The Internet Metadata Library

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The Internet Metadata Library provides an indexed repository for data and information about multimedia objects that are stored or found on the Internet. It doesn't hold the actual metadata; instead it retains a URL connection to it that is cataloged, indexed, and stored in the library. When integrated with its service access tool, the library allows users to easily find the information and objects they want on the Internet, and the retained URL connection allows the information and the objects to be quickly and easily accessed by users without the burdens of an enormous database.

The application of the IML to multimedia file sharing is the model used by us. In our examples, we use the IML to view, modify, and search for objects, and to provide services for subscriptions, tracking, copyright protection, and payment.

Introduction

Most Web users today know metadata as the information that they create on their digital cameras, video recorders, and audio players, and store on media sharing Web sites. Multimedia metadata typically describes their files' technical format and contents and the processes that are used to create the files.

Today, the diversity of metadata that can be collected and stored is limited. Users must keep their metadata separate from their multimedia files to avoid losing the information over time. This is because manufacturers of video and audio equipment and the creators of multimedia file-sharing Web sites typically use proprietary metadata tools that limit the metadata users can store with their files. Except for an occasional custom entry, users cannot add new types of information to those proprietary metadata files. A few digital cameras, video recorders, and audio players allow users to define their own metadata, however those that do require proprietary software to parse, interpret, and store it. And the multimedia objects stored on Web-based media sharing sites not only limit the information stored, but also restrict access to just their members and the resources within their sites, which hinders the freedom and flexibility available to us on the Internet.

Several metadata specification languages have been created to help capture detailed metadata. They are based on XML languages, such as Resource Description Framework (RDF), which makes metadata accessible to a wide range of applications (1). However, formats like RDF are difficult for the average Flickr, YouTube, or Twango patron to use, and even those who take the time to learn them can't take advantage of the metadata that they define for themselves because Web sites do not support its collection, storage, retrieval, or management. What users need is a system with the flexibility to let

them define the metadata they need when they need it and that gives them tools to securely store and easily search for and find metadata and multimedia objects on the Internet when they want them. This type of system is analogous to a library.

The Internet Metadata Library (IML) allows users to easily define metadata that suits their personal needs, provides metadata storage, indexing, and retrieval, and integrates metadata into services such as viewing, searching, and grouping. It also gives users a network-based tool to search for, track, and protect their multimedia objects. It operates freely across the Internet, accessing URL-accessible objects through standard browsers. Most of all, users don't need to know or understand the IML's underlying technologies to use it.

The IML stores links to the metadata and automatically catalogs the links in an indexed repository, which is like a library of metadata links. Links to URL-accessible objects can go into the library, allowing the IML to provide a wide variety of services to users and to Web site owners and administrators.

The User's Perspective: IML Basics

Joe Audio created a jazz music Web site with music, articles, reviews, and history. Some of the information is in a database, so the content of his Web page is generated on the fly. No metadata is provided for the music, text, or image files served by his site.

Anna Listener discovers Joe's site through a search engine. She views a page that provides a link to an audio stream of a song with lyrics that were written by her grandfather. Anna right-clicks the page, and opens a context menu with a list of options. She selects "Provide More Info" from the menu list and her browser displays the title and URL of the page she wants to provide information about. It brings up various hyperlinks, such as links to see information already available for the page, links for specific words on the page, such as "Song" or "Artist," and links for information, such as "Songwriter" or "History." Next to "Songwriter" is an indicator that shows that information has already been provided for that link.

Anna selects "Songwriter," opening a form that shows entries for her grandfather's last name and nationality, but the rest is blank. She provides his full name, stage name, birthplace, and the dates of his birth and death. She saves the form and her information is added to the metadata for the song.

She decides to gather more information about her grandfather from her uncle, so she shuts down her computer, talks to her uncle that night, and then returns to her computer the next day to enter more data. Her uncle gave her more information than the previous form had spaces for, so she goes back to the context menu and selects "Add More Data." This takes her to a Search page where she looks for a vocabulary that matches the information she wants to enter. She enters "Family" and is presented with vocabularies related to Family History and Personal History. She selects "Personal History" and is taken through a series of forms with entries that let her describe her grandfather's life in detail.

Anna then returns to Joe's Web site and right-clicks the audio file link for the song her grandfather authored to see what other data has been collected about it. When she opens it, she sees that the

collected information now includes the details she added about her grandfather along with information previously provided by others.

Anna selects an option to provide feedback about Joe's Web site and her comments are stored as metadata and provided to Joe for a fee.

Accessing Services

The IML requests and provides services using its service access framework (SAF), which is a simple, interoperable tool we developed for this purpose (2). The SAF allows users to access metadata services directly from objects accessible by a URL. The services it accesses are specific to the type of object, and can include operations such as Upload, Download, Open, Copy, Print, Play, Provide More Info, Add More Data, and so on. It does this by configuring browsers, object providers, and resources. In turn, the IML provides metadata repositories where links to the information are stored, indexed, and cataloged. While they enter metadata, users only see friendly interfaces that are suited to their needs.

Figure 1 shows the IML system configuration in its most basic form. It operates from devices that can open a standard browser to search for and display retrieved multimedia objects, such as personal computers, telephones, or PDAs. The browser retrieves information available for an object from the metadata associated with it. The metadata includes a Service URL that links to a Service Profile Application on a server that the browser finds on the Internet.

The Service Profile Application manages profiles that are organized and stored in a database. Each profile lists the services available to a multimedia object based on its attributes, such as its identity, content type, provider, and owner. All available services are kept in a Service Descriptor that tells the browser how to invoke them.

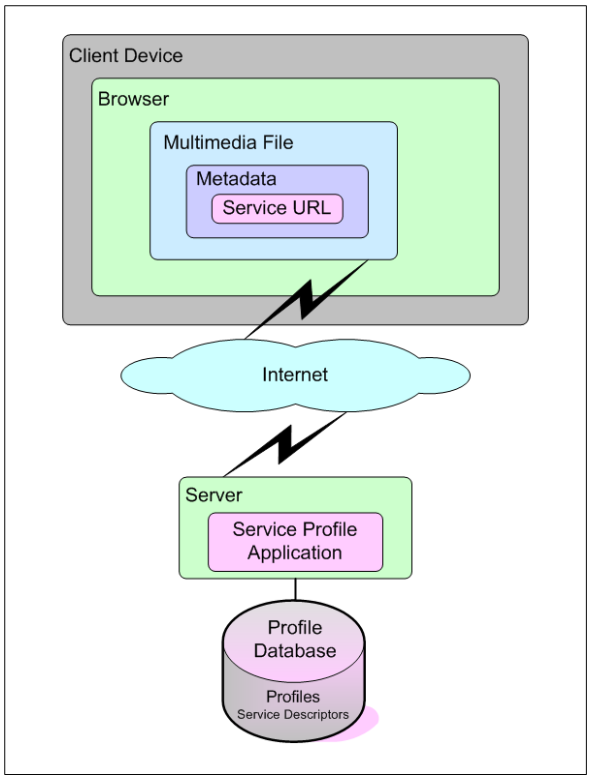

Figure 1. The basic IML system. A client browser finds object information from the object's metadata, including the Service URL, which links to the Service Profile Application, which manages the profile that holds an object's attributes.

Requesting a Service

Users request services by right-clicking a photograph, video, or audio file. The browser first looks to see if a multimedia object's metadata includes a Service URL. If it doesn't, the browser uses a default URL that it finds in its configuration data. Once the browser receives a Service URL, it asks the object's provider application to provide the Service URL from then on, thus registering it and making it readily available to future users.

The browser then sends a Service Request to the Service URL. This request includes attribute data for the object and context data for the browser. The Service Profile Application uses some of the object attribute data and browser context data to construct a Service Profile for the multimedia object, including a list of Service Descriptors that enable the browser to access the services that are needed. Together, the object attributes, the context data, and the rules in the Service Profile Application determine which services to make available and how they are presented.

The browser uses the Service URL to obtain the newly-constructed Service Profile, and the services described in it are made available to the user. A flowchart of these basic browser service operations is shown in Figure 2.

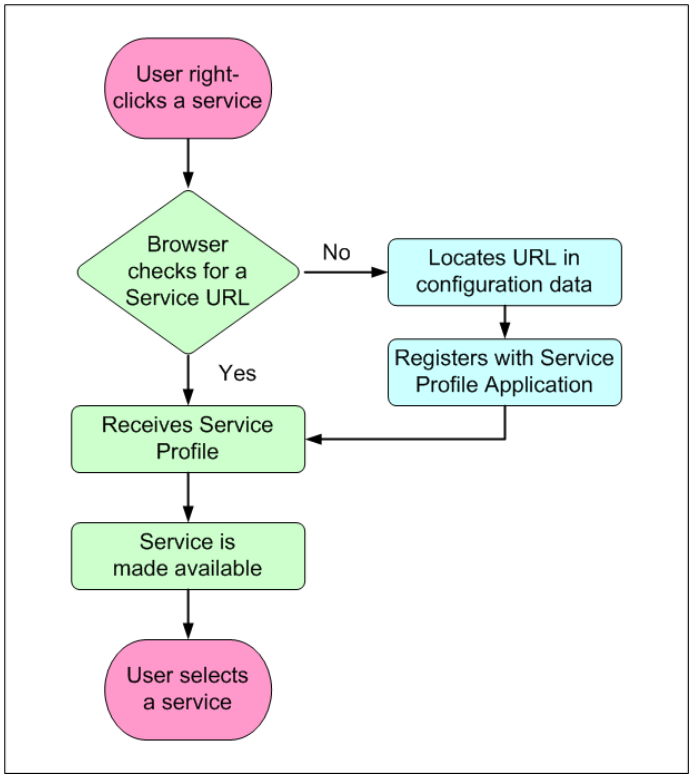

Figure 2. The browser's basic operation in the IML system. When a user right-clicks a multimedia object, the browser checks to see if the object has a Service URL. If it doesn't, it finds one and registers it with the object's protocol. The service profile provides the information for the browser to make the services available to the user.

A similar version of this process occurs whenever a user right-clicks a multimedia object on the Web today. A list of available services opens in a context menu and the user makes a selection from that list, such as Open, Copy, or Download. The IML expands on that concept to provide more services and better connections to metadata and objects. For example, if the object is a photograph, services for printing, sharing, purchasing, and/or locating the image in its original captured format are provided. Additional services, such as usage data collection, copyright enforcement, and searching are also offered, depending on need.

Providing a Service

When a user right-clicks a multimedia object that has access to IML applications, a Service Agent provides the list of services available to that object in a context menu. When the user selects a service, the Agent collects data from the Service Descriptor, then submits a Service Request. If the user selects the IML service, a second list of services opens. That list includes services for metadata collection, searching, and schema creation, and is available to all objects retrieved by IML-compatible browsers.

To provide the services, the browser includes a Content Manager, Content Handlers, a Service Agent for each Content Handler, and a Service Protocol that facilitates communication between the Service Agent

and Service Profile Application. As illustrated in Figure 3, the Content Manager determines the type of content in the object and routes it to the Content Handler, and a Service Agent intercepts it on its way to the Content Handler.

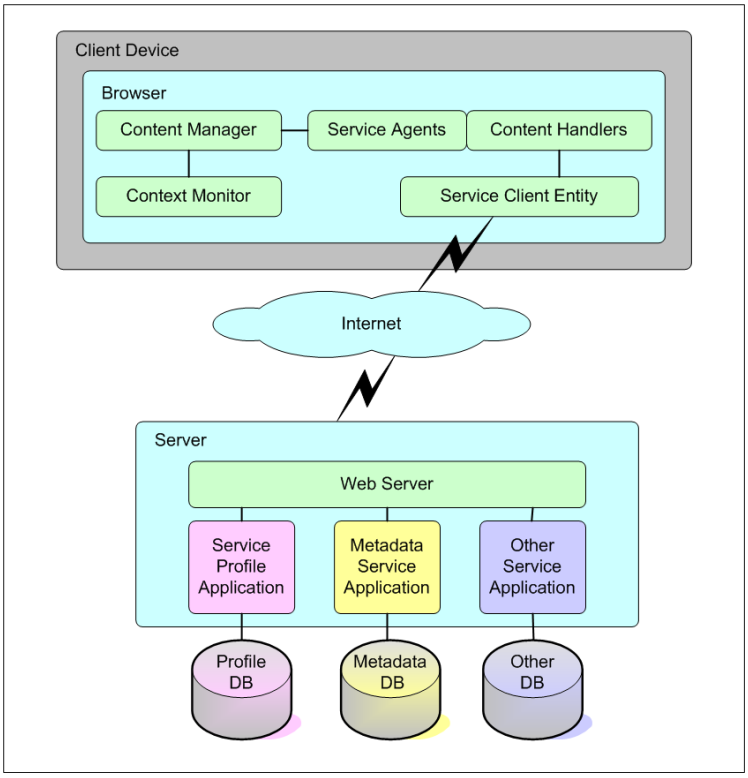

Figure 3. The Service Agents are browser plug-ins that intercept and collect data from the Content Manager as it hands it to the Content Handler. When a Service URL is located, the Service Agent issues a request to the appropriate service application.

Service Agents are plug-ins that extend the browser's capabilities. They are associated with Content Handlers that are specific to the type of content in the object. When the Content Manager receives a message, it determines the content type, then passes the message to the appropriate Content Handler. The Service Agent associated with that Content Handler intercepts it, then finds the Service URL associated with the content.

Once it finds the Service URL, the Service Agent uses it to issue a request to a Service Profile Application server and receives a Service Profile in response. The Service Profile Application uses information in the request to determine which Service Descriptors to return in the Service Profile. The Service Agent processes each Service Descriptor returned in the Service Profile, which enables the browser to make each possible service immediately available to the user.

Once the appropriate Service Agent receives a service selection, it determines if any parameters are required, based on its Service Descriptor. Parameter data are also gathered from object attributes, such as an image's file type or size. Sources for more attribute data include the object, a Web page, an object embedded in a Web page, and any browser or device attribute that is available. If a Service Agent can't

locate required data, the user is prompted to provide it. When all parameters are received, the Service Agent builds the Service Request using the Service Descriptor from the Service Profile. The Service Agent then transmits the request to the IML application and a response is received and processed by the browser. This service response process is illustrated in Figure 4.

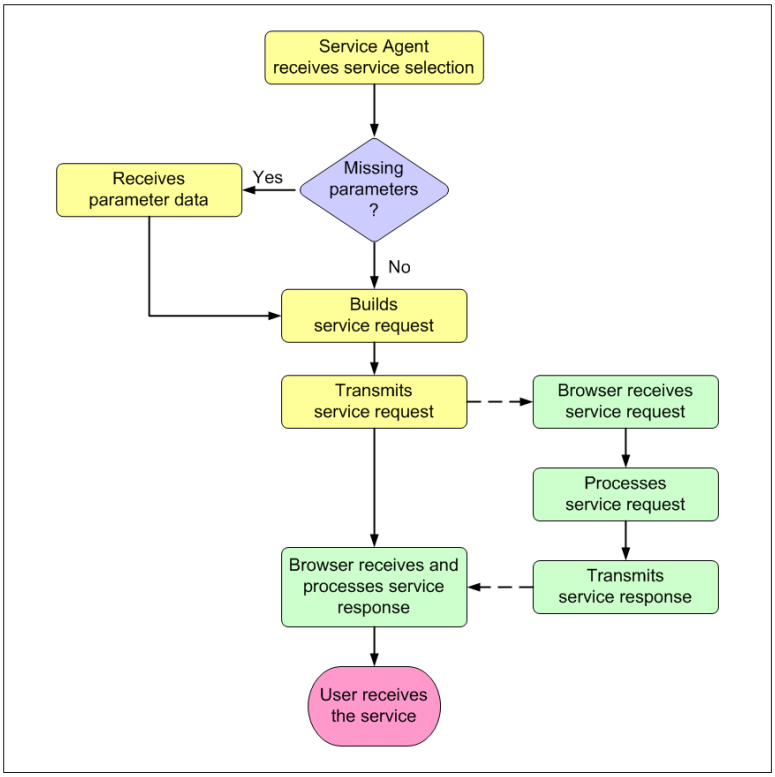

Figure 4. The Service Agent requests and provides a service by making sure all necessary parameters are available, then building and transmitting a service request to the browser, which processes it.

Indexing the Metadata

Vocabularies and the schemas that define them are used to index metadata so that all users of a system can agree on the meanings, spellings, rules, and other attributes of terms used in the indexing, much like the systems used in spoken languages. For instance, English has both British and American spellings, and a well-defined schema eliminates confusion from spelling discrepancies by including various spellings in the vocabulary and equating their terms.

While many open and proprietary vocabulary tools exist, there are few widely-used standards in place that allow the range of interoperability needed on the Internet. The IML has an open vocabulary definition system that allows inexperienced users to develop new custom metadata vocabularies, modify and merge existing vocabularies, associate vocabularies with specific metadata, and share their vocabularies with other users. It is a user-friendly, network-based, interoperable system that can be viewed and operated through all standard Web browsers. It is described in detail in a publication on creating and maintaining metadata vocabularies (3).

The IML uses a schema to specify the rules, syntax, grammar, and vocabulary for the metadata specification language. It also makes the vocabulary available for creating new vocabularies and for associating metadata with an object. The IML application service hides the details of the grammar and syntax of the schema and enforces its rules, making it available to all levels of users.

Users create custom vocabularies through a browser form that is designed to let them select or enter the metadata elements that define it. Because the IML uses RDF as its specification language, image, video, and audio device manufacturers and Web-based providers can easily submit vocabularies to the IML so they can be used by their customers. Using RDF allows interoperability between applications that exchange metadata, and it supports a system where properties are specified according to class. Classes are specified using a schema language, schemas are uniquely identified by assigning each a uniform resource identifier (URI), and the namespace mechanism of XML associates metadata elements with the schema. This process allows a schema to be accessed using the URI identified by a namespace entry.

If no vocabulary is associated with either an object or metadata found by the IML, then a vocabulary is selected or created by users by allowing them to search the IML and make a selection. Users can create vocabularies from scratch or from existing ones, and any vocabulary created is added to the IML vocabulary database and made available for access and use by others.

A simple user interface is all that users see because the IML uses a form-driven tool to specify the metadata that suits their personal needs. While a vocabulary is created, users enter metadata topics and criteria as though they are entering words in fill-in-the-blank sentences. The IML determines the grammar and syntax and checks that the words that users enter are appropriate to those rules. Multiple vocabularies can be assigned to a set of metadata, and the assigned vocabularies are later used to search, view, and modify the metadata.

The User's Perspective: Services and Vocabularies

While browsing a Web site about aircraft, Ima Pilot sees a photograph of a Lockheed L-1011, an airplane she flew years ago. Seeing the image makes her want to look for more information about it and her browser supports a Service Agent that provides Service Descriptors via Service URLs for every image her browser accesses. The Service Agent finds no Service URL in the image data, so it contacts a default Service Profile Application to provide an attribute, such as the image's URL or content type. When it receives the content type, the default Service Profile Application is able to find a Service Profile and returns it to the Service Agent. The Service Agent uses the Service Descriptors in the Service Profile to modify the image's context menu, allowing Ima to access all of the services available for the image.

Ima passes her mouse pointer over the image to display the toolbar with four items:

- View Metadata
- Add Metadata
- Original Image
- Copy Image

She selects “View Metadata,” and her browser’s Service Agent builds the Service Request, transmits it to the IML server identified by its Service Descriptor, and processes the response. The browser responds by presenting a Web page provided by the IML application. It shows only the airplane’s ID and the date and location the image was captured.

Ima decides to add more information about the L-1011 to the photograph. She puts her mouse pointer on the image again, then selects “Add Metadata” and is taken to a Web page where she is guided through the available vocabularies.

Figure 5 represents the Web page that Ima uses. Its toolbar includes:

- Save Image As
- Set As Wallpaper
- Purchase
- View Metadata
- Add Metadata
- Search

When she clicks “View Metadata,” a toolbar lists these vocabularies: Basic, Photographic, Aircraft, Corporate, Geographic, and Other. None of the defined vocabularies has all of the metadata that Ima needs, so she selects “Other” to create a new one.

This opens another context menu with options to:

- Create from Scratch
- Edit a Vocabulary
- Merge Vocabularies

She opts to create her new vocabulary by merging two existing ones: “Flying Machines” and “Characteristics of an Airplane.” Together, they hold all of the metadata she needs. After she creates the new vocabulary, she enters everything she knows about the L-1011 using all of the metadata from the two merged vocabularies, and then she saves it.

From that point on, anyone who accesses a copy of the L-1011 image can retrieve the information Ima provided, and the vocabulary she created is available to all. When future copies of the image are registered with the service, all information about the copies is included in the metadata and added to the IML.

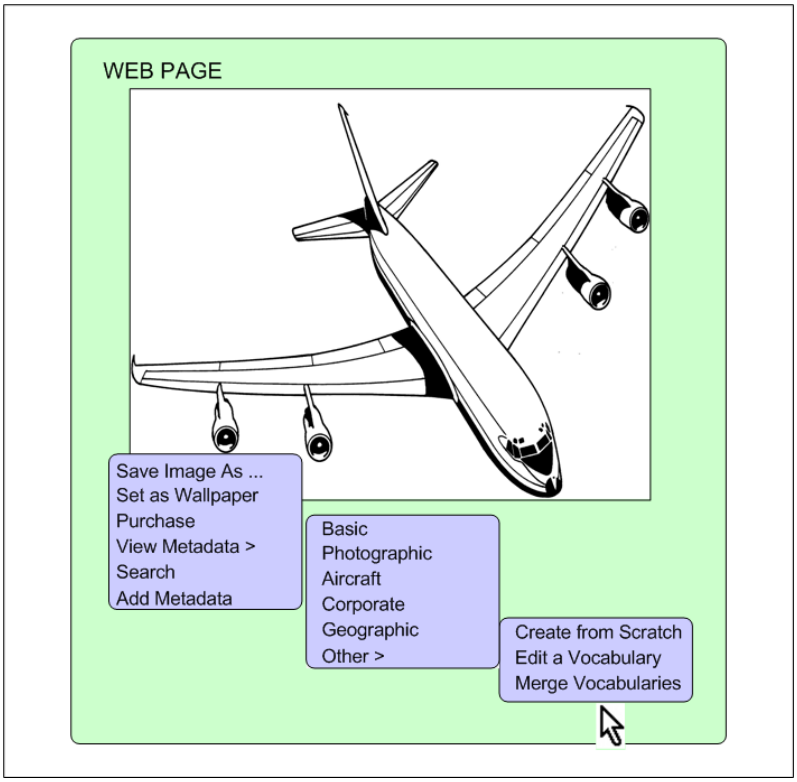

Figure 5. An example of a Web page with context menus and sub-menus that a user sees after right-clicking an image of an airplane. When the user selects "View Metadata," a list of vocabularies opens in a sub-menu. When the user decides to create a new vocabulary, options for different ways to create it are presented.

Ima then uses the context menu to purchase the image through a service that requests a copy of the original for her. The Service Agent sends the request to the IML service which looks up the source URL for the original image and requests it on Ima's behalf. Payment is required, so she is redirected to a payment page where she purchases the image online. Ima retrieves the original and saves it on her hard drive, then edits the image and sends it to others. When she edits it, her photo-editing software interoperates with the IML server to create a new record for the edited copy in the repository, including a reference to the original image as part of the new image's metadata.

Figures 6a and 6b give examples of XML code for a basic Service Profile. The profile includes a description of the image, including its source URL and services available to it, such as a print service (Figure 6a) or a service provided by the IML application (Figure. 6b). Any input parameter descriptors associated with the service are included or specified in the service descriptor.

```
<?xml version="1.0"?>

<profile
  xmlns="http://www.company.fake/spa">

  <description
      about="http://www.skypilots.org/images/lockheed/l1011/image04.jpg">
  <copy>
      <alt>
            <li resource="http://www.imapilot.name/images/l2011/l101102.png"/>
      <alt>
  </copy>

  <service>
      <bag>
            <li resource="http://www.company.fake/service/metadata/descriptor"/>
            <li>
                  <descriptor>
                        <name>Print</name>
                        <description>Order a print</description>
                        <protocol>HTTP Gate</protocol>
                        <address>www.photoservices.com/printOrder</address>
                        <input>
                              <param>
                                    <type>string</type>
                                    <default>&resource</default>
                              </param>
                        </input>
                        <return>
                              <param>
                                    <type>text/xhtml</type>
                              </param>
                        </return>
                  </descriptor>
            </li>
```

Figure 6a. XML coding for a basic IML service profile with a description of the image file, its source URL, and a print service available to the image.

```
<?xml version="1.0"?>

<descriptor xmlns="http://www.company.fake/spa">
      <name>Metadata</name>
      <description>See and add metadata</description>
      <protocol>HTTP Gate</protocol>
      <address>www.company.fakeprint/service/metadata/view</address>
      <input>
            <param>
                  <type>string</type>
                  <default>&resource</default>
            </param>
      </input>
      <return>
            <param>
                  <type>text/xhtml</type>
            </param>
      </return>
</descriptor>
```

Figure 6b. XML coding for a basic IML service descriptor that holds a description of the image file, its source URL, and a metadata library service available to the image.

Servicing Unassociated Objects

When a service rendered is not associated with the source of the multimedia object, such as a multimedia Web site where a photograph is stored or hosted, the Service Agent looks for more

information about the image by parsing the image file and examining the Web page. When it finds relevant information, the Service Agent requests it and adds it to the photograph's metadata.

The metadata vocabularies available for the image are then displayed to the user as part of the context menu. From this point, the user can select a metadata vocabulary for viewing, modifying, or searching the metadata for the image. Metadata collected is stored in the IML apart from the image, and the image file is linked to it.

In this instance, the Service Agents communicate with the server through the client. The metadata service application includes a search engine and a metadata context engine, uses vocabulary terms to search the metadata for the image, and uses the indexes for text stored in an index database. The metadata context engine manages the vocabularies, tables, and their relationships to each other, and all of the information is stored in a metadata vocabulary database, metadata-context tables, and a relationship database.

Additional IML Applications

Tracking and Copyright Applications

Whenever metadata information is added to a particular multimedia object, the IML enables users of all copies of the object on the Internet to learn about and access the new and updated information. It is configured to identify multimedia objects that are duplicates and a service built on it tracks metadata versions and the different copies and versions of objects known to it.

This way, metadata associated with all versions and copies of the same object stay synchronized over time. It tracks the use of multimedia objects and the relationship of any particular object with all other objects on the Internet. With this tracking, the IML identifies potential duplicates and altered copies of multimedia objects and monitors all of them for copyright infringement.

More advanced tracking options are also available, such as multiple Service URLs for multiple services that allow interoperability to create a distributed repository.

Subscription and Payment

Using the same tools as those for the tracking services described above, the IML provides connections to subscription and payment services for all types of multimedia objects. It can be configured to focus on a particular Web site, collection of sites, or type of object.

Object Types

IML applications can be extended beyond multimedia objects, to essentially any type of URL-accessible object on the Internet. IML servers can be provided to allow documents, Web pages, and user groups to be associated with metadata, providing a central or distributed network repository for collecting, managing, and using a wide variety of Internet information.

Because the IML system allows users to specify, customize, and manage metadata that suits their personal niches and needs and doesn't require them to understand the underlying technologies, entire

communities can be developed from the services it offers. Adding information to existing objects is simple. It only requires interested and adventurous users with up-to-date browsers.

New Applications

The IML provides a platform for developing new applications. The relationships that it creates permits extensive indexing, object location, and data mining. The need for these tools is growing and will continue to expand as the volume of available information continues to increase and the Internet endlessly widens and deepens.

Beyond Browsers

In the future, Web services may be provided to allow non-browser applications to use IML services without leaving the application environment. For example, a desktop imaging application will use the Service URL in an image to make services associated with the image available through its user interface. The imaging application will add its own Service URL to each image it processes, so that services associated with it are available to the images when they are loaded into any application that is compatible with the Service URL system.

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