The Clinical Display of Radiologic Information as an Interactive Multimedia Report

Krisellen Maloney and Clare T. Hamlet

We regard the delivery of radiological information as an interactive multimedia report. We use a multimedia report model based on Extensible Markup Language (XML), rather than a traditional workstation model. Others have suggested a similar document-based approach. This display presentation includes image-related and text-based information and may contain interactive components (eg, window, level and zoom). Using XML as a foundation for this multimedia presentation, we achieve flexibility and platform independence at a lower cost. XML allows for the separation of content and form. Content information, defined as elements (eg, images, radiologic reports, and demographic information), is treated as independent information objects. The behavior of the elements can be changed for different users and tasks. In addition, by separating format detail from content, the appearance of the elements within the report can be modified. XML does not replace existing standards (ie, Digital Imaging and Communications in Medicine [DICOM], Transmission Control Protocol/Internet Protocol [TCP/IP]). Instead, it provides a powerful framework that is used in combination with existing standards to allow system designers to modify display characteristics based on user need. We describe our application of XML to the clinical display of radiologic information.

THE DELIVERY OF radiologic information at the point of care and to the clinician's desktop poses some interesting problems for radiology. Although the same radiologic information is captured, the presentation of this information will vary depending on the user and task. For example, clinicians specializing in orthopedic medicine may require an initial display of a high-resolution image combined with a brief radiologic impression, whereas internal medicine clinicians may require the complete textual report accompanied with a low-resolution image. Moreover, the clinicians' information requirements will evolve as they become familiar with the technology. The capability to present information so that it supports the decision-making process (eg, to display information in different formats and to easily develop new display formats) is necessary in a diverse clinical environment.

We regard the delivery of radiological information as an interactive multimedia report. We use a multimedia report model based on Extensible Markup Language (XML), rather than a traditional workstation model. Others have suggested a similar document-based approach.[1,2] This display presentation includes image-related and text-based information and may contain interactive components (eg, window, level and zoom). Using XML as a foundation for this multimedia presentation, we achieve flexibility and platform independence at a lower cost. XML allows for the separation of content and form. Content information, defined as elements (eg, images, radiologic reports, and demographic information), is treated as independent information objects. The behavior of the elements can be changed for different users and tasks. In addition, by separating format detail from content, the appearance of the elements within the report can be modified. XML does not replace existing standards (ie, Digital Imaging and Communications in Medicine [DICOM], Transmission Control Protocol/Internet Protocol [TCP/IP]). Instead, it provides a powerful framework that is used in combination with existing standards to allow system designers to modify display characteristics based on user need. We describe our application of XML to the clinical display of radiologic information.

OVERVIEW

We have developed a clinician-specific interactive multi-media report using a three-tier architecture, illustrated in Fig 1. This implementation offers the advantages of data hiding, flexibility of current and future clinical models, and interoperability. Our goal is to separate the critical components that (1) access and store disparate databases, (2) configure germane information according to specific clinical needs, and (3) enable a wide variety of presentations at a workstation site. We have adopted the metaphor of a multimedia report rather than a

From the Department of Radiology, University of Arizona, Tucson, AZ.

Supported by Toshiba Medical Systems, Tokyo, Japan.

Address reprint requests to Krisellen Maloney, PhD, Department of Radiology, University of Arizona, Tucson, AZ 85724-5067.

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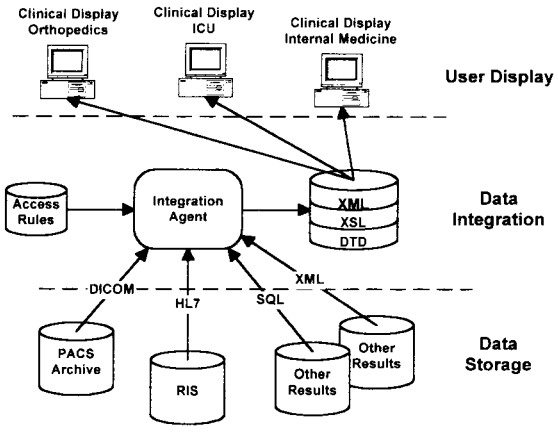

Fig 1. Example of 3-tier architecture.

display workstation to underscore the importance of the integration of information rather than the emphasis on the display of images. In this presentation, we will briefly overview XML and describe each of the tiers of the three-tier architecture. In conclusion, we will discuss the benefits we have realized from this implementation.

XML—A BRIEF DESCRIPTION

XML resembles Hypertext Markup Language (HTML), but it is actually a meta mark-up language allowing unlimited tags to be defined by an application author. HTML tags describe how data should be displayed, such as a table or a bulleted list. XML tags describe the meaning of the information they contain. Table 1 illustrates patient encoding using both HTML and XML. The HTML tags ⟨H1⟩ and ⟨H2⟩ indicate exact formats for displaying information. However, the meaning of the content within the tags cannot be inferred when using HTML. Is it name, phone number, patient identification? Table 1 contrasts the same information encoded in XML. In this example, it is clear that the patient name is Mary Brown and her patient identification is 800-234-6789.

An additional benefit gained from XML content-based tags is hierarchical structure. Again, depicted in Table 1, name and identification are both nested within the same patient. The ordered relationship between these elements is explicit and enforced by a document type definition (DTD). Therefore, parser software can compare and uniquely extract only the tagged information of interest to a given application (clinician workstation). Beyond information validity, the tree-like structure of this information unfolds details as diverse as an image (from a series of a patient's exam) to the radiological report issued for that exam. Drilling down into such richly textured information makes XML a tool with many morphologies.

Table 1. Example HTML and XML Tags

HTML	XML
⟨H1⟩Brown, Mary⟨/H1⟩ ⟨H2⟩800-234-6789⟨/H2⟩	⟨Patient⟩ ⟨Name⟩ ⟨Last⟩Brown⟨/Last⟩ ⟨First⟩Mary⟨/First⟩ ⟨/Name⟩ ⟨ID⟩800-234-6789⟨/ID⟩ ⟨/Patient⟩

Using XML as an exchange standard in our middle tier, we realize the advantages of data hiding, flexibility, customization, and interoperability. Furthermore, identifying and processing self-described data promotes mutual understanding of the data by all users.

STORAGE

The first tier of our architecture consists of stored data. Hospital information system (HIS), radiology information system (RIS), and picture archiving and communications system (PACS) archives all make contributions to the XML middle layer, which integrates related information from multiple servers. In today's hospitals, information is often stored in task-centered servers and is organized to accommodate specialized requirements. For example, the RIS, with its primary purpose to facilitate the Radiology Department, stores data to schedule examinations and perform patient tracking. HIS and PACS archives have very different, albeit related, purposes. Retaining these differences is not only necessary for the sake of the nonhomogenous Information systems departments, but, the multimedia clinician report is enhanced by the very differences which feed it richly textured information.

Our goal, to modularize diverse banks of data, conforms to the object-oriented principles of data hiding and extensibility. Knowing that the content or format of the original data may evolve over time, our system remains safe from such changes, and yet, is prepared to incorporate them as needed. Similarly, as improved techniques are developed to access data, the storage tier will be insulated from side effects.

INTEGRATION

The middle tier of our architecture contains a software agent that we have developed to access information from each of our distributed systems. This agent contains the knowledge to selectively extract data and translate it into information contained in XML formats. XML provides the framework into which structured data from different sources can be combined. Then, data is rendered for display and delivered to the client.

The salient feature of this agent tier is its defining standard for an exchange of information that places no restriction on the nature of the data or on its presentation. Since XML-based data is self-describing, data can be communicated without having a built-in description of the incoming data. Important rules are programmed to construct the XML file with complete and structured information. These rules ensure the integrity of the heterogeneous data collected and the reusability and viewability of the structured data, depending on the clinical configuration desired.

Server-side software proves effective and plays a vital role in delivering consolidated information to a structured XML file. Prefetching information into a server can shield the client workstation from unacceptable speed degradation.

DISPLAY

After being delivered to the client, data in XML format may be parsed and locally manipulated by client applications, rather than merely being presented. XML tags themselves have no display properties, but can be rendered with style sheets or by application programs to associate display properties. In the simplest case, the information can be completely rendered through Extensible Style Language (XSL) to HTML and is suitable for display in any browser. Interactive communications, such as zoom, window and level manipulations and even voice and color overlays, are features that enhance workstation utility and are feasible within the XML framework.

The XML Object Model also allows data to be manipulated with scripting or other programming languages. Built-in object-oriented functionality accompanies the Object Model to ease the programming burden of navigating through the complex XML tree structures. This powerful facility will be employed as we extend our software.

Data computations can be performed without return trips to the server. For example, information about an exam can be pre-fetched through the middle tier agent and included in the XML file that is delivered to the client. The client may choose to invoke the additional information or to ignore it. User interfaces can parse through XML tagged data and its arbitrarily deep subsets to customize presentations.

CONCLUSION

A configurable and timely view, delivered to the desktop, is the final objective of an exemplary multimedia clinician's report. Many software modules are interwoven to accomplish this end result. They borrow strengths from software engineering to protect data and to enable life cycle longevity, even as new demands arise. XML facilitates these software goals along with its natural Web oriented and multimedia propensities.

A serendipitous benefit of XML, as the hub of this clinician workstation, is its natural correlation to the paradigm of structured reporting. Currently, image information is nested along with radiologic reports. Thus, our software is positioned to develop, incrementally, as structured reporting becomes formalized.

REFERENCES

1. Bidgood WD Jr, alSafadi Y, Tucker M, et al: The role of digital imaging and communications in medicine in and evolving healthcare computing environment: The model is the message. J Digit Imaging 11:1-9, 1988

2. Dudeck J: Aspects of implementing and harmonizing healthcare communication standards. Int J Med Info 48:163-171, 1998