Introduction
During the provision of health services to users, a large amount of data is generated in a fragmented manner, due to the fact that the SGSSS actors in Colombia (hospitals, clinics, clinics, pharmacies, laboratories, IPS, EPS, among others) operate usually in an isolated manner using HIS, which partially facilitate the generation of documents necessary for the exchange of information between institutions, in order to guarantee accessibility, opportunity, continuity and quality in the care of services, such as treatments and medical authorizations to other complexity levels [1] and other regulatory standards.

In various investigations and regulations of the national government [2][2][3][4] and international level [5][6][7], Alternatives have been postulated for the exchange of clinical information and architectures that promise to integrate different information systems, in order to provide a solution to the need to interoperate care and administrative records between the institutions providing the health services. Investigative projects of reference, guide this study, to reach a level of interoperability among the HIS of the different IPS in Colombia, which allows the use of information between them, through the design of an architectural model in which involve, the regulations the SGSSS, the HL7 [8][9] development framework and the SOA architecture.
2. Interoperability and health services

The term interoperability can be defined as the ability of systems to exchange and share information between two or more heterogeneous systems and then be processed independently. The interoperability requirements are defined taking into account the scope and subjectively consider the skills, knowledge, socio-political and cultural restrictions present. All this, with the iterations necessary to achieve business objectives [10]. The HIS, health information systems, or hospital information systems, contain the demographic and general information of the patient, the medical agenda and the clinical history, it also stores and organizes all the specific information of the diagnoses and treatments carried out in a health institution and allows access to the treatment information to the staff doctor to obtain a broad knowledge of the patient's condition.

SOA is an architecture that establishes a frame of reference for the integration of systems, which manage to communicate and share functionalities, generally through the network with the implementation of web services, managing to establish functional services in the form of modules for the integration of monolithic systems. In order for the HIS interoperability to be implemented, the main HL7 standards are Messaging HL7, Clinical Document Architecture (CDA), Structured Product Labeling (SPL), HL7 Medical Records, GELLO, Arden Syntax and Clinical Context Object Workgroup (CCOW). Prepared by the HL7 organization, created in 1987 and accredited by the American National Standards Institute – ANSI.

3. Methodology HIS-DF

HIS-DF, integrates the Unified development processes of Rational (RUP), architectural styles such as the Reference Model for Open and Distributed Processing (RM-ODP), Architecture Directed by Models (MDA), Service Oriented Architecture (SOA), and HL7 frameworks. Dividing in 5 phases the process for the development of an architectonic model of interoperability from the implementation of RUP, the HL7 standards and the SOA architecture, described below: I), identification of the system; II), Identification of domains; III), complexity management; IV), Establishment of the reference architecture, V) Establishment of the development process.

Figure 1. Reference views of RM-ODP

Figure 2. Establishing the development process (RUP).
From the use of the methodology, the components of the RM-ODP that refer to business, information and computational views. Subsequently, the development processes that integrate RUP are established, to establish the stages of the design of the interoperability model. In this context, based on the establishment of the development process as mentioned in phase 5 of the RM-ODP model, the architecture of the Hospital Information Interoperability Model is designed. Defining a correlation between them, for the reference of packages, the evolution between them and the integration with UML to facilitate the development and specifications of the system. Is presented below High-level diagram of the business view, the main objective of the business view is to identify the requirements established for the design of the interoperability model, supported by the specification of Requirements according to the IEEE 830 standard and the actions that must be implemented in it, which allow achieving the scope of the functionalities indicated in the general description and based on the identified needs in the characterization stage. The main purpose of the information view, is to understand and describe the type, structure and content of data to be handled, in relation to the types of information used in the business view, taking into account the semantics and use of information for each request.

![High-level diagram of the business view](image)

**Figure 3.** High-level diagram of the business view

Then, in the computational view and in its structures of logical components, we seek to define the logical components, through the representation of a use case diagram, where the design elements and the relationship between them are identified, to generate the architecture of the interoperability model from of the use of SOA. The services are interconnected through a BUS solution (ESB), through which access is allowed from the HIS for interoperability between the IPS, grouped according to the message formats defined in HL7.
Figure 4. High-level information view diagram

Figure 5. Structures of logical components of the computational view.
4. Results and discussion

From the development of the components, for the architectural representation of the interoperability model, business, information and computational views were obtained, by means of which the requirements of the model, the data structure, and the definition of the components are related. Logical respectively. Based on the above, through the implementation of the proposed model, a series of steps are carried out in various interoperability scenarios, to validate compliance with the requirements, which allows to determine the suitability of the design in the horizontal and vertical dimensions. In addition, the steps for the validation procedure of the interoperability model among the IPSs, corresponding to the implementation of the proposed architectural design in an HIS, are presented, describing the requirements, structure of data and implicit logical components, and the analysis of prototype tests implemented in one of the various tested interoperability scenarios.

For the implementation of the horizontal interface implementation, it was developed under the design for the scope of information exchange of the HIS modules among the IPS. Taking as reference the functional requirements, for the records of service requests, which would allow to verify the sender and the requested information, access control, for security through an encrypted code for each IPS. Where they were involved, the actions for requests for exams and diagnostic images, transfer of electronic medical records, user records and administrative records. In the figure 6, the horizontal interface for the exchange of information between the IPS is presented, the interoperability through this interface implies the classifications single service delivery code (CUPS), International Classification of Diseases version 10 (ICD-10), unique code of medicines (CUM), and the message structure CDA of HL7 that can be used by the IPS. From the use of the horizontal interface, from the IPS, it is possible to make requests for the processes and activities that guarantee the quality, accessibility, opportunity, continuity and integrality of the health services to the users. For this process, it is necessary to implement connections between the HIS, through Internet services that allow the transition of data.

![Image of the horizontal interface implementation](image_url)

**Figure 6.** Implementation of the horizontal interface.

The execution of stored procedures corresponds to the set of instructions developed to consult the database of the HIS, in order to have the data structures defined in the information view of the interoperability model, corresponding to the exchange of information with other IPS, transfers of administrative level records, and issuance of reports to the EPS. Figure 7 shows a stored procedure of the database management system for the structure of the mandatory compliance report based on the provisions of resolution 4505 of the Ministry of Health and Social Protection since 2012, and in figure 8, the development of the basic structure of a CDA clinical document of HL7 is presented, where
methods for the construction of the CDA message were implemented from the Information Reference Model (RIM) of HL7, with the attributes of stored procedures, obtaining as a result the main characteristics of electronic documents structured in HL7, such as the use of a header, attributes of the header and the body of the document.

After developing the Basic structure of the HL7 CDA, the Participations in the structure of the header are developed, related acts in the structure of the header, structure of the body of the CDA document of HL7, the sections and the data entries and the structure of the component, sections, data entry and clinical acts. Finally, it is required to establish a set of connections to the HIS database, through a server applications, to enable the exchange of information through the Internet. The configuration of the connections must be parameterized according to the services contracted between the IPS. In this context, a "pool of connections" was established through the glassfish server open source edition. GlassFish is a...
free software application server, compatible with Java EE, developed by the GlassFish and Oracle community. GlassFish integrates an Application Programming Interface (API, for its acronym in English of Application Programming Interface). JDBC, is the API for the execution of SQL statements with Java programming language. The set of functions and procedures can be configured from the glassfish web interface or for development purposes through an Integrated Development Environment (IDE), such as NetBeans, which is a free development environment with no restrictions on use, mainly for the Java programming language, tools of the Oracle Corporation. The GlassFish wizard allows you to create a new connection pool (New JDBC Connection Pool), through which the java.sql.DataSource resource is established, which corresponds to the extension package that provides data source connection and grouping functionality, and also, indicate the database management system used by the HIS. Finally the properties of the available database connections will be displayed, allowing to have a logical architecture, through which, through validations, messaging, transformation and routing are integrated, establishing a logical layer that allows virtual exchange of the information among the IPS, from the use of the HIS.

The scenarios developed in this context, allow the use of an HIS, and validate the compliance of the requirements for interoperability in the horizontal and vertical dimensions, as a basis to determine the suitability of the model for interoperability between the IPS. With reference to the above, the development of three (3) scenarios corresponding to: i) electronic transfer of the clinical records of a user of an IPS, for the request of diagnostic images in another IPS, from the use of the horizontal interface, ii) import of the records with the information of the users, of the affiliation database that is reported from the EPS, and iii) validation of the report in the ERP of an EPS, with the record of the activities of Specific Protection, Early Detection of mandatory compliance (resolution 4505 of 2012). Finally, a summary of the compliance with the architectural interoperability model requirements is presented and one of the validated scenarios is presented in this study.

5. Conclusions
In this research, the design of a model for interoperability between IPS, based on the standards for the electronic exchange of clinical information HL7, and in the architecture to design and develop distributed SOA systems was developed in an effective manner. The interoperability model focused on two dimensions, on the one hand the horizontal dimension was projected, through which the architecture was designed, based on the required components, for the exchange of clinical information of the users among the HIS modules of the IPS, and on the other hand, the vertical dimension was projected, through the architectural design, to exchange information vertically backwards, with actors of the health system that provide information to the HIS, and vertically forward, with entities that receive information from the IPS, processed from the use of the HIS.

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