Proposal of a new Internet Standard for DICOM: DICOM-QR URL

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Abstract

This paper proposes a new Internet standard that is combination of two standards in different domain, Internet and medical informatics. The both standards are described briefly in this paper. We describe how to combine them into a Internet standard. With a new standard, there are several advantages for medical information systems. The standard should be established by the following way of the Internet standards.

Keywords

Internet; URL; DICOM; PACS

Introduction

The DICOM (Digital Imaging and Communications in Medicine) is an essential part for PACS construction, but is not a complete solution for PACS integration with RIS, HIS and other systems [1]. The Internet and, especially, a WWW (World Wide Web) is the heart of evolution in the computing technologies. So a expert of medical informatics should collaborate with Internet experts in constructing a networking system for medicine. The collaboration should not only be bound to each projects, but also a process of standardization. Using the WWW technology, various systems are developed in communicating and displaying of medical images [2-4]. And some of them are integrated with those systems in various way, which are compliant of the DICOM standard. The integration of WWW and DICOM does not be only a project specific technique, but it is a new standard. So we propose a new standard to combine the URL (Uniform Resource Locator) and the DICOM Query/ Retrieve Service Class.

Background

URL

The URL is one of Internet standards, which is in a status of Proposed Standard [5]. It is the first of several types of Uniform Resource Identifiers (URIs) defined by The Internet Engineering Task Force (IETF) [6].

For understanding the URL, the important thing is to clarify the words of "Resource" and "Locator" [7]. The "Resource" has various usage in computing or networking domain. In the case of URL, a resource is a static and dynamic information object. Also it is a service for information objects. Whichever, a resource is accessible via a network. The "Locator" is a new concept in the URL. It is a kind of an information object, which conveys information for accessing to a resource. The information involves they are a protocol, a network address of the host, a resource location inside the host and accessing commands. The URL is a compact string of representation. It is easy to transfer through various media, even hand writing, speech, of course, electric documents.

One of designing criteria of the URL syntax is extensibility of new naming schemes, which will be added later. It is met by allowing an arbitrary (but registered) string to be used as a prefix. The decoding of the rest of the string is defined as a function of the prefix. New prefixed are introduced for new schemes as necessary, in agreement with the registration authority.

In general, URLs are written as follows:

  <SCHEME>:<SCHEME-SPECIFIC-PART>

The syntax for <SCHEME-SPECIFIC-PART> of the URL may vary depending on the particular scheme selected. There are a common syntax for URL schemes that involve the direct use of an IP-based protocol, called Common Internet Scheme Syntax.

  //<USER>:<PASSWORD>@<HOST>:<PORT>/<URL-PATH>

Some or all of the parts "<USER>:<PASSWORD>@", ":<PASSWORD>", ":<PORT>", and "/<URL-PATH>" may be excluded. The scheme specific data start with a double slash "// " to indicate that it complies with the common Internet scheme syntax. The different components obey the following rules:

<USER>
An optional user name. Some schemes (e.g., ftp) allow the designation of a user name.

<PASSWORD>
An optional password. If present, it follows the user name separated from it by a colon.

<HOST>
The fully qualified domain name of a network host, or its IP address as a set of four decimal digit groups separated by ".".

<PORT>

The port number to connect to. Most schemes designate protocols that have a default port number. Another port number may optionally be supplied, in decimal, separated from the host by a colon.

<URL-PATH>

The rest of the locators consist of data specific to the scheme. It supplies the details of how the specified resource can be accessed. The URL-PATH syntax depends on the scheme.

DICOM Query/Retrieve Service Class

The DICOM is, a standard, developed by a joint committee of ACR (the American College of Radiology) and NEMA (the National Electrical Manufacturers Association).

The DICOM standard introduces the several characteristic approaches to managing images [8]. Firstly, the DICOM involves an Object-Oriented approach to represent real-world entities such as a patient, a study, a modality device, and, of course, an image, A real-world entity is represented by an corresponding Information Entity (IE), which has a set of attributes to show characteristic of the entity. Secondly, the DICOM defines a communication between a couple of Application Entities (AE) as a kind of Service Class. Each application entity can be either Service Class Provider (SCP) or Service Class User (SCU). A SCU sends a request, which consists of a command and a set of data for a SCP. Then the SCP returns back a response with or without data to SCU. For example, simple transferring of images is a service of Storage Service Class. Thirdly, Information Object Definitions (IODs) define a set of the Information Entities as an Information Object, which is paired with the Service Class. A coupling of IOD and Service Class is defined as Service Object Pair (SOP).

A Query/Retrieve Service Class in the DICOM is the most important thing for PACS construction. The Query/Retrieve Service Class provides a basic information queries and the ability to retrieve/transfer a set of images [9]. Necessary information for query images is organized in a well defined Query/Retrieve Information Model, which is in four levels of hierarchy information objects: Patient, Study, Series and Image. A searching method of an information model is "Hierarchical Search Method". In top-to-specifies level searching, each level of information objects in the information model is selected by the Identifier of a request, including Unique Key Attributes. These of attributes may include the Patient IDs, the Study Instance UIDs, the Series Instance UIDs, and the SOP Instance UIDs.

DICOM-QR URL

We propose a new URL scheme for DICOM Query/Retrieve Service Class: a DICOM-QR URL. The DICOM-QR URL provides a standard way to locate a DICOM Q/R SCP as an resource on the network.

Relationship

Relationship between the Internet Standard and the DICOM is illustrated in Figure 1.

This figure shows that a standard has relationships with other standards which is in the same domain or another domain. The DICOM-QR URL stands in the Internet standard, because it is the specific schemes of the protocol which is a TCP/IP-based protocol.

Designing

Goals of designing the DICOM-QR URL scheme are

- following a guideline of Common Internet Scheme Syntax.
- conveying minimal, but it is enough information to retrieve image(s) from DICOM Query/Retrieve Service Class Provider (DICOM Q/R SCP) in a single action

In the DICOM-QR URL, a resource is one and more images, served by a DICOM Q/R SCP. It is not explicitly specified that the C-MOVE or the C-GET command might be used to retrieve images. One of those services could be selected at the Association Negotiation time. There is no correspondence of the "USER" and the "PASSWORD" parts, which are in the Common Internet Scheme Syntax, to the DICOM Query/Retrieve Service Class. They are replaced by the DICOM specific infor-
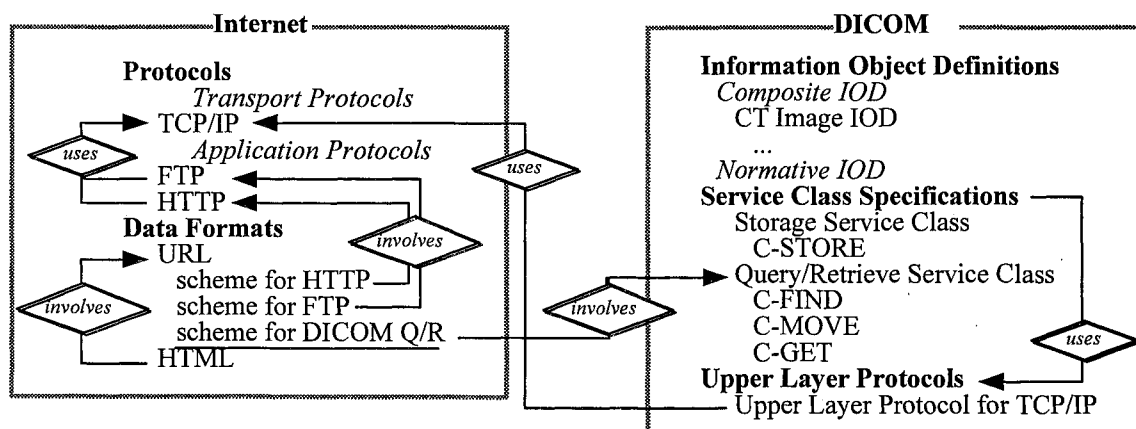

Figure 1 - The standards of Internet and DICOM

mation, the Query/Retrieve Information Model selection. The Hierarchical Search Method is applied to select objects, and Key Attributes are restricted to the Unique Key Attributes.

Definition

Our preliminary designing the DICOM-QR URL syntax is briefly expressed in Figure 2

Where:

<MODEL-SELECTOR>
Select a information model from "PATIENT-ROOT", "STUDY-ROOT" or "PATIENT-STUDY-ONLY". If this part is omitted then the selection is "STUDY-ROOT".

The <URL-PATH> for the DICOM-QR URL is separated to two parts.

<AE-TITLE>
A title of the application entity acts as DICOM Query/Retrieve Service Class Provider.

<UID-LIST>
A sequence of UIDs which identify each level of information objects in a hierarchy of Patient, Study, Series and Image. Each UIDs are divided by "/". The <UID-LIST> may end with an arbitrary level in the hierarchy.

Here is an URL example, represents a DICOM image from a DICOM Q/R SCP, which has a title of "DICOM_STORAGE" on the host named as "ctn.hama-med.ac.jp", a "Study Instance UID" is "1.2.840.777.1.1996. 4.1.109", a "Series Instance UID" is " 1.2.840.7777.1. 1996.4.1.109.1.9.55.43", and a "SOP Instance UID" is "
1.2.840. 7777.1.1996.4.1.109.1.9.55.43.1.21". (Figure 3)

The next example shows how to locate whole images in a patient whose "Patient ID" is "053-3042-9". (Figure 4)

Application

A straightforward application of DICOM-QR URL is to integrate a PACS with WWW. There are several systems, which integrate a PACS with the WWW technology [3], and are implemented in a various way. Figure 5 shows a example of a such system using the DICOM-QR URL. This system is made of many reusable components. "HTTP Server" and "Web Browser" are well-known component in a form of executable

program. "C-GET SCU", "C-GET SCP" and "DICOM to JPEG converter" would made by well-known software packages such as "Central Test Node (CTN)" and "Independent JPEG Group's JPEG Software". These components are reusable in another system and exchangeable for different implementation, because they are based on well-defined standards. If DICOM-QR URL is the standard, "DICOM-QR URL Parser" and "DICOM-QR Generator" are reusable components.

The another application is the Electric Clinical Patient Record Exchange. In Japan, we are in progress to standardize the format of a record and the guideline of usage for clinical record exchange via the electric way [10]. In the standard, a record is described in the MML (Medical Markup Language), a kind of SGML (Standard Generalized Markup Language) [11]. In an MML document, images are not stored in the document but located by the URL. Without DICOM-QR URL, there is no way to locate images stored on the image server, which only accepts the DICOM Query/Retrieve Service Class.

To realize DICOM-QR URL: Enter into the Internet standard track

The process of creating an Internet Standard is called "The Internet Standards Process" [12]. Specifications that are intended to become Internet Standards evolve through a set of maturity levels known as the "standards track".

At first, it may be published as RFC (Requests for Comment) or Internet-Draft. It undergoes a period of development and several iterations of review by the Internet community and revision based upon experiences, is adopted as a Standard by the appropriate body, and was published. For DICOM-QR URL, the appropriate body might be the DICOM standard committee, but any other body may play the part, because that is not DICOM Standard itself. Following the way of the Internet standard to enter the standards track, the body publishes a specification of the DICOM-QR URL and several parties make experimental implementations to evaluate it.

Conclusions

We have described the new standard which combines the URL

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dicom-qr://<MODEL-SELECTOR>@<HOST>:<PORT>/<AE-TITLE>/<UID-LIST>
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Figure 2 - DICOM-QR Syntax

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icom-qr://ctn.hama-med.ac.jp/DICOM_STORAGE/1.2.840.7777.1.1996.4.1.109/1.2.840.
777.1.1996.4.1.109.1.9.55.43/1.2.840.7777.1.1996.4.1.109.1.9.55.43.1.21
```

Figure 3 - Examples of DICOM-QR URL for single image

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dicom-qr://PATIENT-ROOT@ctn.hama-med.ac.jp/DICOM_STORAGE/057-3042-9
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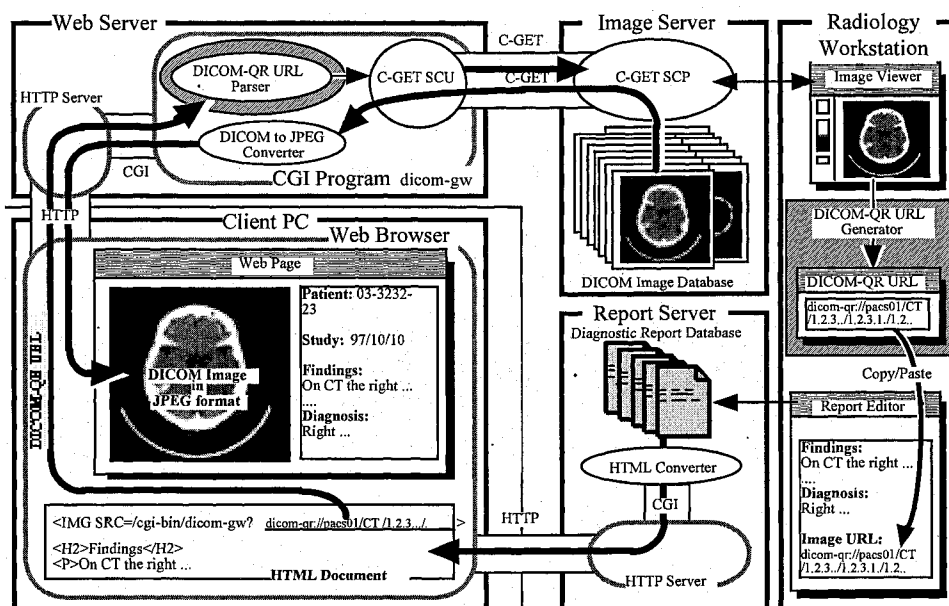*Figure 4 - Examples of DICOM-QR URL for multiple images*

Figure 5 - A example of WWW and PACS integration using DICOM-QR URL

(Uniform Resource Locator) and the DICOM Query/Retrieve Service Class.

The DICOM standard involves other basic standards such as ISO and ANSI. To expand the field of application of the DICOM, it should be involved in other standards, which is more widely used such as the WWW. The DICOM-QR URL would be the first case.

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