Paper

The use of HL7 as an interoperability framework in a regional healthcare system in Greece

Alexander Berler, Pantelis A. Angelidis, and Dimitris Koutsouris

Abstract—The integration of information systems represents one of the most urgent priorities of a regional healthcare authority in order to meet its clinical, organizational and managerial needs. Current practice shows that the most promising approach to achieve a regional healthcare information system is to use a health level 7 (HL7) message-based communication system implemented by an asynchronous common communication infrastructure between healthcare sites. The system is a complete and integrated information system at a regional level that comprises all types of healthcare levels, that includes interoperability issues, that covers most of the needed components, and that is able to work efficiently in a secure wide area network to ensure data privacy and confidentiality. Another important feature of the proposed solution is that it creates an interoperability framework that can be replicated from one healthcare institution to another. In that sense, common interoperability messages can be used to interconnect heterogeneous information systems. In response to this strategy, more than 10 different consortiums have submitted proposals to the Greek government and the proposed interoperability framework seems to be widely accepted as a solution to enhance information and communication technologies developments in the healthcare sector in Greece.

Keywords— interoperability, HL7, regional healthcare information system.

1. Introduction

The advantages of the introduction of information and communication technologies (ICT) in the complex healthcare sector are already well known and well stated in the past [1, 2]. It is nevertheless paradoxical that although the medical community has embraced with satisfaction most of the technological discoveries allowing the improvement in-patient care, this has not happened when talking about healthcare informatics. Many reasons could be proposed for this matter, though with a short analysis it is rather clear that new ICT are having integration problems in healthcare because of the way this sector is organised. It is common knowledge that in order to install any type of information system in healthcare, six main groups of issues have to be dealt with [3, 4]:

- Organizational and cultural matters related to healthcare.
- Technological gap between healthcare professionals and information science experts.
- Legal requirements on the confidentiality of personal data, of patient related data and on data privacy.
- Industrial and market position of healthcare informatics and interoperability complexity.
- Lack of vision and leadership of the health care managers and health authorities.
- User acceptability and usability of the proposed information systems.

In 2001 a reform of the Greek national healthcare system [5] was introduced in order to enhance the performance and control of healthcare provision in Greece. One of the main changes was the division of the country in 17 autonomous healthcare regions where the regional healthcare authorities (RHA) are responsible for the regional healthcare strategy. In order to support this reform a series of ICT oriented interventions were introduced. After a period of analysis and design the Greek government started issuing a number of extremely detailed (more than 500 paged each) request for proposals (RFP) for each RHA [6].
The integration of existing and forthcoming information systems represents one of the most urgent priorities in order to meet the increasing clinical, organizational and managerial needs [7, 8]. In that context, the use of standards is essential since data processing needs vary widely in the complex regional healthcare environment. All RHA have a major concern in evaluating the existing operational hospital information systems and other information system infrastructure in order make a decision on whether to maintain or replace them. In Greece, more than ten distinct vendors have installed healthcare IT related products (hospital information system – HIS, laboratory information system – LIS, radiology information system – RIS, etc.) that mostly work independently as IT niches. It is known that the lack of healthcare information standards is one barrier to the broad application of IT in health care units. The inability to share information across systems and between care organizations is just one of the major impediments in the health care business's progress toward efficiency and cost-effectiveness, as well as, the absence of a unique national or even regional patient identifier in Greece. Integration of these existing diverse systems with the future information systems to come remains problematic with a number of competing approaches, none of which alone represent the perfect solution. Current practice shows that the most

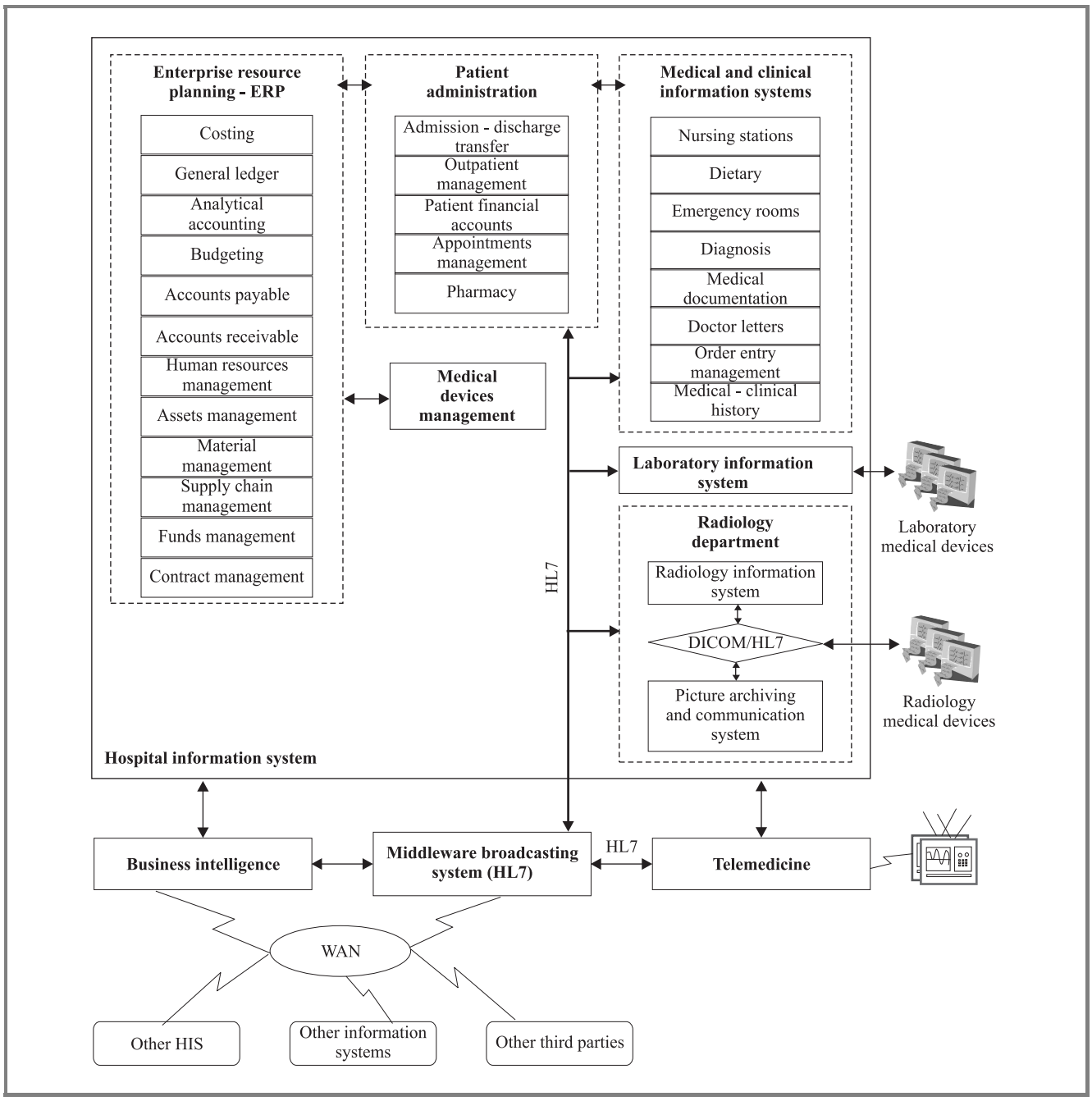

Fig. 1. Regional healthcare information system basic software components.

promising approach to achieve a regional healthcare information system is to use a HL7 message-based communication system implemented by an asynchronous common communication infrastructure between healthcare sites.

2. Methodology

The proposed information system in the RFP consists of a series of subsystems as depicted in Fig. 1, covering information management issues in a regional healthcare system. The system is innovative in the sense that it required the design and implementation of a complete and integrated information system at a regional level that comprises all types of healthcare levels (primary care, secondary care, home care, etc.), that includes interoperability issues, that covers most of the needed components and that could be able to work efficiently in a secure wide area network (i.e., a VPN) to ensure data privacy and confidentiality.

Through the aforementioned RFPs, the need has arisen to make healthcare information systems in Greece to work together as the components of regional healthcare network (RHN), where newly introduced information systems must communicate with systems already present in vari-

ous healthcare institutions. The proposed solution features the use of middleware broadcasting systems that are based on information exchange via messages utilising some application protocol (ISO-OSI level 7).
The proposed architecture fulfils at least the following requirements:

- Existing systems do not need to be altered.
- No significant extra (hence unanticipated) load on existing systems is introduced.
- Connecting existing systems is an economical viable activity.

The three requirements are met by an *asynchronous message based* information exchange infrastructure defining a uniform interface for any system that must or receive information. All systems are connected, through a uniform interface, to an interoperability framework or more technically to a common communication infrastructure (CCI). In an asynchronous message based CCI, information is exchanged between two systems by breaking up the information into chunks. These "chunks" are called application protocol data units (APDU). An APDU has an explicit structure that is defined by the APDU (or message) *syntax*. Additional encoding and decoding rules help sending and receiving systems to construct and to analyse APDUs. Sending systems can insert information into APDUs and receiving systems can extract information from the APDUs.
The APDUs are not transmitted directly; they are embedded in so called protocol data units (PDU). APDUs form the "payload" of PDUs. PDUs contain enough information for the CCI to be able to "route" the information sent to the receiving application. Additional "meta" data help the receiving side to understand if the PDU has been received intact and contains the APDU anticipated.
Using (A)PDUs to exchange information between systems bring a number of distinct advantages:

- All systems can be interfaced in a uniform way with each other.
- There is decoupling between systems which allows information to be routed, stored and forwarded, and processed independently from the actual exchange.
- Information exchanging does not need to reveal their internal structure to each other. This form of "information hiding" significantly improves the connectability of systems.

As depicted in Fig. 2, the use o a middleware broadcasting system is enabling the interconnection of information systems without creating extra workloads on existing information systems. When a system provide a uniform interface for sending and receiving information they can be connected easily and even routing of information becomes feasible. The latter is very important to connect remote system that cannot communicate directly. Clearly the third

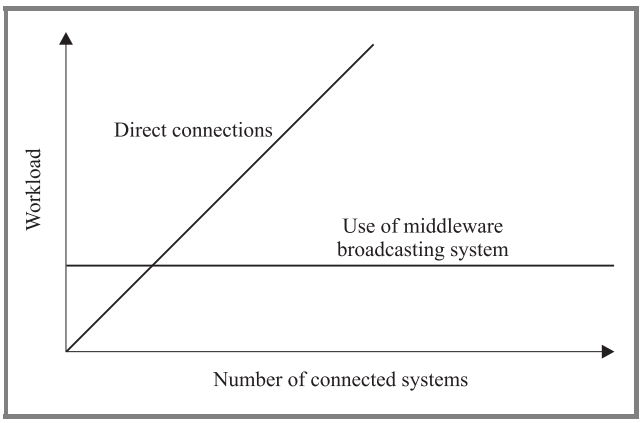

Fig. 2. Workload produced by connected systems.

advantage is the most important. The fact that two information systems do not need to know each others database schemata, database connection technology, tremendously simplifies the task of interfacing these systems. Figure 3 below depicts the change that occurs when introducing a middleware broadcasting system.

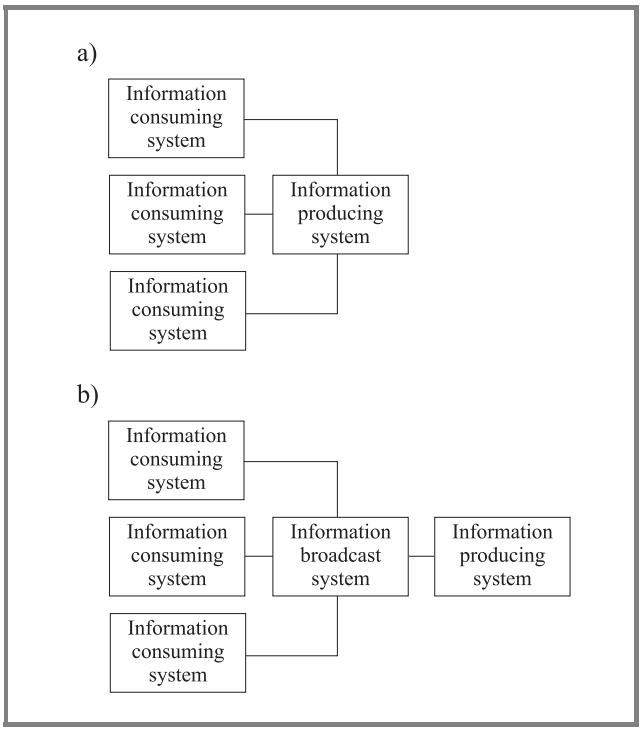

Fig. 3. Schematic representation: (a) direct connection; (b) use of middleware broadcasting system.

Another important feature of the proposed solution is that it creates an interoperability framework that can be replicated from one healthcare institution to another. In that sense, common interoperability messages can be used to interconnect heterogeneous information systems within a healthcare institution or even at a regional healthcare level if a centralized information system is in place, as depicted in Fig. 4.

Table 1

Basic HL7 based interoperability requirements

Requirement	Involved information systems
Patient identification (PID) master patient indexing (MPI)	From all healthcare institution and patient administration system to the MPI.
Order entry	From all departments internally in an institution and between institution (ordering from primary care to hospitals).
Admission – transfer – discharge (ADT)	Within an institution and between institution when a patient journey requires transfers (from primary care to a hospital, from a hospital to a specialized institution, etc.).
Collecting EHCR data	The electronic healthcare record is an aggregation of all data referring to a specific patient, of any type that have any clinical, medical, administrative or nursing value. Aggregation of such data is mainly done at a healthcare institution level but can be done at a regional level also.
Patient referrals	Within primary care settings and from primary care to secondary care.
Transfering information to another RHA	Gathering patient information at a regional level (raw data or pointers to specific data sources) enable the transfer of data to other RHA (for example many hospitals in Greece often transfer cases to specialized or universitary hospitals situated in another RHA).
Claim processing with insurrance companies and social security institutions	The interoperability framework can be used to settle claims from medical institutions towards social security funds to reach shorter reimbursment times.
Transfering medical documents	Medical documents (claims, patient referrals, doctors letters, etc.) can be processeed through an HL7 based interoperability framework by using HL7 clinical document architecture (CDA).
Telemedicine data transfer	The HL7 can be used as an interoperability framework between information systems residing within the healthcare institutions and information systems that manages specific telemedicine scenarios such as emergency telemedicine (from an ambulance to the emergency rooms in a hospital) or homecare scenarios (remote telemonitorimg).
HIS – LIS interface	Within a healthcare institution where the HIS requests laboratory tests to an LIS and the LIS responds by sending the results back.
HIS – RIS interfaces	Within a healthcare institution where the HIS requests radiology tests to an RIS and the RIS responds by sending the results back (imaging and doctor letters).
Appointment management	Appointments can be managed at an institution level but managing them at a regional level has a lot of advantages (shorter waiting lists, better resource combination, no overbooking, no doublebooking of a specific appointment to two or more practitionners, etc.). In that sense a master record of appointments created by a patient relationship management system (web portal and call centre enabled) needs to send appointment data to the healthcare institution and expect a positive or negative acknowledgment.

The proposed interoperability framework greatly simplifies the data exchange issue in a regional healthcare information system since a lot less interoperability connections are required and messages used are homogenized between all involved healthcare institutions.

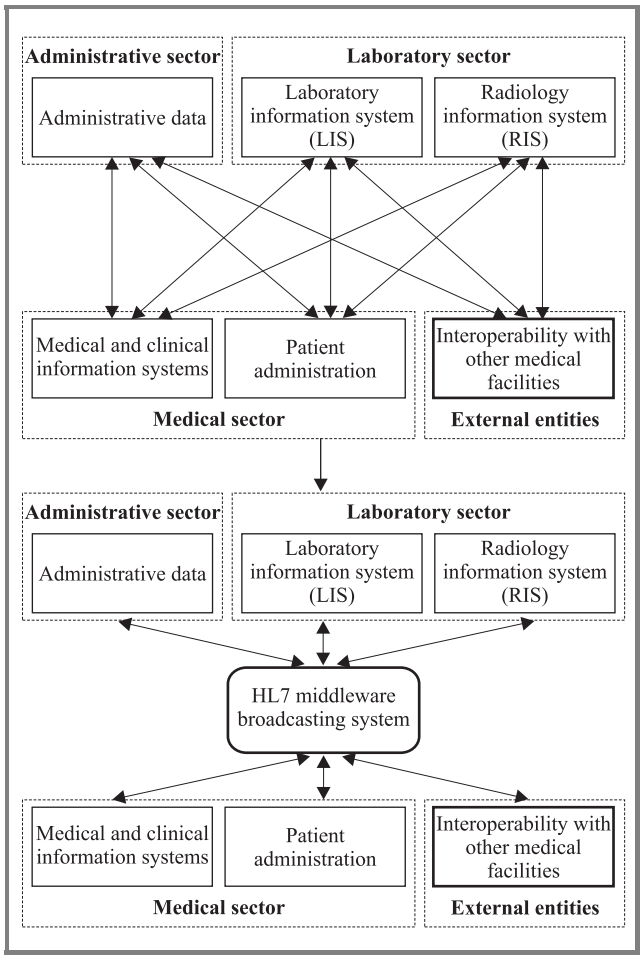

Fig. 4. Creating an interoperability framework.

Level HL7 [9] is by far the most widely used message based information exchange standard in the clinical environment. It is in use on all continents of the world. Also HL7 is clearly the most mature message based information exchange standard. As a consequence, HL7 was set as a mandatory requirement in the selection process for the implementation of the RHN for each RHA in Greece.

Level HL7 is the mostly the result of a pragmatic effort to come up with a mechanism to make it possible to exchange information between a variety of systems that communicate in a wide variety of ways. This has led to many ad hoc solutions that complicate the exchange of messages. Also the implementers of HL7 based communication between applications did have (and still have) a liberal view on the HL7 standard. In order to deal with this issue the proposed RFPs have included in the selection process the evaluation of an HL7 conformance statement based upon the work done by the "HL7 conformance special interest group" (SIG) established by HL7.

Figuers 3 and 4 mostly deal with interoperability issues within a healthcare institution where typically hospitals are mostly concerned since they produce the wider range of medical data. Figure 5 though is extending and describing the proposed interoperability framework and clearly depict the basic interoperability paths required at a regional healthcare level. As stated before, a regional healthcare system can be either an aggregation of interconnected distributed and variable information system, either a totally centralized system based upon an application system provider's (ASP model) approach or a combination of the aforementioned architecture. In all cases information flows, patient journey data, electronic healthcare record data (data collected from various institutions, in various formats and appointed to each individual based upon a mater patient index – MPI) are creating very important interoperability issues. Table 1 describes the basic HL7 based interoperability requirements within a regional healthcare information systems. It is without saying that data privacy issues are important when transferring or gathering data at a regional level and should be dealt with according to EU directives and additional national laws. Data privacy issues are addressed by the means of creating the proper patient consent mechanism, by creating and imposing strict and firm data manipulation and data storage procedures and by avoiding aggregation of sensible data when not strictly required.

Figure 5 depicts the interoperability point within a regional healthcare information system. The interoperability framework can be implemented either centrally with one middleware broadcasting system that interconnects all concerned information systems in a regional healthcare network (VPN based) setting or with an aggregation of interconnected and networked middleware broadcasting systems (one for each institution in the regional setting) that all communicate by an agreed numbers of HL7 based messages. In that sense, the cooperation of such middleware systems could be expanded nationwide, thus enabling patient mobility and data consistency within a nationwide electronic healthcare record.

3. Results

In order to assess the interoperability framework described before, a pilot project was implemented between two RHA and two hospitals one from each RHA [10]. This pilot tested two HL7 based interoperability scenarios: the creation of a central MPI at the RHA headquarters (by comparing 5 basic data elements of the PID segment of HL7) and the aggregation of specific financial data based upon a specific treatment billed at a packaged price in Greece. This pilot showed that HL7 could be used as a valid and operable interoperability framework that can integrate existing information systems into an interconnected regional healthcare information system.

In response to the aforementioned RFPs and the proposed interoperability framework, more than 10 different consortiums have submitted their proposals to the Greek gov-

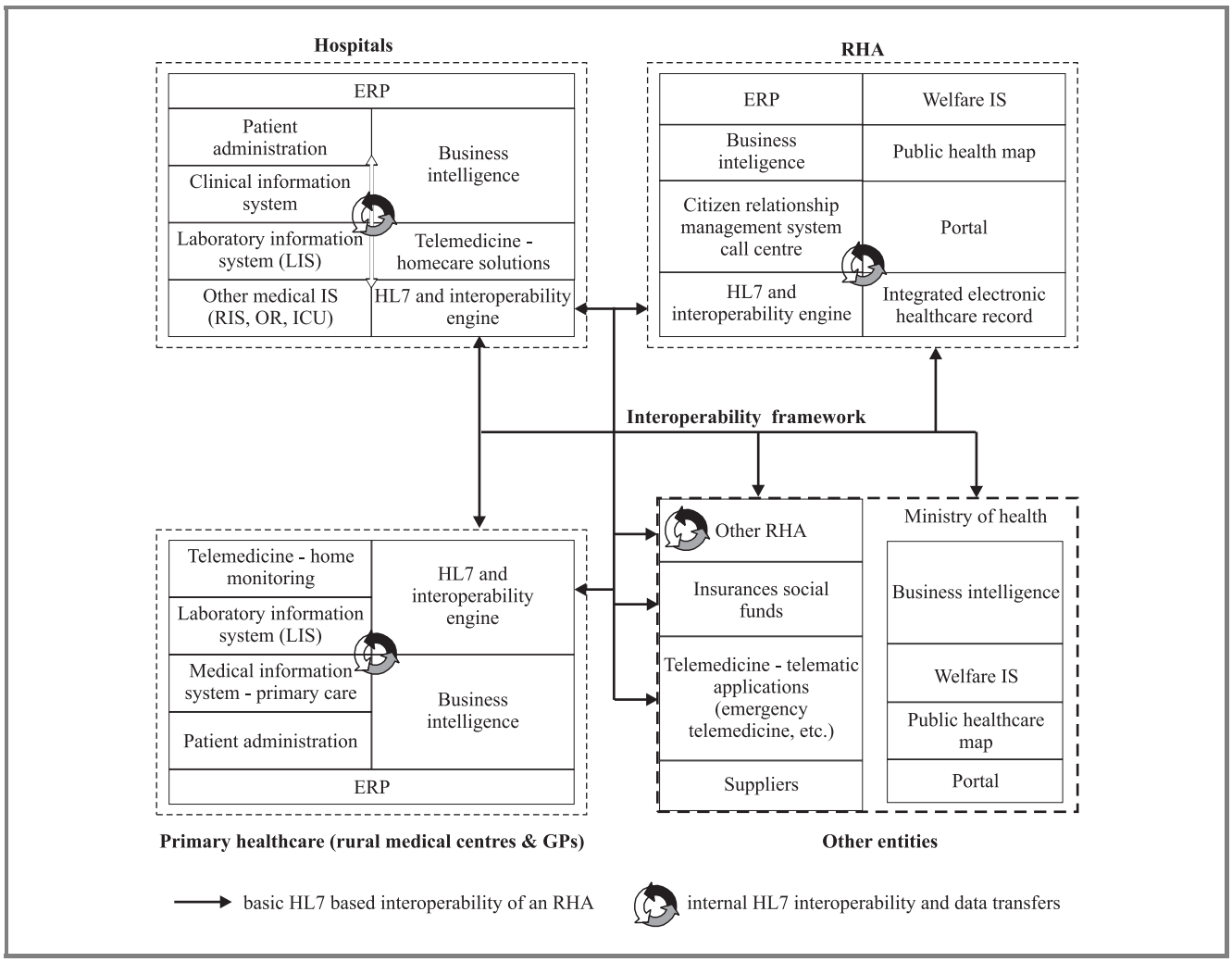

Fig. 5. Regional healthcare based interoperability framework.

ernment. Most of the solutions were based upon well-established IT products and the proposed interoperability framework was well taken into account. All proposals had a clear systems architecture which varied from a totally centralized solution where all information systems are common to all healthcare institutions to a totally distributed one were each hospital or other healthcare facility has its system that are interconnected with a common interoperability infrastructure. Many consortiums proposed a combination of the aforementioned solutions. As the interoperability framework is concerned three main implementation solution were proposed:

1. In the centralized solution the middleware broadcasting system is mainly used to interconnect with third party information systems.

2. In the distributed solution each institution has its middleware or other HL7 engine, while a master middleware broadcasting system is installed at the regional healthcare authority level in order to achieve a common communication infrastructure.

3. In combined solutions, where some existing information systems were maintained, other were centralized (for example the ERP modules) since data exchange can be achieved by internal processes (common database, etc.), while most medical information systems are distributed and interconnected via HL7 based middleware systems.

In all cases the proposed interoperability framework was integrated in each technological solution proposed. The proposed solutions had important variations such as:

– technological differences,

– the complexity of the proposed interoperability framework,

– the level of maintainability of existing information systems,

– the level of complexity in combining various vendors and products,

– the quality of the delivered conformance statements.

The latter point is of great importance since it is a proof of knowledge of each consortium as HL7 usage is concerned. Each consortium included in its proposal a series of HL7 conformance statements.

Table 2
Proposed HL7 messages (non-exchaustive list)

HL7 message profile	Description
ADT/ACK ^ A01	Admit/visit notification
ADT/ACK ^ A02	Transfer a patient
ADT/ACK ^ A03	Discharge/end visit
ADT/ACK ^ A04	Register a patient
ADT/ACK ^ A05	Pre-admit a patient
ADT/ACK ^ A06	Change an outpatient to an inpatient
ADT/ACK ^ A07	Change an inpatient to an outpatient
ADT/ACK ^ A08	Update patient information
ADT/ACK ^ A11	Cancel admit/visit notification
ADT/ACK ^ A12	Cancel transfer
ADT/ACK ^ A13	Cancel discharge/end visit
ADT/ACK ^ A23	Delete a patient record
ADT/ACK ^ A29	Delete person information
ADT/ACK ^ A34	Merge patient information – patient ID only
ADT/ACK ^ A45	Move visit information – visit number
ORM ^ O01	General order message
ORR ^ O02	General order response message
OSQ/OSR- ^ Q06	Query response for order status
OMG ^ O19	General clinical order message
ORG ^ O20	General clinical order acknowledgement message
OML ^ O21	Laboratory order message
ORL ^ O22	General laboratory order response
ORU ^ R01	Unsolicited observation message
OUL ^ R21	Unsolicited laboratory observation message
QRY/ORF ^ R02	Query for results of observation
SRM ^ S01	Schedule request message
SRR ^ S01	Scheduled request response

Table 2 is a short list of the most common message proposed to be part of the interoperability framework. In most of the cases, the quality of the HL7 conformance statements was high, thus increasing the probability of successful implementation of this complex interoperability framework.

4. Discussion

The results of the request for proposal is encouraging from a technological point of view since most of the targeted goals were met and understood by the vendors' community. The described framework requested a common communication infrastructure in order to achieve data exchange in a manageable manner between the different levels of the RHA (RHA headquarters, hospitals, primary care centers, homecare, etc.). Nevertheless, important issues have still to be faced and solved in the implementation process in order to achieve a successful interoperability framework. Some issues are purely technological, some are organizational and some refer to data quality and uniformity. Data quality means dealing, amongst others, with missing database schemata from existing information systems, making decision about common terminologies and taxonomies (i.e., use of ICD10, LOINC, or other classifications), solve the misuse of databases tables, fields and the inconsistent use of data types. From a technical point of view it is probable that databases are not accessible, local area networks are not reachable, communication protocol issues arise or even that computing environments are instable. Finally organizational issues are most likely to tamper the implementation process since there is not enough competent staff placed in healthcare institutions, there is a lack of individual co-operation, complex rules and procedures are in place and still executive officers lack of decision-making will.

5. Conclusion

An important set of ICT developments has started in Greece that intends to promote the quality and continuity of care. The designers of these developments have recognized that the establishment of a robust and mature interoperability framework has to be set up in order for information systems to interconnect and exchange valuable administrative and medical data. HL7 has been proposed as the most valuable solution since the advantages of HL7 clearly outweigh its disadvantages, namely: one standard for the exchange of information between medical applications, and systems, wide spread knowledge of HL7, word-wide acceptance of HL7 by the academic world and the industry and continuous improvement of the HL7 standard through the international HL7 standard organization.
The HL7 integration approach is pragmatic, achieves data integration and provides acceptable integration costs. Finally, the proposed interoperability framework seems to be widely accepted as a solution to enhance ICT developments in the healthcare sector in Greece.

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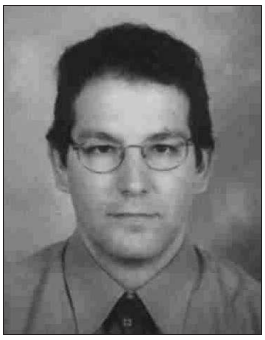

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