XMedIA Communication System: An XML driven Medical Image Processing and Archiving Environment

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Abstract- **This paper addresses the contribution of XML and related technologies, to the integration of a distributed healthcare system that inherits characteristics from the extended framework of eXtended Markup Language, XML, the distributed Simple Object Access Protocol, SOAP and Distributed Component Object Model, DCOM, architecture. The solution that this system suggests is a two-module architecture that involves the familiar, secure and effective environment of a distributed architecture using DCOM and the flexible, lightweight and ideal for distributed applications protocol named SOAP. The XMedIA system meets the requirements for secure search, transaction, and presentation of medical information to the end users, whether patient or healthcare professional. Key features of the work include personalized access and efficient management of distributed medical knowledge, intercommunication of heterogeneous systems and presentation of information in a concise way, across different platforms.**

***Keywords* – DCOM, SOAP, XML, Distributed Databases, Electronic Healthcare Record, Image Processing**.

I. INTRODUCTION

The health care domain has a longstanding problem with the proliferation of disparate information systems. XML extensible framework has already provided a way to bridge the gap by becoming "the" enabling Internet standard for web-based communication [1]. The XML-based medical records enable a computer to capture the meaning and structure of a document on the Web [1][9]. Recently the need for a "lightweight" object-oriented protocol built on a Web server has become a major requirement. The solution is given by SOAP, an advanced protocol for distributed applications that utilises remote procedure calls.

Two major issues that define the current technological framework have inspired the conception of our work. The need to capture the medical information in a standardised way, has already motivated many research laboratories to connect XML technology with the overall domain of healthcare documents. Standards developing organizations such as HL7, National Electrical Manufacturers Association, NEMA, and specific work groups like Seagaia with Medical Markup Language, MML, and CEN/TC 251 have been actively working with XML technology [2][3][4]. Also the current trend to exploit the World Wide Web as the major mean for exchange activities in a client-server model constitutes a challenge for the information technology community. In this concept, work group such CEN/TC 251, and projects such SynExML have developed related work that constitutes the framework of XML-driven healthcare services [4][5][11].

Previous experience and advances in health telematic applications and communication technologies motivated our research and led to the design and development of an XML driven Medical Image Processing and Archiving Communication System, the XMedIA Communication System. The main objective of XMedIA is to provide the means for integrating the existent legacy systems that comprise the core elements of the healthcare information sector [11]. XMedIA addresses the interoperability challenges in a platform- and technology-neutral manner, building its architectural specification upon standards and emerging Internet technologies such as Hypertext Transfer Protocol, HTTP, XML, SOAP and Component Object Model, COM [7][13][14]. The aim for the XMedIA Communication System is to specify and develop the rules that will enable

1. existing legacy healthcare information systems (e.g. electronic patient record systems, medical imaging, archiving and communication systems) to cooperate.
2. applications to work with different operating systems.
3. different document formats that already exist to be reused, facilitating the integration and extension of existing information systems.
4. the distribution of the information structure to advanced handheld devices, such as Personal Digital Assistants, and mobile phones.
5. heterogeneous systems that support different security models (e.g. firewalls) to communicate.

In a typical description of the system, several sets of patient medical images and clinical data are stored in distinct databases that are geographically distributed over a healthcare information network. Access to the medical information can be achieved through a variety of terminal devices such as personal computers, PDAs, mobile phones, in order to browse the computer-based patient record, to view and process the various record's objects (e.g. medical images, text information). The system functionality is accomplished through the integration of intelligent data storage procedures, flexible data retrieval and processing operations, efficient transfer and representation mechanisms.

XML and related technologies enable the exchange of data among heterogeneous systems; SOAP can provide a "lightweight" mean for object-oriented procedure calls over HTTP. Common Object Model, COM, can provide a secure, reliable and flexible distributed computing environment. The integration of these technologies in the

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
25 Oct 2001	N/A	-

Title and Subtitle XMedIA Communications System: An XML Driven Medical Image Processing and Archiving Environment	**Contract Number**
	Grant Number
	Program Element Number
Author(s)	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) Dept. of Computer Science, Medical Technology and Software Development Unit, University of Ioannina GR 45110, Ioannina, Greece	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) US Army Research, Development & Standardization Group (UK) PSC 802 Box 15 FPO AE 09499-1500	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)

Distribution/Availability Statement
Approved for public release, distribution unlimited

Supplementary Notes
Papers from 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, October 25-28, 2001, held in Istanbul, Turkey. See also ADM001351 for entire conference on cd-rom.

Abstract

Subject Terms

Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU

Number of Pages
4

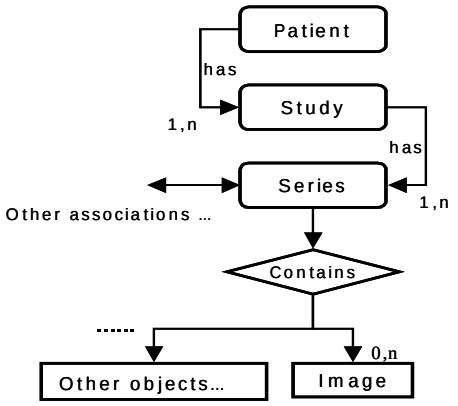

Fig. 1. The core of DICOM Information Model

XMedIA Communication System, the information model, the communication environment and the methods that will be employed, in order to achieve the presumable result are described in what follows.

II. Methodology

In this section, we describe methods for transferring of medical documents, using component object model architecture and representation of the medical record related data using the XML. We also describe methods for integrating a system, using a simple protocol for Remote Procedure Calls over the Hypertext Transfer Protocol. This system addresses the needs of specific user groups and the proposed solutions.

A. Information Model and Data Structure

The prime care of XMedIA Communication System's information model is to offer an architectural structure based on the most advanced standards and ensure effective interoperability. Data Structure and Information Model design is based on the Digital Imaging and Communications in Medicine, DICOM, Information Model. According to this model, the healthcare procedure is represented as a sequence of related entities. The DICOM view of the Real-World identifies the relevant Real-World Objects and their relationships within the scope of the DICOM Standard [12]. The DICOM Information Model identifies the various information objects specified by the DICOM Standard and their relationship. The Patient Information Entity, IE, defines the characteristics of a patient who is the subject of one or more medical studies, which produce medical images (Fig. 1). The Study IE defines the characteristics of a medical study performed on a patient. A study is a collection of one or more series of medical images, which are logically related for the purpose of diagnosing a patient. Each study is associated with exactly one patient. The Series IE defines the attributes, which are used to group images into distinct logical sets. Each series is associated with exactly one Study [12]. This model can be represented as a hierarchical tree in which each information entity is represented by a node and the relationship between entities is represented by a link. In addition, according to the DICOM standard specifications we can define in detail the relationship between these entities and the attributes that describe them. The patient entity is the root node that has no parent node. The study, series and the other information entities are either children or leaves, but all of them include attributes that describe their character in the information model. That hierarchical information tree can be transformed to an XML document using a structural specification Document Type Definition, DTD file. DTD file is the basis for dealing with XML documents. It sets the instructions for the structure of the XML document, (it consists the grammar for the information model that we use). In accordance with our needs the transformed document can be manipulated using Document Object Model, DOM, or the Simple API for XML, SAX interface. DOM is a platform neutral interface that allows us to dynamically access and update the content, structure and style of documents [14], SAX is a serial-access mechanism for accessing XML documents. Using DOM or SAX, we can hold the information from the XML document into an object. Additionally using this model to structure the information it provides us an effective way to transmit and receive XML documents.

The XML document can now be distributed over the hospital information system. When the document is received by a client (e.g. a medical professional) the information can either present its contents as a tree structure, or can extract its contents to the local database. One significant feature of XMedIA Communication System's information exchange is the association rules between the provider's and the client's supported format, the way that the contents of XML object will be presented to the client's devices. Each client sends a request to the server with some additional information (stylesheet) that describes: the client supported format for data presentation, the user's personal information and additional information in order to classify both the user and the request to an existing group. This module has been designed to facilitate the flexible distribution of data to a great variety of terminal devices (e.g. Palmtop Devices, mobile phones and Hand Held Devices) and also to determine the classification and authentication level that will be used to transmit the information (according to the importance of requested information). Many methods can be employed in order to process the XML document with the corresponding XSL stylesheets. The processing can either occur on the server or on the client side. In the XMedIA Communication System, the whole procedure takes place on the server side, that means that the data are received by the client in a ready to publish format.

In addition, we have to investigate the gap that exists between XML document's contents, defined by the corresponding DTD, and the database data, defined by the database schema. The integration of an XML-based information model into an existing healthcare system will be

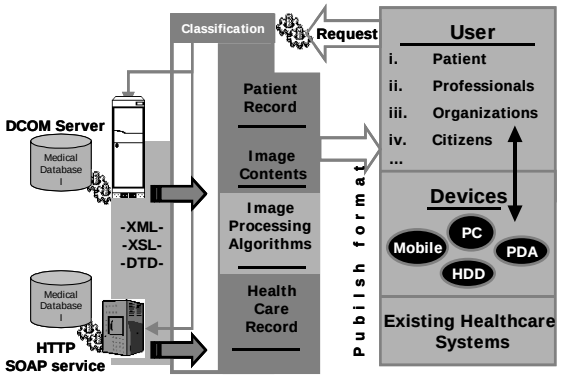

Fig. 2. The major components and procedures of the XMedIA Communication System

achieved by defining the relationship between their data items. If the data is transmitted between same database modules, we can define the relationship into the associated DTD. In the case of different database modules, association rules must be defined in order to correlate the data items, if that is possible. In any other case, the suggested solution is to create a new database to accommodate the data items of the XML document.

B. Communication Environment

The second basic module of the XMedIA Communication System is the platform for effective communication of information among the involved actors (e.g. clinicians, healthcare consumers, professionals). Some typical problems that we had to face during the implementation of the communication environment were:

1. the requirement for security,
2. the heterogeneity of cooperating systems,
3. the systems' disability to work through qualified security systems like firewalls
4. the fact that different applications must have the same format and sequence of data during their transaction.

XMedIA Communication System uses a two-module architecture in order to satisfy its communication needs. The first module, as it is shown in Fig. 4, is a DCE-RPC based distributed environment that has been implemented using DCOM. That system offers a distributed environment serving all the needs of healthcare domain. A significant advantage of using that distributed model is the provision of a security model. DCOM provides multiple levels of security that can be selected as needed. In addition, DCOM offers a rich set of integrated services, including controls, transactions, and database access that is a strong motivation for using COM technology.

The second module that XMedIA Communication System provides is a distributed computing environment over the WWW, based on the SOAP, (Fig. 3). Although the role of SOAP in distributed applications is not truly reliable, SOAP as an XML-based invocation protocol promises a new age of interoperability between the various distributed computing functions. An important characteristic of this scenario is its client side processing where request and response are made. The requests to the server are themselves formatted in XML. The client sends a specified XML document that describes the sequence of the functions and the parameters. At the server side, after the XML object is parsed, the specific functions are executed and the produced XML document returns to the client.

A main requirement is to specify the integration scenario between the architectures that are described above. In other words, a good way is needed to describe the messages and the way they are exchanged. Web Services Description Language, WSDL, is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information. WSDL file can be generated from a type of information such as COM IDL file. Both SOAP client and application clients have the ability to share some public Component Object Models or some methods derived by them.

Both DCOM and HTTP are used to implement a three-tier architecture model in order to serve client's requests. Following the sequence of events, a client sends a request to the server that includes additional information (preliminary information) defining the independent entity of the client (Fig. 2). The request specifies the requirements for information acquisition, messaging, image or other healthcare resources acquisition, processing functions, retrieval or update of laboratory results, etc. A component-based infrastructure layer is responsible to execute these procedures and to make the requested information available. A server-side software module processes the preliminary information in order to classify the request to an existing group. The information that this software module needs is the client's device properties, user's accessibility of the services and other information of peripheral interest. The main objective of this component is to define the rules for data presentation and to delimit user's access. The requested information can be either a document object, or an XML document or another set of binary data that cannot be encoded in an XML document (e.g. medical image). DCOM and SOAP can be used in a large variety of systems ranging from messaging to RPC systems. For an RPC call the requirements is a specific data serialization format and a mean in order to transfer the message to the server and to return the response. DCOM protocol has specified a set of rules for addressing the endpoints, activating remote objects and transporting the RPC. SOAP uses XML to structure the data serialization and HTTP to achieve message and RPC

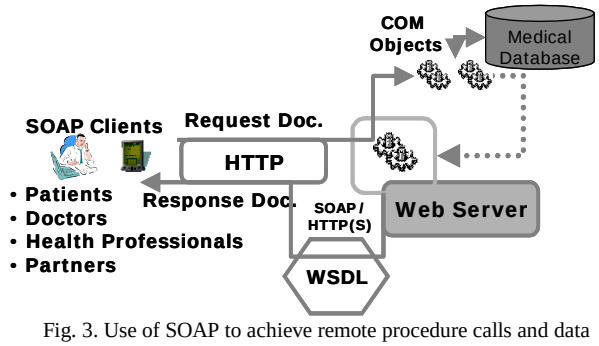

Fig. 3. Use of SOAP to achieve remote procedure calls and data exchange over HTTP

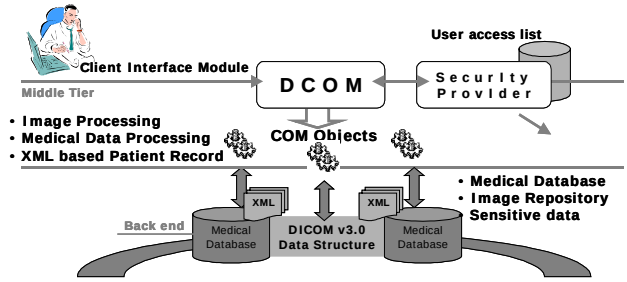

Fig. 4. DCOM architectural module of the XMedIA Communication System

transportation.

III. Results

The major components that a system must have in order to exploit XMedIA Communication System's services are a web server, a DCOM platform, a web client and a gateway server. The DCOM platform and Web client (browser) are used to support the exchange mechanism from and to the server.

XMedIA Communication System improves the way that the current healthcare systems deliver the information. According to the current implementation, the main services of XMedIA Communication System are the electronic patient record management, the medical image archive and process. In addition these services are supported over a distributed environment, providing a powerful tool to manage and process the medical information.

IV. Discussion

XMedIA Communication System uses XML-based hierarchical trees to represent the information produced during healthcare procedures. It deals with COM based distributed environment as a mean to exchange the information. In addition, it exploits the benefit of SOAP in order to eliminate lack of interoperability between separating distributed computing platforms [15][10]. Current information healthcare framework has been inspired by the XML technology, in order to create a common infrastructure layer that will host an overall set of healthcare services. It is achieved either by integrating the existing legacy healthcare systems or by defining the common rules to standardize the integration procedure. XMedIA Communication System supports this concept by defining the rules for the integration the existing legacy healthcare systems. Its goal is to meet the interoperability needs of the local healthcare network. The distributed environment that has been developed, provides a mean to manage heterogeneous clinical data. The information exchange takes place under a secure environment that uses classification levels for its services. Finally, the suggested neutral communication platform, named SOAP provides a "lightweight" solution to exchange information in a decentralised, distributed environment [7].

V. Conclusion

After years of work, healthcare information community still tries to integrate a set of standards that satisfy the needs of the healthcare domain. However, two important issues prove the gap that appears. First, the lack of a common, generally accepted terminology; and second the inflexibility of the currently used interchange formats [16]. XML is the tool that offers us the ability to manage the knowledge more efficiently, and the mean to share and communicate medical information in an effective manner [17]. Also the need for overall exploitation of the most popular transport protocol, HTTP, and the need for an XML-based ORPC protocol has driven our research towards the use of SOAP, hoping that the next version of the standard will better define its security issues.

The achievement of health information community is that a common framework based on the most forward looking technology environment, has been developed in order to design and implement interoperability standards for the entire healthcare's information domain [18].

Acknowledgment

The work is partially supported by the IST –2000-26353 "h-Life: Intelligent Personal Health Assistant" project.

References

[1] C. T. Liu, A. G. Long, Yu C. Li, K. C. Tsai, H. S. Kuo, "Sharing patient care records over the World Wide Web". *International Journal of Medical Informatics*, vol. 61, pp 189–205, June 2001
[2] HL7 Homepage: http://www.hl7.org
[3] MML Working group, Japan Association for Medical Informatics http://www.medxml.net/sg_e.html
[4] Comité Européen de Normalisation (CEN), Technical Committee 251: http://www.centc251.org
[5] The SynEx Project, http://www.gesi.it/synex
[6] B. Dolin, P. V. Biron, "XML and the PRA in Depth", 2000 14th Plenary Working Group Meeting (09/27/2000)
[7] SOAP 1.1: http://www.w3.org/TR/SOAP
[8] A. Riva, K. D. Mandl, D. H. Oh, D. J. Nigrin, A. Butte, P. Szolovits and I. S. Kohane, "The Personal Internet worked Notary and Guardian", *International Journal of Medical Informatics*, vol. 62, pp 27-40, 2001
[9] H. J. Tange, A. Hasman, P. F. de Vries Robbé and H. C. Schouten, "Medical narratives in electronic medical records", *International Journal of Medical Informatics*, vol. 46, pp. 7–29, 1997
[10] T. Jepsen**, "**SOAP cleans up interoperability problems on the Web", IT Professional, vol. 3, pp 52-55, January 2001
[11] Y. Xu, D. Sauquet, E. Zapletal, D. Lemaitre, P. Degoulet, "Integration of medical applications: the 'mediator service' of the SynEx platform", *International Journal of Medical Informatics*, vol. 58-59, pp. 157-166, 2000
[12] NEMA Standards Publication, Digital Imaging and Communications in Medicine, DICOM v3, October 29, 1993.
[13] HTTP 1.1: http://www.ietf.org/rfc/ /rfc2616.txt
[14] XML 1.0, http://www.w3.org/ /TR/1998/REC-xml-19980210.
[15] SOAP for Platform-Neutral Interoperability, www.xmlmag.com
[16] J. Dudeck, "Aspects of implementing and harmonizing healthcare communication standards", *International Journal of Medical Informatics*, vol. 48, pp. 163–171, 1998
[18] S. Brennan, "XML in healthcare computing", GCA Conference: "XML Europe 2000, Paris"
[19] ISO/TC 215 on Health Informatics, http://www.astm.org/ /COMMI/ISO/tc215.html