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# A health information infrastructure enabling secure access to the life-long multimedia electronic health record

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**Abstract.** In this paper, the requirement for delivering an Integrated Electronic Health Record (I-EHR) service in the 21st century is emphasized and the technological issues related to the development of the required computational infrastructure, enabling the creation and consistent use of a life-long I-EHR service, are addressed. A fundamental requirement for achieving continuity of care is the seamless sharing of clinically significant multimedia information. Thus, in the context of the emerging global information society, many countries consider the creation of and access to the I-EHR of a citizen to be of high priority. This paper discusses the technological infrastructure required for providing access to the life-long I-EHR, consisting of all the health data acquired during interactions of an individual with the healthcare system. In addition, an I-EHR implementation is presented, and issues related to the security of the I-EHR service are also addressed, based on experiences with deployment of the service within HYGEIAnet, the integrated regional health information network of Crete. 

*Keywords:* Integrated Electronic Health Record; Health information network architecture; Health information integration; Role-based access control

## 1. Introduction

Healthcare is a sector that currently experiences a number of pressures, both from inside and outside. The continuing innovation in medicine and healthcare technologies results in new methods and tools in healthcare. The demographic changes of an ageing European population, combined with citizen empowerment, stretch the limits of what countries can afford to offer as services of their national health systems. Governments are confronted by the urgent need to find means to limit the rise in healthcare costs (cost containment) without compromising quality, equity and access. Consequently, new ways to organise and deliver health services are being investigated and experimented with. Public–private

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partnerships in care delivery are emerging. Citizens and patients are given more responsibility in the management of their own health and chronic illnesses.

Within such an environment, the creation and efficient access by all authorised users to a single Integrated Electronic Health Record (I-EHR) for every citizen is the cornerstone for supporting continuity of care and the emerging, novel e-Health and m-Health services, by ensuring prompt and secure access to relevant information resources. Developing an I-EHR service requires the resolution of complex technical issues. The most critical one is the specification and development of a set of generic and domain-specific middleware common services and their integration for the creation of the required Healthcare Information Infrastructure, enabling the required semantic information integration and data security and confidentiality.

## 2. The Integrated Electronic Health Record

The arguments for deploying an I-EHR service are so compelling that a number of countries are striving to develop workable models [1,2]. An I-EHR is *a collection of all of an individual's lifetime health data, generated during relevant interactions with the healthcare system* [3]. A scalable I-EHR would provide the means to access all available clinical information, at an organisational, regional, national or international level, and to meet the challenges posed by patient mobility and the fact that an individual's health data usually resides at many geographically dispersed clinical information systems.

The real and specific problem that underlies the I-EHR concept is *co-ordinated resource sharing and problem solving in dynamic, multi-institutional virtual organisations*. This sharing is, necessarily, highly controlled, with resource providers and consumers defining clearly and carefully just what is shared, who is allowed to share, and the conditions under which sharing occurs.

The task, therefore, from the technological viewpoint is to make data and information securely available in this inter-enterprise environment where needed, when needed and in the format needed. In defining the R&D issues to be resolved for the creation of an Integrated Electronic Health Record for every citizen, we start from the perspective that effective creation of a Virtual Healthcare Organisation requires that we are able to establish efficient and dynamic sharing relationships among any potential participants.

Today the most promising approach toward achieving these objectives is based on a federation of autonomous clinical information systems and a modular underlying Health Information Infrastructure (HII), with services facilitating the seamless integration of and unified access to the distributed clinical data of a citizen.

## 3. Implementation of the technological infrastructure

All necessary electronic activity, dealing with numerous kinds of information in a variety of formats from a variety of sources, is facilitated by the specified integration platform and its common services. Generic and Healthcare-specific IT services track the transmission, processing, and delivery of the raw clinical information. These services constitute what we refer to as the middleware layer of a Regional Health Information Network (RHIN) architecture, i.e. the common services needed to support a set of end-user applications in a distributed networked environment.

The proposed, federated approach towards the I-EHR is based on a set of fundamental principles that include:

- the use of open standards to enable interoperability and integration among multi-vendor applications and services;
- the adoption of a modular architecture to facilitate the development, maintenance and evolution of a scaleable, secure, and affordable computational infrastructure; and finally;
- the ability to support incremental evolution, building upon existing systems, while adding new capabilities as they become necessary.

The Center of Medical Informatics and Health Telematics Applications (CMI-HTA) of the Institute of Computer Science (ICS) of FORTH has deployed HYGEIAnet, an integrated regional health information network on the island of Crete, Greece.

From the technological point of view, a diverse set of state of the art technologies have been developed and deployed as part of the required scalable HII of HYGEIAnet [3]. These include fixed, wireless and mobile communications, distributed computing and middleware (i.e. ActiveX/COM, CORBA), web technologies and services, H.323, X.500, X.509, and also a number of healthcare-specific standards for the implementation of systems and services.

In the above effort, the main challenge has been the design and development of a single, life-long Integrated Electronic Health Record (I-EHR) service, which is capable of supporting unified and authenticated access to clinically significant, multimedia information, including diagnostic medical images and biosignals, in order to support continuity of care and facilitate evidence-based medical decision-making.

A number of dedicated and well-defined services of the underlying Healthcare Information Infrastructure are required for enabling such a service.

These are shown in Fig. 1 and the most critical of them are:

- a patient identification service for the unique identification of patients and the correlation of patient IDs across different ID domains;
- security services under a common public key infrastructure framework to counter all kinds of security threats;

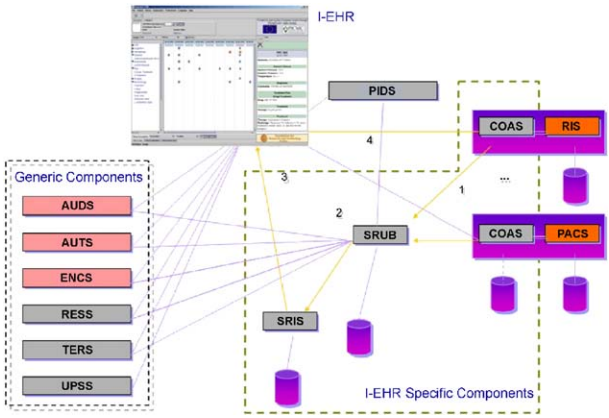


Fig. 1. Generic and specific components of the HII required by an I-EHR service.

- terminology services for the association of existing coding schemes and to enable the transformation of information from one form or representation to another, thus enabling ontology-based information integration;
- health resource services for identifying availability of related resources and the means for accessing them;
- I-EHR indexing services for maintaining meta-information related to the primary health information of a person, maintained by different clinical information systems;
- clinical observation access services enabling access to the sources of primary healthcare information. The Clinical Observation Access Service [4] is a set of interfaces and data structures used by clinical information systems to supply the I-EHR service with clinical observations;
- update brokers responsible for the timely propagation of clinical information to the indexing service and the federation layer.

## 4. Visualising information in the I-EHR

The I-EHR service, as it has been developed and used, provides a decentralized view of the life-long, multimedia health record by dynamically integrating clinical information residing in a variety of heterogeneous clinical information systems [5].

In order to provide uniform access to multimedia clinical information (medical images, ECGs, structured data, etc.), important issues to be considered include the standardization of multimedia data formats and the provision of components for visualising the information contained in the I-EHR. In addition, innovative HCI metaphors are required for effective navigation through the multi-dimensional information space represented by the I-EHR, in order to reduce information overload.

The I-EHR HCI interface (Fig. 2) allows end-users to navigate in the I-EHR information space at various levels of abstraction and supports the viewing of patient demographic data, the time and location of a citizen's encounters with the health system,

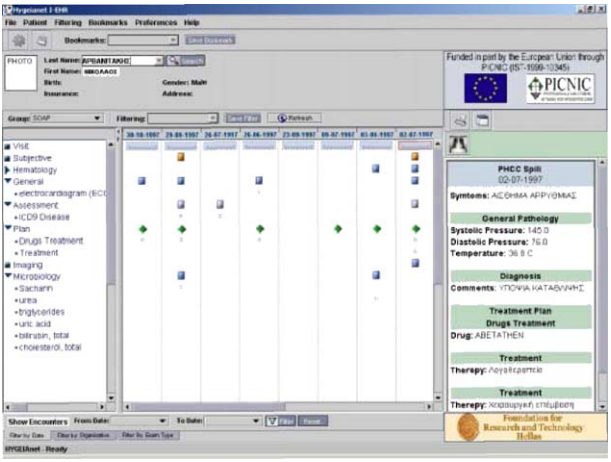


Fig. 2. The I-EHR user interface.

and actual medical data presented according to the Subjective-Objective-Assessment-Plan (SOAP) model. Specifically:

- Patient demographic data provide information required for the unique identification of the subject of care.
- The browsing of encounter-oriented information facilitates the review of a patient's health record through visual cues indicating the availability of specific medical information.
- A viewer of clinical findings is used to display actual medical data. The viewer supports a number of dedicated multimedia plug-ins for the visualisation, processing and analysis of multimedia medical data. Thus, a DICOM viewer and a SCP-ECG (Fig. 3) viewer enable the visualisation and analysis of medical images and ECG data.

The I-EHR interface also supports healthcare professionals in constructing information filters that help them converge on the most relevant data, related to each case under investigation, by hiding data considered to be of no interest, thus minimizing the risk of missing important information as a result of information overload.

## 5. Security-related issues

Deployment of an I-EHR service in the context of HYGEIAnet, as well as in the South and East Belfast Trust (SEBT) in Northern Ireland, has revealed a number of clinical and operational benefits. At the same time, a formal risk analysis of the I-EHR service revealed that user confidence, in relation to the trust and security infrastructure of the RHIN, is an important factor influencing user adoption.

Trust and security is a critical area in which healthcare presents demanding and challenging needs. Confidentiality and security of patient data is considered paramount. Private data needs to be accessed by professionals having a qualified role, with the consent of the patient and under strict audit controls. The trust and security framework emerging from these needs are realised in HYGEIAnet by using VPN, SSL, smart cards, PKI, security certificates and digital signatures.

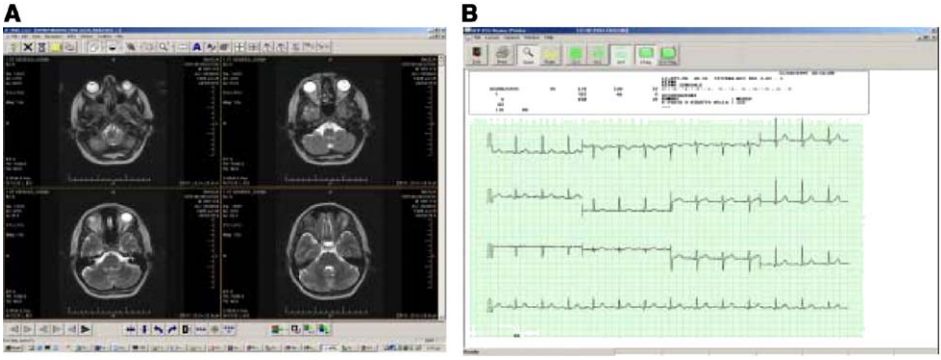


Fig. 3. Visualising multimedia clinical data through the I-EHR user interface.

Specifically the design and implementation of proper models for authorisation and access control [6] have proven essential for adoption of the I-EHR by end users in modern RHINs. The I-EHR implementation, presented in this paper, is based on a role-based access control (RBAC) authorisation model, as proposed by the National Institute of Standards and Technology (NIST) RBAC reference model [7].

RBAC regulates a user's access to computer resources based on organisational roles. The authorisations are not assigned directly to particular users, but to roles. A role denotes a job function describing the authority and responsibility conferred on a user assigned to that role. The RBAC model has suitable capabilities to support the access control requirements to the I-EHR at enterprise level, such as feasible fine-grain access policy administration for large number of users and resources, policy neutrality and the need-to-know security principle. It is equally suitable in a RHIN, when such a RHIN is viewed and implemented as a Virtual Healthcare Organisation.

## 6. Conclusion

In this paper, issues related to the creation as well as consistent and secure use of the I-EHR service are addressed and technological requirements for delivering the I-EHR service in the 21st century are emphasized.

The findings to date are extremely encouraging and suggest that the I-EHR service can benefit not only the patients, but also health professionals by fostering their collaboration and serving as a tool for continuing education. Available evidence also indicates that, in addition to providing support for continuity of care, the I-EHR is a valuable tool for basic and clinical research, medical decision-making, epidemiology, evidence-based medicine, and in formulating public health policy.

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