A framework for the integration and homogeneous management of electrocardiography formats

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Abstract: **In recent years, a large variety of protocols and standards have been proposed in the context of digital electrocardiography. This multiplicity generates a clear lack of integration and interoperability in electrocardiogram (ECG) standardization. Some pairwise converters have been proposed and developed but such an approach is not cost-effective, since it requires a large number of mappings. Therefore, to efficiently administer the various formats, some management systems are required. In this paper, a framework for the integration and management of the different ECG formats is proposed. This framework is a Java-based application comprising four main parts: a servlet, an applet, a database and a web page. The primary idea of this approach is to provide with converter classes to a central format. Then, since ECGs are stored in the same format, they can be homogeneously managed, stored and visualized.**

Introduction

The electrocardiogram (ECG) is the most commonly performed cardiac test. With the rapid development of new telemonitoring platforms, the transmission, storage and management of digital ECG signals have turned into major topics of debate and investigation.

In this context, a wide range of standards have been proposed as, for example, the Standard Communications Protocol for computer assisted ElectroCardioGraphy (SCP-ECG), HL7 annotated ECG (HL7 aECG), or Digital Imaging and Communication in Medicine (DICOM). But the list of proposed formats seems to be endless: Medical waveform Format Encoding Rules (MFER), General Data Format (GDF), File Exchange Format (FEF), PhilipsXML, ecgML along with some other XML proposals, etc.

In the literature, several projects covering the relationship between two or more of these standards can be found. Examples of those relationships are:

HL7 aECG with Philips XML [1], SCP-ECG with DICOM [2-3]; or SCP-ECG and HL7 aECG with DICOM [4].

However, this point-to-point approach is not cost-effective, since the number of pair converters required is n*(n-1)/2, whilst with a central format approach the number of converters needed is n (being n the number of involved formats). Besides, hospital management services face up to a challenging problem, since they are forced to cope with several different formats and visualization applications.

Some other initiatives have been already carried out in this integrating direction [5-7], but in [5] there is no central format, in [6] the chosen central format is HL7 aECG and some fields for example from DICOM could not be translated into this format, and in [7] only XML files are considered.

Methods

The proposed framework is based on Java and it comprises four main parts: a servlet, an applet, a database and a web page (Fig. 1). The servlet is in charge of the parsing and subsequent conversion of ECG files into the central format. Thus, it contains the different converters that have been developed. In our framework, we have considered the following formats: SCP-ECG, HL7 aECG, DICOM and Philips XML. The applet is basically the visualizer itself. It displays the ECG signals as well as patient and manufacturer information. It also allows taking measurements on the ECG signal. An applet vastly simplifies the accessibility, since only a standard web browser is required to use the system. Within the database, the ECG files are stored. The database is accessed through the web page (to list the stored ECG) and the servlet (to extract an ECG file or to store a new one). Finally, the web page is used to emulate a Hospital Information System. It interacts with the database, the servlet and the applet.

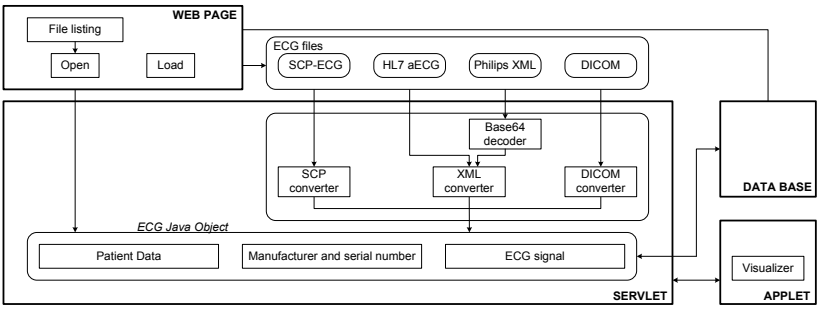

Fig. 1 – Software architecture of the system.

The central Java ECG Class uses an internal XML-based ECG format, which provides versatility and integration. It has been designed by analyzing the common point of the four standards considered.

In Fig. 2 the entity-relationship diagram of the system is shown, including the core classes and methods implemented and the main actions that can be performed. The front-end of the application is shown in Fig. 3.

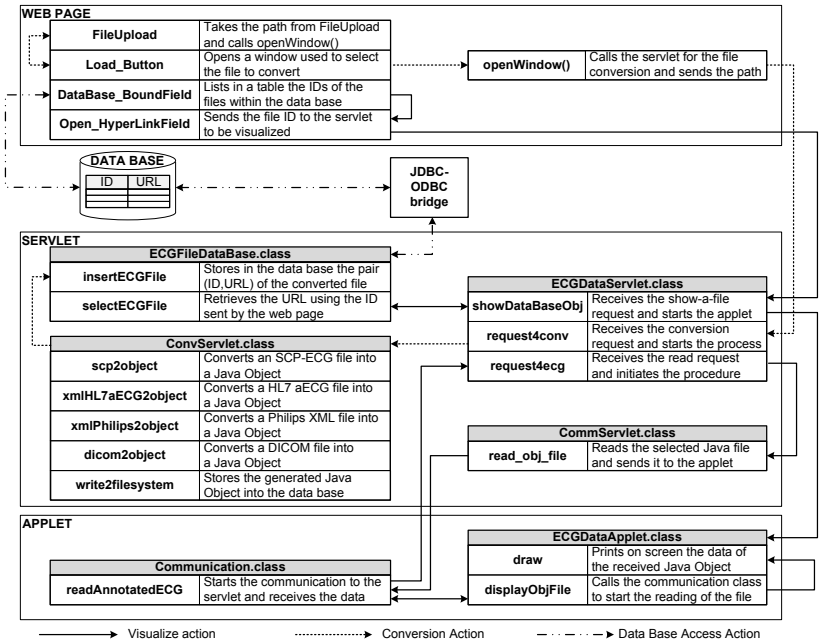

Fig. 2 – Entity-relationship diagram

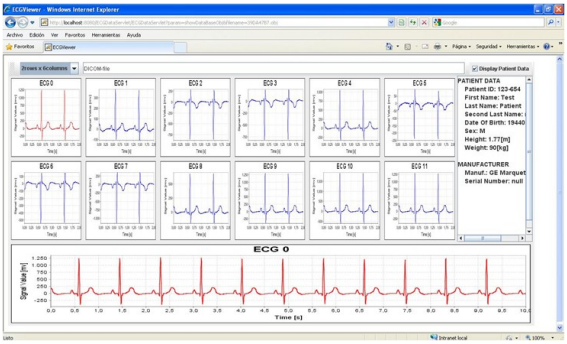

Fig. 3 – ECG visualizer

Conclusions and Future Lines

A framework for the integration and homogeneous management of electrocardiography formats that could arrive to a central hospital server has been designed and developed, solving this way the problem of co-existing ECG formats and avoiding the use of different managers.

After analyzing the varied architectures of the most prominent ECG formats it can be concluded that, in the current context of ECG standardization, there is no consensus regarding neither the structure nor the fields that a digital ECG file should contain. That is the rationale behind the decision of creating a new open central format, able to manage all the different fields of all standards.

The designed framework also provides with modularity (supporting a new ECG format is as easy as developing its converter class) and accessibility (just a web page is required to use the system).

Future lines include adding new converter classes; adding support for comments and annotations; and the design of the central format based on an ECG ontology. Another issue currently under consideration is the inclusion of privacy and security in the system in order to guarantee confidentiality, integrity and origin of the signal.

Acknowledgment

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