REFLEXIÓN

Integration model for health services in the colombian social security system

Modelo de integración de servicios de salud del sistema de seguridad social colombiano

Lilia Edith Aparicio Pico*, Pedro Arco Ríos**, Alexandra López Sevillano***

ABSTRACT

This article proposes an Integration Model for Health Services whose extent of complexity of care are included in the General System of Social Security in Health (SGSS) aimed at setting up a basic tool to enhance the effective and decisive response of the Colombian Healthcare System in the use and management of resources. The model allows carrying out an intrinsic assessment of the system administration, as well as of the resources and actors to be applicable to other integration systems and management of hospital resources at the national and international consensus. The analysis of complex systems is taken as fundamental issues to abstract the basic structure of interactions and assessment of possible emerging situations in the Management of Health System.

Keywords: Administration of Resources, Complex Systems, Components in Health, Health System, Integration in Health, Integration of Components, Integration Services Model, Management Model, System of General Social Security in Health.

RESUMEN

El artículo propone un Modelo de Integración de Servicios de Salud, cuyo grado de complejidad de atención están comprendidos en el Sistema General de Seguridad Social en Salud (SGSS), para instituir una herramienta básica que mejore la respuesta efectiva y resolutiva del Sistema de Salud colombiano en la utilización y gestión de los recursos. El Modelo permite realizar una evaluación intrínseca de la administración del sistema, de los recursos y actores para ser aplicable a otros sistemas de integración y administración de los recursos hospitalarios en el consenso nacional e internacional. Se toman como aspectos fundamentales el análisis de los Sistemas Complejos para abstraer la estructura básica de interacciones y evaluación de posibles situaciones emergentes en la Gestión del Sistema de Salud.

Palabras clave: Administración de recursos, Sistemas complejos, Componentes en salud, Integración en salud, Integración de componentes, Modelo de integración de servicios, Modelo de gestión, Sistema General de Seguridad Social en Salud, Sistema en salud.

*   PhD. Lilia Edith Aparicio Pico, Electronic Engineering, PhD, professor, Universidad Distrital Francisco José de Caldas, Bogotá, Colombia, medicina@udistrital.edu.co
**   PhD. Pedro Arco Ríos, Electrical Engineer, PhD, professor, Universidad Central Marta Abreu De Las Villas, Habana, Cuba, parco@uclv.edu.co
*** Msc. Ing. Alexandra López Sevillano Software Engineer, Msc, Doctor's degree student in Engineering, Universidad Distrital Francisco José de Caldas, Bogotá, Colombia, alelose@gmail.com

INTRODUCTION

In Latin America and the Caribbean there are marked concerns in health care (WHO, 2013). A set of components limit the access to a timely and quality health care, the lack of infrastructure resources, "is part of a series of studies of the regional program of social policies in Latin America" (SOPLA, 2012), equipping (technology), drugs, human talent and geographical distance, "Health and TIC" (CEPAL, 2012), including the public or private supply and the population demanding health care services.

Advances in the setting up of appropriate mechanisms for management among the main actors of a health system such as specialists, infrastructures and appropriate medical technologies and system users have been important in recent years. However, integration difficulties persist due to the multiplicity of factors and legal, economic, social frameworks which go even beyond the medical ethics.

The referents review highlights a good number of proposed solutions, such as the general structure model of the "information systems in hospital management", where essential components are grouped and monitored such as data information (information architecture), Hardware-Software-Networking (Technology Architecture), process-tasks-applications (domain architecture) and user management (Architecture Control); however, the component of quality of service delivery component is neglected and no direct correlation is set between the management of technology resources and its social impact (Joseph, 2001).

Another similar proposal is the strategy and architecture of the information system of medical care proposed by Bourke, where a management model of physical and human resources is depicted, but it fails to incorporate the element of information management.

More recent past history, as the case of the "medical information technology" journal: clinical management and technology", approaches the issue of management models in health as a problem where obstacles in the human, technical and normative dimension shall be overcome (Rojas, 2009).

Several studies carried out in low-and middle income countries have shown that integrated systems in health services reduce the fragmentation of caregiving, avoiding the duplication of infrastructure and services, lowering the production and transaction costs, and they give a better response to health needs of the community (CEPAL, 2012).

Furthermore, it is mandatory to establish the cross-sectorial approach and relationships between components by measuring the effective and decisive response through indicators resulting in knowledge levels as proposed by Figuerola, where the processes and procedures of the organization (including standards, policies, templates, plans) and the corporate basis of knowledge that is the "knowledge management" which organizes, stores and shares vital information, so that everyone can be benefited from its use. Therefore, the structural and functional presentation of relationships among data, information, knowledge and wisdom must be seen from producers and consumers (Figuerola, 2013).

Another approach to the management of resources and services is that addressed in the data fusion model established by the Data Fusion Group, known as JDL where the development of information systems of multiple profitable sources requires a standard method for specifying the processing functions of data and control fusion, interfaces and associated databases (Blasch et al., 2006)

The proposal herein set forth has its central axis in the design of an integration model of health resources and services to contribute to the reduction of production costs, effectiveness of services, timeliness in service supply, real-time availability and occupancy rates. Similarly, lesser unnecessary hospitalizations, in the excessive use of diagnostic testing and services, decreases in the time of

hospital stay; involving own technological break-throughs of scale economies and joint production "in pursuit of increased production volumes and productivity of the system", as it is presented in the Reorganization, Redesign and Network Modernization in Delivery of Health Services Program (SDS, 2013).

The management and clinical technology of today strongly appear the computer tools based on GRD: plan, measure, evaluate and compare focused on cost control and performance evaluation in Health in a comparative manner, delivering performance and efficiency indicators (Emilio, 2014).

Therefore it was considered relevant within the proposal, to develop simulation scenarios for the scalable health model under an approach of integration of services and levels.

FUNDAMENTALS, METHODS AND TECHNIQUES FOR THE MODEL DEVELOPMENT

Interoperability

Decision 2004/387 / CE of the European Parliament and of the Council on the inter-operating provision of Electronic Management Services to the Public Sector, Business and Citizens (IDABC). This document defines the interoperability as "the ability of Information Technology Services and Communication (TICs) and business processes they support and exchange data and enable the sharing of information and knowledge", as well as the definition first used in the document (DO387, 2004). As a case of study of the Desert Storm, by Sterling D. Sessions and Carl R. Jones, of the National Defense University, Washington DC, and added to the document AAP-6 NATO as an official definition. "The ability of systems, units or forces to provide services and accept services from other systems, units or forces and to use the exchanged services to operate effectively" (AAP-6.1993). The interoperability of processes is one of the fundamental pillars of a

management process, and it becomes an indicator of the performance of a whole management system. This indicator is embedded and optimized in part generating implementation guides. Often the "out-of-the-box" standards are abstract and flexible, so that a message or document complying with the standard does not necessarily suit a particular purpose. The implementation guide should include specific requirements or purposes, expression of restrictions, detail of vocabularies, references to standards (of HL7 or others), examples (fragments and entire documents), textual expression (Word or PDF document) and actionable (schematron or style sheet). (HL7 Argentina, 2012).

As examples of implementation guidelines in Spanish are those of SACYL, of Spain; that of the Hospital Italiano de Buenos Aires, Argentina; that of SUEIIDISS, of Uruguay, and HL7 Spain, of Spain; and IHE XDS-I, for radiology; the PCC, for continuity of clinical care, and the XDS-LAB, for laboratory. (HL7 Argentina, 2012).

What to order from systems providers? A statement of compatibility with standards and specific scenarios, through implementation guides: what messages or types of documents are exchanged and at what time? A good example of industry consensus to this regard are the IHE profiles that combine HL7, DICOM standards and its own adaptations to carry the standards to the level of process. The specification of vocabulary and cross-mapping of support for each item of coded data, depending on the application context, which can be expanded over time (from in-hospital to regional interoperability). These requirements for adaptation and cross-mapping of vocabularies can be increased. For instance, support for LOINC for LIS vendors; SNOMED-CT support for LIS vendors for pathology Anatomy; ICD10-ICD9- SNOMED-CT support for EHR systems. Accompany us in the growth of interoperability with the necessary flexibility to start with the exchange of documents or messages with a format, but with the awareness of being enabled to evolve to a higher level of interoperability over time. Finally, the compliance with the security

and privacy standards as defined by the local regulations. (Regulations, 2010).

In the field of standardization there is HL7 International, which provides a comprehensive framework for the exchange, integration, and retrieval of electronic health information that supports the clinical practice and the management and assessment of health services. It is the standard for the exchange of clinical documents instead of messages. Their latest release is the 2005 Regulation, CDA R2; while the CDA R3 is under discussion (no ballot). ARDEN SYNTAX / GELLO: for the exchange of clinical rules. CCOW: for the integration of applications at the desktop level. It allows an application vendor to integrate its HIS product with a RIS with another vendor transparently to the user, sharing the context on the desktop, at the level of user ID, patient who is being consulted and up to the study or examined report. (Regulations, 2005).

Sources of Development

JavaSIG is the library that is best suited to implement the messages because, through a previous investigation, it is tailored to the particular needs of this project. JavaSIG is an Open Source implementation of the HL7 RIM classes using Java technology. Grails Framework Open Source oriented to an agile development process. It bears the paradigm of "coding by convention" to the Groovy language and it is oriented to the development of web 2.0 applications. It is based on frameworks and Java technologies like Spring, Groovy, Hibernate, Site Mesh, Quartz Scheduling, Jetty, HSQLDB, among others. Groovy is the Java's dynamic language; it presents a dynamic extension to the Java language, providing all the features of Java API plus new builders and features such as closures (a construction of functional programming). Furthermore, Groovy is compiled to byte code which is not a big performance problem. The Web Services E1 AXIS2 plugin for GRAILS to expose web services easily on the PIX Manager component; in turn, for

the consumption on the PID component. Apache Service Mix is an ESB Open Source developed by the Apache foundation which complies with JSR 208 specification for JBI. It also features a Normalized Message Router (NMR), as required by the JBI specification. Mirth is an ESB independent Open Source of platform, oriented to HL7 messaging. The transmission occurs through defined channels through a graphical interface. These channels operate with input and output connectors, filters and transformers. Currently supported connectors are: LLP, database, JMS, Web services SOAP, File, PDF, FTP, and SFTP. Through the graphical interface, it is possible to select which filters and transformations are applied to the incoming message before sending it to the output (HL7 Argentina, 2012).

Information System

An Information System is a set of strategies that enable to carry out an efficient management of processes in an organization. "A group of people, data, processes and information technology that interact to collect, process, store and provide the information necessary for the proper functioning of the organization." (Whitten, Bentley & Dittman, 2004). HLT is specifically involved in creating standards, guidelines and flexible and cost-effective methodologies that enable the interoperability among the information systems and exchange of electronic health records.

Since 1994 the organization started to be accredited as SDO (Standards Developing Organization) by the ANSI (American National Standards Institute). As organization, HL7 has a formal structure and procedures based on the pursue of consensus and the balance of interests among the various sectors represented: software companies, funders of health, national states, universities, health care providers, consultants, etc.

The early versions of the messaging standard 1.0 and 2.0 were adopted in 1987 and 1988 respectively. Since then, these

were the succession of approved standards: Approved standards:

Table 1. Messengers standard

1990	1994	1997	1999	2000	2003	2007	2008
2.1	2.2	2.3	2.3.1	2.4	2.5	2.6	2.7

Source: HL7 Manual (2013).

Architecture

Centralized and distributed architecture is defined, and the distributed computing has been designed to solve too big problems for any supercomputer and mainframe. Thus, grid computing is naturally a multiuser environment; therefore, the secure authorization techniques are essential. The centralized architecture provides the computational power and an incredible internal storage. The disadvantage of this architecture is that it lacks self-contained computer processors (Tanenbaum, 2006).

In Architecture of Next Generation Networks NGN, it is proposed as a project within the International Telecommunication Union in 2002, seeking to carry out the concepts defined for the Global Information Infrastructure, the first recommendations on NGN: the Y.2001 (ITU, 2004) and Y.2011 (ITU, 2006), which generally define the Architecture of Next Generation Networks and its characteristics. Much of the work of conceptualization within the ITU was based on the initial approaches made by the European Telecommunications Standards Institute (ITU-T, 2011).

In works carried out by ETSI and ITU, the points and interconnection interfaces are generally identified which should be available in the next generation network, highlighting the functional separation of the network in plans (Strata) of Transportation (Infrastructure) and services.

• User Network Interface (UNI - User Network Interface): Through which the functions of end users to NGN are interconnected.

• Network - Network Interface (NNI - Network to Network Interface): Through which a network is connected to another (different domains).

• Application Interfaces – Network (ANI - Application to Network Interface): Through which they are connected to providers of third party applications.

Clinical management

It increases the efficiency and quality of health care benefits provided by the health care units. "The best use of human, professional, technological and organizational resources for the best patient care." (Merced, 2007). The clinical management model used is that of Joseph, where the essential components such as data information (information architecture), Hardware-Software-Networking (Architecture of technology), process-tasks-applications (domain architecture) and user management (Control of architecture) is the general structure of information systems for health management (Joseph, 2001) and complemented with which we will define the clinical management model that will be developed and on which we have been working so-far using the framework of causal model system (See Figure 1).

It is started with the causal model as it allows to state that health problems must include the dialectical relationship between chance and necessity, between casual and causal versus the determinism and the mechanism prevailing in the analysis of health science. It is relevant to keep in mind that there is a consideration to that there is determination in indetermination and indetermination in determination.
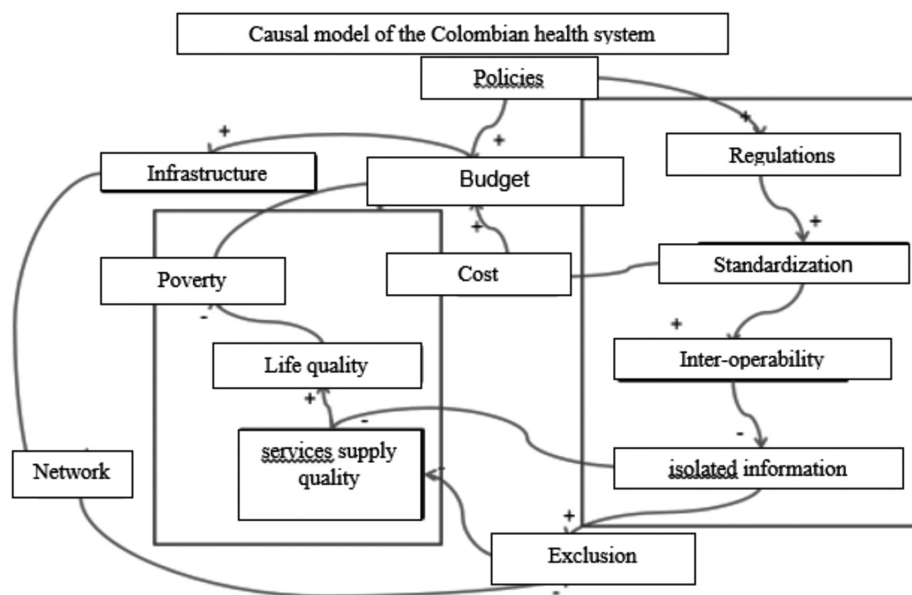
Figure 1. Causal Model representing the Colombian health system components

Source: Own work.

Causal Model

It is framed within the setting of statistical causal inference, based on the estimate of the causal effect on Medicine (Christakis & Iwashyna, 2003, Hirano & Imbens, 2001), epidemiology (Oakes & Church, 2007).

Experimental data in principle, if the assignment to treatment is at random, the causal inference is simple, since the two groups have been drawn from the same population, and by the treatment construction and assignment it is independent from all reference variables. In an experimental setup, something can go wrong. What does the statistical adjustment require? (Barnard, Frangakis, Colina, & Rubin, 2003).

When the compliance problem has a more complicated structure, it is difficult to move forward without making structural assumptions and statistical corrections for the compliance (Green & Gerber 2008).

One of the assumptions that the at random allocation by itself is not justifiable is that "observation in a unit should not be affected by the particular assignment of treatments to the other units" (Cox, 1958). Rubin (1978) refers to this case as "no interference between units."

Observational data in a framework of observation, unless something special is done, the treatment groups and untreated groups are almost never balanced because the two groups do not originate from the same population (Rosenbaum & Rubin, 1983).

Complex Systems

Complex systems will be used as they consist of several interconnected or interlinked parts whose ties produce non-visible additional information that makes it easier to accurately analyze the system. Complex systems have more information than that given by each independent part.

Several philosophers like Hesse (1963) and Hughes (1997) have studied the traditional scientific methodology and they have proposed the same general outline as the modeling process. According to these authors, scientists models are built to develop inference processes on certain aspects

of previously observed actual systems. It is through these inference processes, that the construction and use of scientific models enhances the understanding of observed real systems.

A system can be defined as "a set of elements in interaction" (Bertalanffy, 1968). Complex systems (i.e. multicellular organisms, ant colonies, ecosystems, economies, societies...) are characterized by having a structure composed of several levels, in these complex systems (Vicsek, 2002, Gilbert, 2004).

When there is one or more intermediate layers between the real system and our formal model, the modeling basic sequence is substantially modified (Edmonds et al., 2001; Galan et al., 2008). Regardless of the nature or complexity of the real system, to explain each stage in the modeling process of complex systems we find it useful to distinguish three roles (Drogoul et al., 2003): expert, modeler and ruler.

Agent-based Simulation

The agent-based simulation has proven to be an extremely useful technique for modeling complex systems, and especially social systems (Conte et al., 1997, Gilbert & Troitzsch, 1999; Gilbert & Terna, 2000, Gilbert, 2007). Through agent-based simulation, the modeler explicitly recognizes that complex systems, and in particular the social system, are the outcome of individual behaviors and of their interactions.

The agent-based systems are characterized by comprising multiple agents which are to a larger or lesser extent autonomous, heterogeneous and independent, each showing their own goals and objectives, which generally are able to interact with each other and with their environment (Torsun, 1995).

The agent-based simulation has been widely used to model systems in a wide range of scientific disciplines, i.e. Economics (Tesfatsion, 2002, 2003), Finance (LeBaron, 2000), Natural Resource Management and Ecology (Bousquet & Le Page,

2004; Lopez & Hernandez, 2008), Political Science (Axelrod, 1997b; Johnson, 1999), Anthropology (Kohler & Gumerman, 2000), Sociology (Comte et al., 1997 Gilbert & Troitzsch, 1999; Gilbert, 2007), Biology (Paton et al., 2004;. Walker et al., 2004a; Walker et al., 2004b) or Medicine (Mansury et al., 2002; Mansury & Deisboeck, 2004), in which starting from rules determining the agents individual behavior, it is intended to infer the global properties of the whole system (Holland, 1998).

System Dynamics

The systems dynamics is another technique for modeling complex systems. It is also widely used for modeling systems in engineering (Ford, 1997; Ford & Sterman, 1998), Economics and Business (Sterman, 2000; Ellis, 2007), Planning and Project Management (Rodrigues & Bowers, 1996; Lyneis & Ford, 2007), Environmental Management (Martínez & Esteve, 2007), Public Health (Homer & Hirsch, 2006) and even History (Cruz, 2007). Unlike the agent-based simulation, the philosophy of system dynamics deals on the concept of feedback or circular causality between observable variables. These observables can describe some attributes of the basic components of the system. System dynamics studies observable variables of complex systems and attempts to identify the causality relationships (usually circular) existing among them. Once such relationships are identified, it is easier to explain the origin of the system global behavior from their causal structure.

METHODOLOGIES

The following is an explanation of the elements referred to the processes of the health services integration model to be developed.

The data types will be quantitative and qualitative for the variables of standardization, interoperability, infrastructure, networks and service delivery quality components, in an effort to categorize each variable. This study uses the following three data

gathering techniques: Observation, semi-structured interviews and the documents review or analysis.

Accordingly the Rubin Causal Model (RCM) is proposed, cases of observational and experimental studies of causal inference and estimation by matching methods (Rubin, 2006). In order to identify, analyze and set the relations between the components the following is provided: Experimental data, observation of data and the matching method, the most common method of multivariate game based on the Mahalanobis distance (Cochran & Rubin 1973; Rubin 1979, 1980), where the framework of potential exits of Neyman is based on the potential exits, and the allocation mechanism where each component has a different exit potential according to a given conditional assignment. Indicators as variables that attempt to measure or objectify quantitatively or qualitatively collective events (especially events bio demographic) are identified, so as to backup political actions, evaluate achievements and goals. WHO (2000) has defined them as "variables used to measure changes." Health indicators often used in various combinations, are used in particular to assess the effectiveness and effects. Surveys will be carried out using sampling techniques (population surveys) and data from other sectors (economic, political and social welfare). The method is quantitative and qualitative. Donabedian (2001) was the first to propose that the methods for assessing the quality of health care can be applied to three basic elements of the system: structure, process and outcomes. This approach is kept to monitor the quality of health and hospital care.

For quality and usefulness of an indicator it is primarily defined by the following criteria:

- Validity (if it actually measures what it intends to measure).
- Reliability (if its repeated measurement under similar conditions produces the same results).
- Specificity (to measure only the phenomenon to be measured).
- Sensitivity (that can measure changes in the phenomenon to be measured).

- Measurability (that is based on data available or easy to obtain).
- Relevance (able to give clear answers to the most important issues of health policies).
- Cost-effectiveness (that results justify the investment in time and other resources).
- It is used for the developing of simulations, the modeling of complex systems through agent-based simulation and systems dynamics. Basically, a system can be defined as "a set of interacting elements" (Bertalanffy, 1968). Complex systems (i.e. multicellular organisms, ant colonies, ecosystems, economies, societies...) are characterized by having a structure composed by several levels. In these complex systems (Vicsek, 2002, Gilbert, 2004):
- The components of lower hierarchical levels usually show a significant degree of autonomy.
- The behavior of the system arises from the self-organization of its components, without this organization is controlled or directed by any agent out of the system.
- The basic components of these complex systems (cells, ants, individuals, populations, businesses...) perceive their environment and respond to changes in it in potentially differently ways.
- Many complex systems are also adaptive. In these adaptive systems (organisms, ecosystems, economies, societies...), the behavior of the basic components of the system may evolve over time, resulting in some capacity to respond to changes in the environment through mechanisms:
- Learning at the individual level, and/or
- Selection and Replacement (which results in a population-based learning).

The inference resulting from running a computer model has the following forms: The results obtained when running the computerized simulation are derived by deduction; therefore, using the logical need to apply algorithmic rules which define the model to the set of initial conditions with which the model has been parameterized. Thus, regardless of their larger or lesser degree of internal complexity, a computerized simulation is

a perfectly valid sufficiency theorem (see, for example, Axtell, 2000).

The agent-based simulation has proven to be a useful technique for modeling complex systems and more specifically the social systems (Conte et al., 1997; Gilbert & Troitzsch, 1999; Gilbert & Terna, 2000; Gilbert, 2007). Through the agent-based simulation, the modeler explicitly recognizes that complex systems and particularly the social systems are the result of individual behaviors of their interactions. What distinguishes the agent-based simulation from other modeling techniques is the way the first abstraction of the real system is built and consequently the formal model.

EXPECTED RESULTS

It is expected to test an integration of health services model, which supported via software applications allows the optimization of human resources, technology, financial resources allocation, acquisition and processing of information from the various health centers and/or hospitals, clinics that make up the health services in the Capital District.

It is foreseen this approach will lead to a substantial improvement in primary care of patients, having access to basic information and medical history as well as the resources available for their care throughout the network, through the management of relational databases that will be supported through mechanisms of cloud computing. For the different health care facilities, and/or hospitals, clinics that are networked, the Integration System will allow the real-time access to each patient information and of the available resources and interactions among them all. The system modeling backed up by TICs seeks to speed up the entry and recognition process of the patients' specific characteristics through infrastructures of biometric identification such as fingerprints or the recognition of iris patterns.

The UML language is used for the model (Unified Modeling Language) (Engels, 2000); for the

application of user interfaces (Lopez, Espejo & Drake, 2004) and databases: Visual Net and MySQL as a valid tool to test the modeling through UML (Parra, Ruiz & Paz, 2005). The cases of Use are carried out for conventional and alternative scenarios to a priori assess the behavior that application may adopt to be developed as the Integration System of Health Services support. Subsequently, the class diagrams are proposed, specifying therein the variables, their types and operations on them. Finally, the sequence diagram is established to see how all the patient information, resources and underlying interoperability in each process is displayed (protocols of a patient's admission or triage, resources allocation, critical paths of processes, among others) who arrive at any health care facilities and/or hospitals, or clinics in the network.
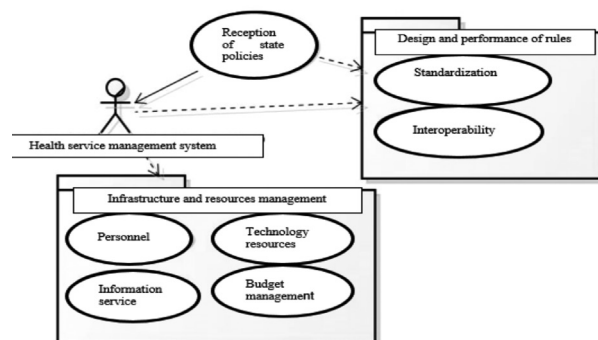

Figure 2. Integration Model for the Distribution Network

Source: Own work.

For testing the verification of the application, the algorithmic complexity is assessed based on the criteria of the system response-time in the light of nominal scenarios or usual sequence (Perez, Orejas & Fuentes, 2005), alarm generation in non-conformity scenarios or faults such as the non-previously validated users access into the system and the capacity of memory used on the machines where the application is running. For the case of using the integration system of health services, see Figure 2.

CONCLUSIONS

This project draws a solution from the information technology standpoint to the integration of services issues to comprehensively care for health, the fragmentation of processes, mitigate the scarce prevention, the disruption of related bodies and agencies and other collateral issues.

Regarding the project scientific and technological impacts on the participating institutions, the development of technical knowledge is relevant to contribute to the appropriation of international best practices in the managing the Life Cycle of applications, their implementation and use.

Impacts on productivity and competitiveness of the beneficiary entity to the related sector will be transformed into a competitive and nationally well-known sector as it will integrated into its services the use of technology, communications and service delivery being one of the first to provide with the above mentioned components, the implementation of the project and will position us nationally as a pioneer in health innovation, which in turn reinforces the credibility and confidence of the sector entities and will open the possibility of offering this service to other regions at national and international levels.

The impact on the population/territorial area in epidemiological terms where the platform can generate analysis information to generate early warnings about epidemiological phenomena will be another asset. In socio – economic terms, the project implementation will allow to reduce the training times, so as to increase productivity in integration between the different health entities. Moreover it will be sought to reduce the patients care costs per patient for both the institutions and patients themselves, and thus achieving the optimization of financial, technological and professional resources.

REFERENCES

Axelrod, R. (1997a). "Advancing the Art of Simulation in the Social Sciences". En Conte R, Hegselmann, R. & Terna, P. (Eds.) Simulating Social Phenomena, Lecture Notes in Economics and Mathematical Systems 456: 21-40.

Berlin: Springer-Verlag. (1997b). The complexity of cooperation: Agent based models of competition and collaboration. Princeton NJ: Princeton University Press.

Bertalanffy, L. (1968). "General System Theory". New York: George Braziller Publisher.

Bousquet, F. & Le page, C. (2004). "Multi-agent simulations and ecosystem management: A review". *Ecological Modelling*, *176*(3-4), 313-332.

Comisión Económica para América Latina (CEPAL, 2012). "Equipamiento y tecnología".

Comisión Europea (2009a). "Directrices comunitarias para la aplicación de las normas sobre ayudas estatales al despliegue rápido de redes de banda ancha". Diario Oficial de la Unión Europea, 2009/C 235/04.

Comisión Europea (2009b). "Movilizar las inversiones públicas y privadas con vistas a la recuperación y el cambio estructural a largo plazo": Desarrollo de la colaboración público-privada (CPP).

Cox, D. R. (1958). *Planning of Experiments*. New York: Wiley.

Cruz, M. M. (2007). "Evaluando la dinámica de sistemas como una herramienta para enseñar Historia". Revista de *Dinámica de Sistemas, 3*(2), 3-60.

Drogoul, A., Vanbergue, D. & Meurisse, T. (2003). "Multi-Agent Based Simulation: Where are the Agents". En Sichman, J. S., Bousquet, F. & Davidsson, P. (Eds.), Lecture Notes in Computer Science 2581. Proceedings of MABS 2002 Multi-Agent- Based Simulation, 1-15. Bologna, Italy: Springer-Verlag.

Edmonds, B., Moss, S. & Davidsson, P. (2001). "The Use of Models - Making MABS actually work". In Multi-Agent-Based Simulation, Lecture Notes in Artificial Intelligence 1979, 15-32. Berlin: Springer-Verlag.

Engels, G. (2000). "UML- A Universal Language?", ICATPN 2000, LNCS 1825, Berlin, Heidelberg, Springer-Verlag.

Figuerola, N. (2013). Gestión del conocimiento (Knowledge Management) Pirámide D-I-K-W.

Ford, A. (1997). "System dynamics and the electric power industry". *System Dynamics Review*, *13*(1), 57-85.

Ford, D. N. & Sterman, J. D. (1998). "Dynamic modeling of product development

Gilbert, N. (2004). "Agent-based social simulation Dealing with complexity". Centre for Research on Social Simulation, University of Surrey. (2007). "Agent-Based Models. Quantitative Applications in the Social Sciences". London: SAGE Publications.

Green, D., & Gerber, A. (2008). "Field Experiments and Natural Experiments." In Janet M. Box-Steffensmeier, Henry E. Brady, and David Collier (Eds), *The Oxford Handbook of Political Methodology*, New York: Oxford University Press.

Hesse, M. B. (1963). Models and Analogies in Science. London: Sheed and Ward.

HL7 Argentina. (2012). "13° Edición Curso Virtual HL7 Introducción a los estándares HL7 V2.x, V3 y CDA orientados al intercambio de información entre sistemas de salud".

Holland, J. H. (1998). "Emergence. From chaos to order. Reading, MA": Addison-Wesley.

Holt, L. & Jamison, M. (2009). "Broadband and contributions to economic growth": Lessons from the US experience, Telecommunications Policy, 33, 575-581.

Hughes, R. G. (1997). "Models and Representation". *Philosophy of Science, 64*(4), S325-S336.

ITU. (2004). General overview of NGN. ITU-T. Recommendation.Y. 2001.

ITU. (2004). General Principals and general reference model for Next Generation Networks. ITU-T. Recommendation.Y. 2001.

ITU. (2006). Requisitos y arquitectura funcional de las redes de la próxima generación, versión 1. ITU-T. Recommendation.Y. 2011.

K. H. Tan, J. (2001). *Health Management Information Systems*. Editorial Services: Joan Sesma.

Kohler, T. & Gumerman, G. J. (2000). "Dynamics in human and primate societies: Agent-based modeling of social and spatial processes". New York: Oxford University Press & Santa Fe Institute.

Lebaron, B. (2000). "Agent Based Computational Finance: Suggested Readings and Early Research". *Journal of Economic Dynamics & Control*, *24*(5-7), 679-702.

López Paredes, A. & Hernández Iglesias, C. (2008). *Agent Based Modelling in Natural Resource Management.* Insisoc. España. ISBN 978-84-205-4560-8.

López, P. et al. (2004)

Lyneis, J. M. & Ford, D. N. (2007). "System dynamics applied to project management: A survey, assessment, and directions for future research". *System Dynamics Review*, *23*(2-3), 157-189.

Mansury, Y. & Deisboeck, T. S. (2004). "Simulating the time series of a selected gene expression profile in an agent-based tumor model". Physica D: Nonlinear Phenomena *196*(1-2), 193-204.

Mansury, Y., Kimura, M., Lobo, J. & Deisboeck, T. S. (2002). "Emerging Patterns in Tumor Systems: Simulating the Dynamics of Multicellular Clusters with an Agent-Based Spatial Agglomeration Model". *Journal of Theoretical Biology*, *219*(3), 343-370.

Normativa (2005). "HL7 CDA R2-Documentos clínicos".

Normativa (2010). "HL7 V3- Mensajería a nivel regional".

Organización Panamericana de la Salud/Organización Mundial de la Salud (OPS/OMS, 2013). "Modelo de salud".

Paton, R. et al. (2004): "Evolvable social agents for bacterial systems modeling". IEEE Transactions on Nanobioscience, *3*(3), 208-216.

Programa Regional Políticas Sociales en América Latina (SOPLA, 2012). "Forma parte de una serie de estudios del programa regional de políticas sociales de América Latina".

Rosenbaum, P. R. and Rubin, D. B. (1983). "The Central Role of the Propensity Score in Observational Studies for Causal Effects." *Biometrika, 70*(1), 41-55.

Rubin, D. B. (1978). "Bayesian Inference for Causal Effects: The Role of Randomization." *Annals of Statistics, 6*(1): 34-58.

Rubin, D. B. (1979). "Using Multivariate Sampling and Regression Adjustment to Control Bias in Observational Studies". *Journal of the American Statistical Association*, 74, 318-328.

Rubin, D. B. (1980). "Bias Reduction Using Mahalanobis-Metric Matching." *Biometrics, 36*(2), 293-298.

Secretaría Distrital de Salud (2013). "Programa de Reorganización, Rediseño y Modernización de Redes de Prestación de Servicios de Salud".

Sterman, J. D. (2000). *Business Dynamics: Systems thinking and modeling for a complex world*. McGraw-Hill.

Tesfatsion, L. (2002). "Agent-based computational economics: Growing economies from the bottom up". *Artificial life, 8*(1), 55-82.

Tesfatsion, L. (2003). "Agent-based computational economics: Modeling economies as complex adaptive systems". *Information Sciences*, *149*(4), 263-269.

Torsun, I. S. (1995). *Foundations of Intelligent Knowledge-based Systems*. New York: Academic Press.

Vicsek, T. (2002). "Complexity: The bigger picture". *Nature, 418*(6894), 131.

Whitten, J., Bentley, L.D & Dittman, K.C. (2004). *Systems analysis & design methods*. Citado por Fernández Vicenç, 2006: Desarrollo de sistemas de información: Una metodología basada en el modelado".