

# Interoperability with XForms for medical reports. Application to echocardiography

P.G. KAPIRIS<sup>1,3</sup>, J.G. KAPIRIS<sup>2</sup>, G. KONTOYIANNIS<sup>1</sup>, C. NOMICOS<sup>1</sup>  
C. SKOURLAS<sup>4</sup> and P. CHATZIDIAKOS<sup>1</sup>

<sup>1</sup>Technological Educational Institute of Athens, Dept. of Electronics

<sup>2</sup>Cardiology clinic, General hospital of Athens "ELPIS"

<sup>3</sup>University of Athens, Dept. of physics

<sup>4</sup>Technological Educational Institute of Athens, Dept. of Informatics

TEI of Athens, Egaleo, Agiou Spyridonos 1, 12210

GREECE

*Abstract:* - XForms in e-Health is the key of interoperability of clinical data and Personal health records. The health system is one of the most complicated and enormous system of social activities and the data exchange is important for health service quality. XML combined with XForms reveal a rosy prospect in efficient and flexible data mining. Before any standard, starting from a simple office application in a laboratory of Echocardiography we propose a way of managing medical reports to be applicable in future medical data Banks.

*Key- Words:* - XForms, e-Health.

## 1 Introduction

Personal health records (PHRs) are an emerging technology to enable people to electronically manage their health information and that of others for whom they are authorized. PHRs allow an individual to store and manage important information about his or her current health status, and their medical history. PHRs are available in several formats today, such as stand-alone software applications installed on a personal computer, or a website hosted by a private company, provider or insurance agency. They may be populated by Electronic Health Record systems (EHRs) managed by provider organizations. Using a PHR can allow an individual to be more involved in his or her own care and health management. Therefore, PHRs have the potential not only to improve personal and family health but also to support national objectives for health care quality, safety, efficiency and ultimately, health outcomes.

There are currently many models of personal health records. Two broad types of PHRs are evolving in the private and public sectors, distinguished primarily by their relationship to EHRs. One is a patient-facing extension of clinician-

controlled EHRs; the other is not routinely linked to the patients EHRs.

Some large health care organizations are developing models in the first category. These PHRs give enrollees a view of their EHRs along with other functionalities that facilitate administrative tasks (e.g., appointments and medication refills), health and disease self-management (e.g., exercise or blood pressure records), communication with physicians, and access to health information resources.

Free-standing PHR products are offered by several dozen companies. In general, there is greater variety among these products, which typically are made available to consumers through a third-party sponsor such as a health plan, employer, or disease management program. By definition, the PHRs in this group do not derive from EHRs, although some are designed to link to users EHRs through voluntary participation by their health care providers.

## 2 The XML goal

In this article we try to propose a design model for hospitals and health care providers of enhanced PHRs containing almost full clinical data. The technology proposed is the XML which is a standard representation or exchange format. It provides a standard framework for structuring textual documents but it does not standardize the content of these documents. The key is the keep of clinical data in local repositories associated with at least the patient's id number in national medical assurance system. An efficient data exchange may construct the full medical history with the data and the medical reports. This will likely reduce health care costs and improve patient care while it shall be possible to re-examine past information no matter where previous health care services were offered.

The standards in the contents may take a long time to be adopted as it must be acceptable by the community of physicians. Although the messaging should be standard. We simply propose the use of e-forms instead of hard-copy forms of medical reports that results output an XML document designed inside each health care provider, e.g. a hospital, in order to content the usual practice and capabilities of the provider. Then let a central more sophisticated system to combine and unify all collected XML records found anywhere.

In the followings, we shall explain how XForms can be a useful tool to bypass usual desktop office activities like the word processing of a medical report to an XML composer of medical information that can be easily and automatically submitted to a local or inside an intranet repository system.

As a case study we deal with the composing of a medical report of an ultrasound imaging of heart. Ultrasound imaging is ideal for imaging the heart and the blood vessels. It can evaluate heart wall, chamber and valve motion, as well as blood flow within the heart and blood vessels. We translate a form that is filled by the physician to Xform and we produce an XML that is transferred to an XML collection database.

## 3 XML for office applications

Recently almost all the best featured office applications like "Star office", "Microsoft Office" and "Open Office" have adopted the XML as the for-

mat for saving the documents. Recently, Microsoft has announced its plan to use XML schema in the new "Microsoft Office Open XML Formats" for its next version of Microsoft Office editions, now referenced under the code-name "Office 12." These "default" XML file formats are designed as an extension of the WordprocessingML and SpreadsheetML schema and are intended to be interoperable with binary formats of Office 2000 and later.

On the other hand, OASIS, a non-profit, international consortium that creates interoperable industry specifications based on public standards such as XML and SGML, issued a Call for Participation in a new "Open Office XML Format Technical Committee". The TC members intend to create an open, XML-based file format specification for office applications. Michael Brauer (Sun Microsystems) will chair the TC. The proposed XML file format is to be "suitable for office documents containing text, spreadsheets, charts, and graphical documents." It will be compatible XML v1.0 and W3C Namespaces. The file format will "retain high-level information suitable for editing the document and keep the document's content and layout information separate such that they can be processed independently of each other." For interoperability, it must be "friendly to transformations using XSLT or similar XML-based languages or tools. The design will borrow from similar, existing standards wherever possible and permitted. Since the OpenOffice.org XML format specification meets these criteria and has proven its value in real life, this TC will use it as the basis for its work. Sun Microsystems intends to contribute the OpenOffice.org XML Format to this TC at the first meeting of the TC, under reciprocal Royalty Free terms. TC work will be done in two phases, each resulting in a Committee Specification that includes (1) a set of XML DTDs/schema setting the vocabulary, constraints and semantics of the file format in question, and (2) a set of written specifications that describe the elements and attributes of the DTDs/schema in plain English." Now the so call "Open document" has become an OASIS standard

InfoPath [codename "XDocs"] is the Microsoft Office Information-Gathering Application. XDocs was the code name for a new product in the Microsoft Office family which streamlines the pro-

cess of gathering information by enabling teams and organizations to easily create and work with rich, dynamic forms; the information collected can be integrated with a broad range of business processes because XDocs supports any customer-defined XML schema and integrates with XML Web services. In other words “XDocs” is a piece of software that connects data entry with XML.

XForms uses XML for data definition and HTML or XHTML for data display. XForms separates the data logic of a form from its presentation. This way the XForms data can be defined independent of how the end-user will interact with the application. Separating data from presentation makes XForms device independent, because the data model can be used for all devices. The presentation can be customized for different user interfaces, like mobile phones, handheld devices, and Braille readers for the blind. The XForms are now implemented by vendors and are ready to be used in production applications. Although they are new they meet a great support by the community. In our case the XForms standard are already included in the “OASIS Open document v1.0” used by the “OpenOffice v2.0”.

After all “XDocs” and “XForms” applications seem pretty similar. What really are the differences?

- XForms is a Royalty-free W3C technology. There are multiple choices of tools, both commercial and open source. You never need a subscription to Microsoft Office in order to fill in a form and you never need to pay a fee of few hundreds of dollars.
- XForms is ready today and spread in enough applications and people are already being productive with XForms tools.
- As a W3C technology, XForms focuses on interoperability. The XForms Working Group is finalizing a Test Suite to ensure that no single vendor sets the standards. Note that the matter of interoperability is essential for e-Health applications.

## 4 A proposed e-form for medical report of ultrasound heart imaging

An example of using the XForms is the composition of an XML opendocument in OpenOffice that shall imitate the medical report of exercise echocardiography (ultrasonic examination of the cardiac muscle mobility during stress) [1, 2]. The hard-copy form was kindly offered to our group by the cardiology clinic of the Greek general hospital “Elpis”, which means “hope” in English. According to that report, the heart is divided into sixteen parts. Six sections (1-6) are located in the “base” (upper part of heart), six more sections (7-12) are located in the “middle” (middle part of heart) and finally four sections (13-16) are located in the “apex” (lower part of heart).

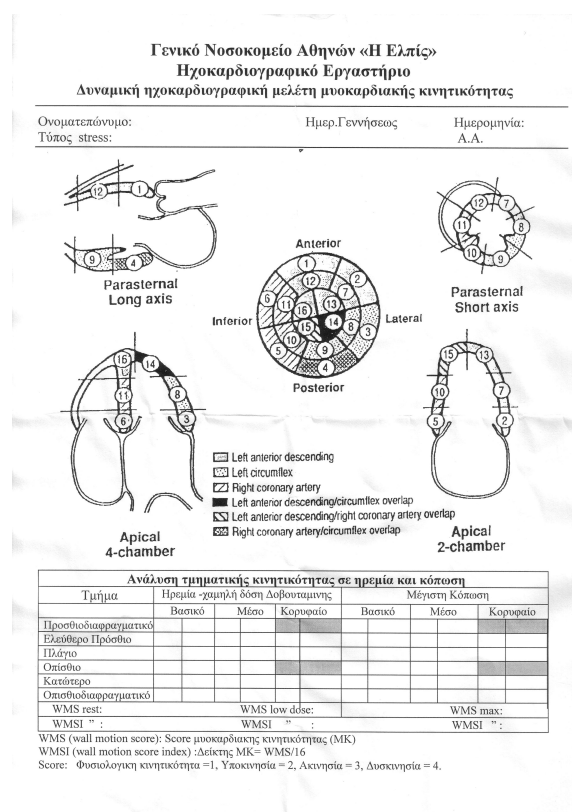


Figure 1: The original hard-copy form in Greek language.

The report refers to the wall motion score that is the score of cardiac muscle mobility in each of the sixteen sections in four different conditions induced either with physical activity or pharmacologically (a) rest state (b) state of low dose of dobutamin (c) state of maximum exhaus-

tion(d)post exercise. Finally the wall motion score index (WMSI) is calculated as the average over all scores. The score grades are four, 1 for normal mobility, 2 for sub-mobility, 3 for immobility and 4 for unliveliness. The walls of the heart are divided as follow: the base part and the middle part has the (a) anterior septum, (b) anterior free wall, (c) lateral wall, (d) posterior wall, (e) inferior wall and (f) posterior septum. The apex has the (a) anterior free wall, (b) lateral wall, (c) inferior wall and (d) posterior septum.

The above scenario is a case of structural data that can be implemented in XML format. The present status is the filling of a table of the form in Fig. 1 (table with Greek notations). A proposed custom XML shcema is the above

## 5 Working process

### 5.1 The e-Form

We choose the opendocument format used by the openoffice v2.0 and with the writer program of the suite we build an electronic version of the form of Fig. 2. The way to do so is to define the instance XML and to add the appropriate controls into the cells of the table. The filled table can be printed and a hardcopy version can be given to the patient following the usual procedure.

The great advantage is the submission procedure that is declared in XForms. Many employers are not experienced and do not have the knowledge to efficiently manage the “File System” of an operating system even if they operate quite well a word processing application like MSworld or OooWrite e.t.c. So a non expert may be able to compose an e-form in a world processor which must be a very “user friendly” application (both MSword and OooWrite is WYSIWYG programs). After the operation of a submission a handler is triggered to make the rest of the job. the OooWriter program in its new implementation of XForms, the submission procedure is just an http request to a server containing the XML instance data of the Xform. The http request is defined by an associated URL to the submission control (usually a button). In our case the handler of the delivered XML is a Servlet or a JSP page. That’s why a servlet and JSP container engine must be

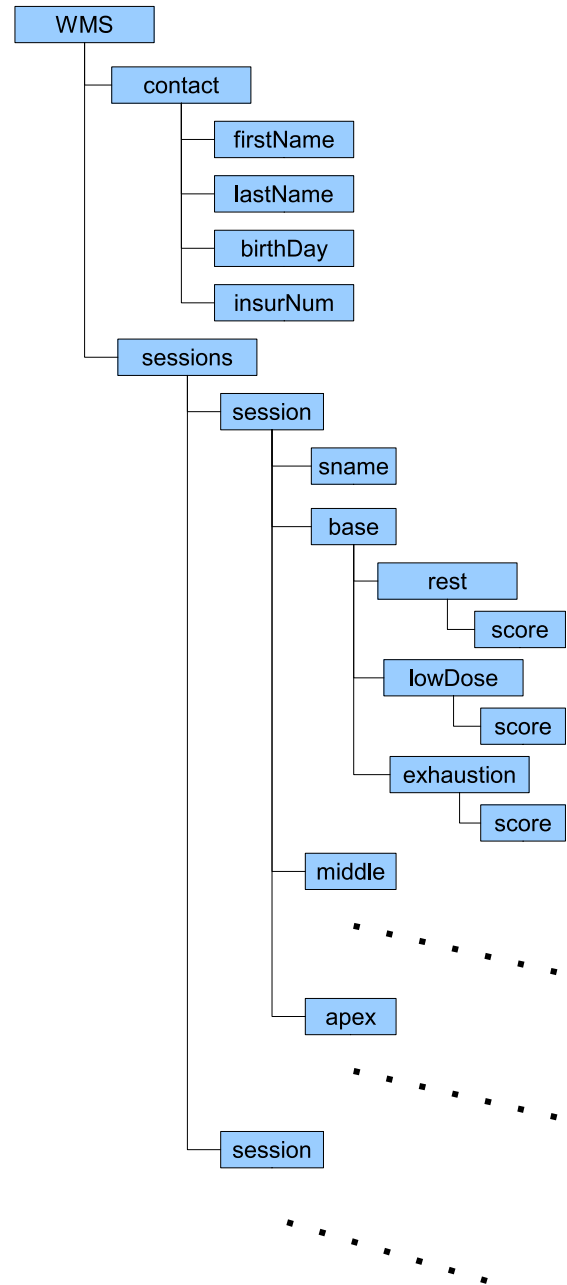


Figure 2: Schematic diagram of a proposed XML schema for reporting the cardiac muscle mobility

installed in the PC that serves the XForm or somewhere in the intranet that the PC belongs to. A minimal code of such a JSP page should look like this.

```
<%
/*
this code simply saves the
supplied xml instance
*/
    Reader reader = request.getReader();
    char[] buf =
    new char[request.getContentLength()];
    reader.read( buf );
    String s = new String(buf);
    s = s.toLowerCase();
    //Sanity Check , change to lowercase
    //response.setContentType("text/xml");
    //out.write( s );
    try {
    /*
    a code here may parse
    the XML and decide
    the filename to be written to
    */
        FileWriter fw =
        new FileWriter(
            "/a fulpath to filename");
        fw.write(buf);
        fw.close();
    }catch (IOException e) {}
%>
<%@ page import="java.io.*" %>
```

The above code is based on an example code inside the Chiba web project. The same code as in the above scriptlet can be the core of a servlet code. The JSP container used was the "Apache Tomcat server". For a higher level of integration the "Jetty server" offer a monolithic embedded servlet container that can handle the XML in background.

That way a very simple framework can be made to create a collection of file in an automated way with minimum coding providing a ready to be imported data bank.

## 5.2 Migration to a possible forthcoming future consolidated standard

An arbitrary XML schema like the one we used before can be easily transformed to an XML through an XSLT processor. So the present collection of

XML of the above schema can be imported to bigger projects of medical data banks. The question is how easy is to modify the e-form to interact straightly to a new standard. As it is shown from until now experience, the form design need not to be changed because it covers the information the physicians can provide. So, extensions cannot be decided by software engineers but only by the physicians' community in order to conform new scientific facts and new technological capabilities in diagnostics methods. So, the only modification that has to be done is to apply the new data schema to the instance of the XForms and to change the bindings of the control elements inside the form to conform the new xpath declarations.

## 6 Plans and conclusions

Excepting OpenOffice, there are other XForms engines that use different approach than that of an office document processing application. For example an free XForms engine is "Chiba" that is a web application (in actual it is a framework one can use to implement XForms) translate XHTML and XForms to normal HTML forms. The technology of medical report e-form can very easily pass to HTML forms in a zero installation way. But this forces users to be online in a network. Similar project to "Chiba" is the commercial project "ORBEON". Recently, some implementations focus on client side. Such projects are the "x-ports", "Novel XForms" and "Oracle wireless client" that uses the plugin technology of web client to extend the XForms functionality. Very soon the "Mozilla/Firefox" project will have native support to XForms. Although the Office Applications are more widely used it is almost sure that the XHTML+XForms shall be the next standard for online form completion. One way or another the server side handling will be invariable.

The next effort is to combine the OooWrite program with the "Jetty" Project and "eXist" project. The API needed in the servlet is the "XML:DB API". This allow the programmer to combine XML files in collections and to manage data with single xpath queries. That way of working reveal a rosy prospect in efficient and flexible data mining. In combination with XSLT every single embedded database can easily produce well formed XML of any schema. This operation is

a key of interoperability in a complicated, multitudinous and multi-furious environment such as the health care system. Interoperability is the key for automated enhanced PHRs combining health care records with full clinical data that may help to construct a full and accurate health history of the patient.

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#### *References :*

- [1] N Bom, CT Lancee, J. Honkoop, and PC Hugenholtz. Ultrasonic viewer for cross-sectional analyses of moving cardiac structures. *Biomed Eng*, page 6:500, 1971.
- [2] N Bom, CT Lancee, G Zwieten, F Kloster, and J Roelandt. Multiscan echocardiography i. technical description. *Circulation*, 48:1066–1074, 1973.
- [3] <http://www.w3.org/TR/xforms/>. *XForms 1.0*.
- [4] <http://www.w3.org/MarkUp/Forms/>. *The Next Generation of Web Forms*.
- [5] <http://www.w3.org/XML/>. *Extensible Markup Language (XML)*.
- [6] <http://www.w3.org/TR/REC-xml>. *The XML 1.0 specification*.
- [7] <http://www.w3.org/TR/xml11>. *The XML 1.1 specification*.
- [8] <http://www.sun.com/software/star/staroffice/index.xml>. *StarOffice 7 Office Suite*.
- [9] <http://office.microsoft.com/en-us/default.aspx>. *Microsoft Office*.
- [10] <http://www.openoffice.org/>. *OpenOffice*.
- [11] <http://www.microsoft.com/office/preview/fileoverview.mspx>. *Microsoft Office Open XML Formats Overview*.
- [12] <http://www.oasis-open.org/home/index.php>. *OASIS*.
- [13] <http://www.w3.org/MarkUp/SGML/>. *SGML*.
- [14] [www.sun.com/](http://www.sun.com/). *Sun Microsystems*.
- [15] <http://www.w3.org/TR/xslt>. *XSLT*.
- [16] <http://office.microsoft.com/en-us/FX010857921033.aspx>. *Microsoft InfoPath*.
- [17] <http://www.w3.org/TR/xhtml11/>. *XHTML*.