XML Furthers CPR Goals

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Many healthcare facilities have instituted Internet-based healthcare computing applications to better manage and communicate health information.[1] Realizing the power and potential of the Internet, various health information system vendors are developing Web-based applications. The advent of these computing applications is encouraging; however, the extent to which each system is able to accommodate and represent the detailed, textual compilation of documents that make up the medical record is questionable.

These applications rely on databases to store and manage patient records, which are made accessible through the Web by converting database tables into HTML (hypertext markup language) documents.[2] There are two drawbacks with this approach. First, although database systems have proven themselves effective in managing health information, they may not be the best way to store and represent the medical record. Second, HTML was created to determine how information should be displayed over the Internet, not the context in which it should be displayed.

Meeting Technical Needs

In response to the need to develop a universal language to describe and store documents published on the Web, the World Wide Web Consortium adopted the eXtensible Markup Language (XML) as the standard for describing information and structuring Web documents to conform to a common set of rules. A markup language is a method to present and describe the contents of a document. This is accomplished through the use of tags to enclose data elements of a document. (For more detailed information on markup languages and tags, see "XML Makes Its Mark" in the *Journal of AHIMA* 70, no. 10 (1999): 21-24.)

One of XML's predecessors is HTML, which does a fine job of presenting and displaying documents, but it cannot describe the context of the data in these documents. Instead, HTML tags simply tell the Web browsers how a document should look. HTML is a static and non-extensible language, meaning that the syntax or semantics cannot be modified as they can in an extensible mark-up language.[3] Extensibility, the ability to be modified or changed as well as produce other markup languages, is an important feature when dealing with complex documents where it is useful to define relationships between data elements.[4]

XML's Many Advantages

With XML, we have an easy-to-learn, standardized mark-up language with customizable tags that describe the data within documents. It is a metalanguage, meaning that it is a language used to describe the content of data contained in documents, and it is designed for use on the Internet.

One attractive feature of XML is the ability to develop custom tags for describing data elements in a document.[5] This is a major improvement over HTML, where a limited number of tag sets are available, and the tags provide little or no indication about the type of data that is being marked up with the tags. With XML, the tags can be self-explanatory, making it easy to determine the type of information contained in each tag set.

Another benefit of XML relates to the established set of rules that must be followed in order to develop a well-formed XML document. In other words, XML documents must meet certain standard requirements that are used to validate the document. These rules are contained in what is called a document type definition (DTD), which is a file associated with an XML document that defines how the mark-up tags should be interpreted by the application presenting the document. Each well-formed document follows the rules in the DTD.

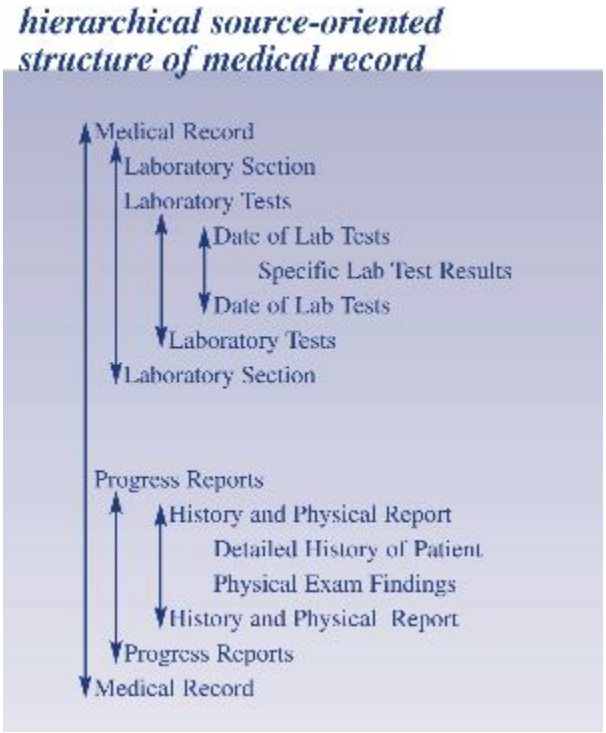
As a result, different XML documents can be categorized according to classes, whereby documents with similar characteristics are grouped together hierarchically. This type of organization makes it easy to develop new documents that exhibit characteristics of the base class, yet possess unique attributes that are not a part of the main class of documents from which the new document was created. Just as XML documents are organized according to classes, so too is the source-oriented medical record (where the documents are organized according to the department that generates the information), making a possible marriage between XML and the medical record a good fit.

Following are some XML characteristics that make it relevant to the development of the Web-based medical record:

- XML, together with standard classification systems already in use (ICD-9- CM), can potentially improve the completeness of medical records by providing a clear description of the content of data in the medical record, thereby making it easier to assign a classification code [6]
- XML provides a document-centric solution to how data contained in the medical record can be organized in a meaningful and searchable form
- XML can serve as the standard for the exchange of patient information (via the Web) to support patient care, which before has been impeded by the fact that different healthcare facilities use heterogeneous and stand-alone information systems to store and manage patient information

Exploiting the Document Hierarchy

The paper medical record can be described as a collection of various documents or forms. Within the medical record, there are administrative forms, clinical forms, operative forms, ancillary forms, etc., that are used to document data about each patient.[7] These forms can be organized into different views or formats. Most commonly, the format used in today's healthcare facilities is the source-oriented approach, whereby the patient data are grouped together according to the source or department that generates the data. For example, all lab reports will be filed under the lab section in the medical record, all radiology and x-ray related reports will be found in the radiology section, and so on. In essence, this record format follows a hierarchical or tree-like structure.[8]



"Hierarchical Source-Oriented Structure of a Medical Record" illustrates the idea of the medical record being grouped hierarchically according to departments, where the lab section contains a lab report, and the lab report displays a lab test, and the lab test has a specific value. Each category of data contains within it smaller subcategories, and within those subcategories of data, further divisions occur. This source-oriented approach of organizing the documents of the medical record lends itself to being "marked up" by XML and has been determined to be effective in structuring the computer-based patient record.[9]

Most electronic medical record applications today rely on the use of a relational database management system to manage patient information. Relational database systems have proven themselves effective, yet these systems are deficient in their ability to provide as detailed levels of data granularity as XML is able to represent. Data granularity refers to the level of detail associated with data and their attributes.[10] The use of XML to represent medical record documents is a completely different concept than the use of a database management system to maintain patient information. Where-as relational databases organize information into tables according to entities and their associated attributes, XML employs a document-centric approach to organize the information, just as the information is organized in the source-oriented medical record: hierarchically.

Fortunately, the Internet has also brought a monumental change to the development of database systems. Recognizing the importance of XML as a common language for Internet-based data management and exchange, major database vendors have

adopted XML into the core engine of future database management systems. The new database systems will be capable of capturing XML-based records into the database, as well as storing and retrieving the records from the database. Examples of such systems are the upcoming Microsoft SQL Server 2000 and Oracle 8i.

Example of Source-Oriented Medical Record Structure Using XML Source Code

The use of XML to mark up medical record documents assumes that each type of document included in the medical record can be represented hierarchically. Therefore, the development of standard hierarchical document structures for common forms found in the medical record is paramount to the success of XML in supporting an electronic medical record that is represented in a standard form. Using the logical relationship structure that exists in the source-oriented medical record, we can create well-formed documents that can be parsed, which is illustrated in "Example of Source-Oriented Medical Record Structure Using XML Source Code." There are XML software tools available to assist in this effort. Further, medical record information exchange between disparate computer systems has primarily used the HL7 messaging standard to represent necessary patient data segments and efforts to determine whether XML can support the HL7 messaging standard have proven successful.[11]

XSL Adds Critical Style

The Web-based medical record will need to be flexible to accommodate the many different types of users of the record. Healthcare professionals requiring access to information contained in the medical record need to view the information in specific presentation formats that meet their information needs.[12] XML facilitates custom medical record information display using XSL (eXtensible Style Language) style sheets. XSL style sheets are XML documents that contain rules regarding how specific XML tags should be displayed.[13] The original XML document and its respective style sheet are merged together to form an HTML document that will be displayed on the Web. XSL style sheets allow different XML medical record documents to be presented and displayed according to the needs of the user.

Each data element contained in XML documents can be custom formatted using five properties available in the style sheets: font, color, text, box, and classification properties. Most applicable to the healthcare professional might be the text and box properties. The text property allows the user to modify spacing, alignment, and other features that determine how the text is displayed, while the box property makes it possible for the user to define the specific data element location on each page.

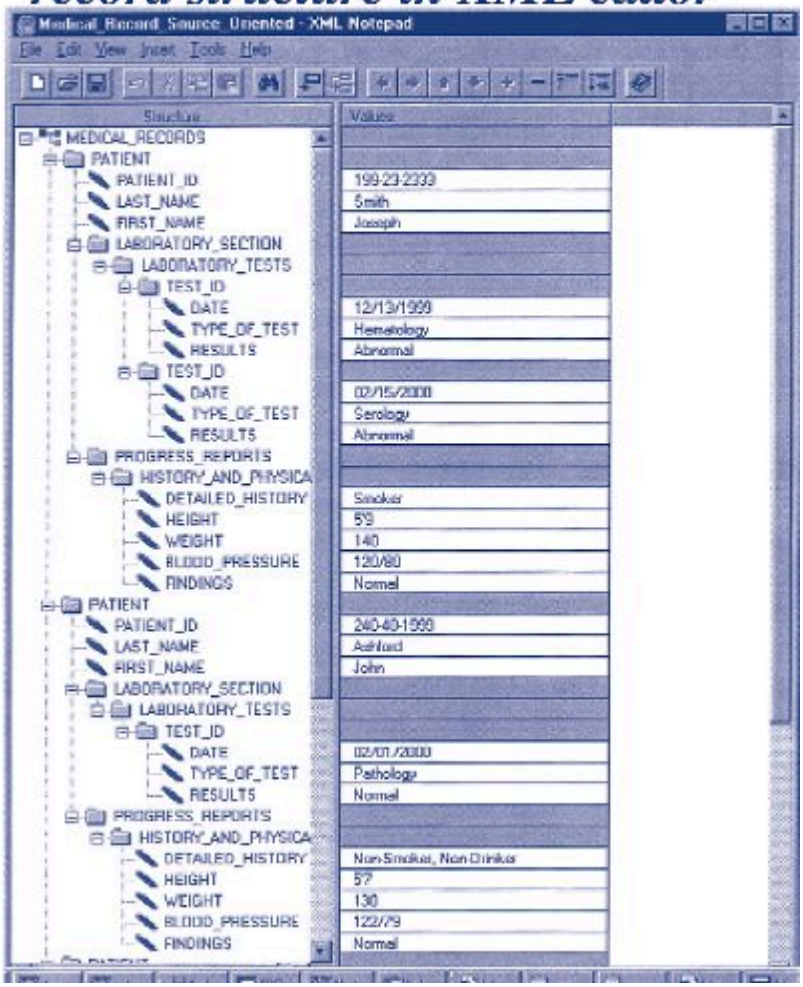
Challenges to XML Implementation

The advent of XML and its associated benefits in representing the content of the medical record on the Web is not problem-free. First, while the extensibility of XML is touted as one of its main advantages, one of its primary features poses a problem: the reuse of information modules to develop new XML mark-up specifications.[14] To realize the full potential of XML as a standard mark-up language in which individuals have the ability to develop custom specifications while at the same time allowing access to these specifications to allow for information resources sharing, the need to develop and maintain some sort of repository to facilitate

```
<?xml version="1.0"?>
<?xml-stylesheet type="text/xsl" href="medrecordlabstyle.xsl"?>
<MEDICAL_RECORDS>
 <PATIENT>
 <PATIENT_ID>199-23-2333</PATIENT_ID>
 <LAST_NAME>Smith</LAST_NAME>
 <FIRST_NAME>Joseph</FIRST_NAME>
 <LABORATORY_SECTION>
 <LABORATORY_TESTS>
 <TEST_ID>
 <DATE>12/13/1999</DATE>
 <TYPE_OF_TEST>Hematology</TYPE_OF_TEST>
 <RESULTS>Abnormal</RESULTS>
 </TEST_ID>
 <TEST_ID>
 <DATE>02/15/2000</DATE>
 <TYPE_OF_TEST>Serology</TYPE_OF_TEST>
 <RESULTS>Abnormal</RESULTS>
 </TEST_ID>
 </LABORATORY_TESTS>
 </LABORATORY_SECTION>
 <PROGRESS_REPORTS>
 <HISTORY_AND_PHYSICAL>
<DETAILED_HISTORY>Smoker</DETAILED_HISTORY>
 <HEIGHT>5 9</HEIGHT>
 <WEIGHT>140</WEIGHT>
 <BLOOD_PRESSURE>120/80</BLOOD_PRESSURE>
 <FINDINGS>Normal</FINDINGS>
```

```
 </HISTORY_AND_PHYSICAL>
 </PROGRESS_REPORTS>
 </PATIENT>
 <PATIENT>
 <PATIENT_ID>240-40-1999</PATIENT_ID>
 <LAST_NAME>Ashford</LAST_NAME>
 <FIRST_NAME>John</FIRST_NAME>
 <LABORATORY_SECTION>
 <LABORATORY_TESTS>
 <TEST_ID>
 <DATE>02/01/2000</DATE>
 <TYPE_OF_TEST>Pathology</TYPE_OF_TEST>
 <RESULTS>Normal</RESULTS>
 </TEST_ID>
 </LABORATORY_TESTS>
 </LABORATORY_SECTION>
 <PROGRESS_REPORTS>
 <HISTORY_AND_PHYSICAL>
<DETAILED_HISTORY>Non-Smoker,
 Non-Drinker</DETAILED_HISTORY>
 <HEIGHT>5 7</HEIGHT>
 <WEIGHT>130</WEIGHT>
 <BLOOD_PRESSURE>122/79</BLOOD_PRESSURE>
 <FINDINGS>Normal</FINDINGS>
 </HISTORY_AND_PHYSICAL>
 </PROGRESS_REPORTS>
 </PATIENT>
 ..... (other patient record entries).....
</MEDICAL_RECORDS>
```

source-oriented medical record structure in XML editor



XML module sharing exists. It has been determined that that these XML modules will need to be classified, annotated, catalogued, cross-referenced, and indexed in this repository so that there is not a duplication of effort among developers of new XML specifications.[15]

Next, protecting the confidentiality of patient-identifiable information is imperative in any electronic medical record application, but is of even greater importance when this type of information is intended to be transmitted over an insecure channel, like the Internet.[16] XML affords the ability to transfer marked-up medical record documents over the Internet while at the same time protecting any patient identification information. The beauty of XML-based medical record security lies in the fact that it relies on two powerful standard technologies: secure socket layer (SSL) and digital signature. Because the transmission of the medical record on the Internet is conducted over the HTTP (hyper text transfer protocol) protocol, secure transmission provided by SSL (which is currently used for e-commerce transactions) can also be used for medical record transmission. SSL provides protection on three of four aspects of secure medical record transmission over the Internet: confidentiality, integrity, and authentication. For protection against repudiation, the XML-based health record will rely on the use of digital signatures. Another feature of XML that can be used to protect patient confidentiality is that XML and XSL make it possible to not display those tags that contain patient-specific information to certain users.[17]

Despite the strength and simplicity of XML security, protecting Internet-based medical record information will remain a serious challenge. Just as XML introduces us to a new solution to represent and exchange medical record information over the Internet, it also raises confidentiality concerns that must be addressed to protect patient-identifiable information. Further security efforts related to XML and its capabilities in protecting sensitive information are needed to ensure safe transmission of medical record information over the Internet.

What Do HIM Professionals Need to Know?

As the healthcare universe moves toward an increasingly mobile environment where a patient can have multiple encounters in diversified healthcare settings over a lifetime, the idea of combining XML and the Web to achieve an electronic patient record holds much promise.[18] HIM professionals need to have an understanding of the principles behind XML and how it will play a key role in future electronic patient record developments. Because HIM professionals have a thorough understanding of the context of the documents found in the medical record, their involvement in the development of standard document types to facilitate representation by XML is critical for future electronic medical record initiatives.

Notes

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