Fig. 5-1 Digital Silk Roads Web site.

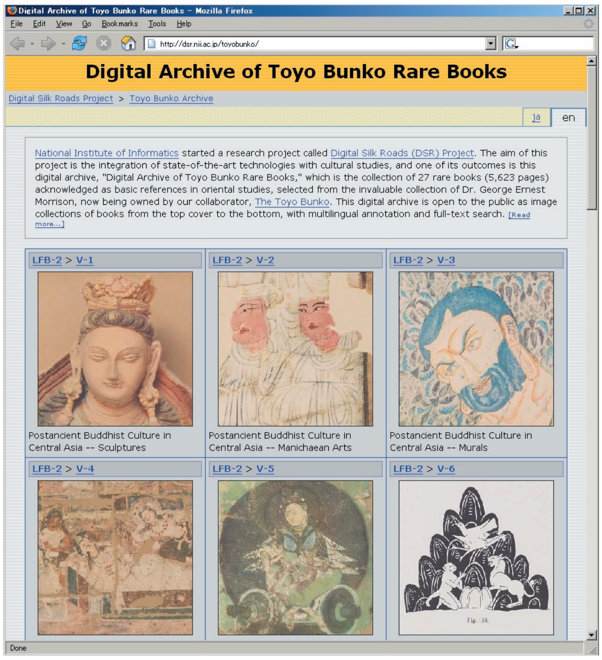


Fig. 5-2 Toyo Bunko Rare Books Web site.

dexing. Technical detail will be explained in Section 5.4.

5.2.3. The Citadel of Bam, Iran: Keeping Memories and Gathering Information for Post-earthquake Reconstruction

"The Citadel of Bam, Iran: Keeping Memories and Gathering Information for Post-earthquake Reconstruction" (Bam Web) (http://dsr.nii.ac.jp/bam/) is a portal started as a quick response to aid the destruction of cultural heritages of Bam (Figure 5-3). More than 70 percent of the historical district of Bam was destroyed by an earthquake on the morning of Friday 26, December 2003, and this Web site was opened to the public on December 31, 2003, just a few days after the earthquake. The purpose of the Web site can be summarized as follows.

– To keep the memory of the great monument and city of Bam.
– To gather data from around the world related to Bam and its remains.
– To provide a forum for collecting digitized data from all over the world.
– To allow people from all over the world to share visual and/or textual data of Bam and the Great Citadel.
– To provide a foundation for the documentation and further reconstruction and restoration of Bam.

This Web site consists of a collection of photographs and videos, contributed by various people who agreed to share their data on this Web site with other people around the world. Our appeal for the contribution of data attracted a number of contributors from locations all around the globe, ranging from Iran, Japan, and Germany, to the Czech Republic. As of January 2005, we have received more than 100 pictures and 1 video from about 10 contributors around the world, who generously submitted their photographs and videos to aid in the reconstruction of Bam. The collected data, along with other related data of Bam recorded before its destruction, will be used in the future for the reconstruction of Bam, both physically and virtually. Results of reconstruction will also be presented on this Web site to show the progress of reconstruction effort.

5.2.4 Advanced Scientific Portal for International Cooperation on Digital Silk Roads

"Advanced Scientific Portal for International Cooperation on Digital Silk Roads" (ASPICO-DSR) is the portal site of the Digital Silk Roads Initiative Framework (DSRIF), which is the international research collaboration between National Institute of Informatics (NII) and UNESCO explained in Section 1.2. This Web site is designed to be a common access point for international researchers and experts to share information and their knowledge about cultural heritages across a variety of disciplines.

The ASPICO-DSR portal addresses two separate

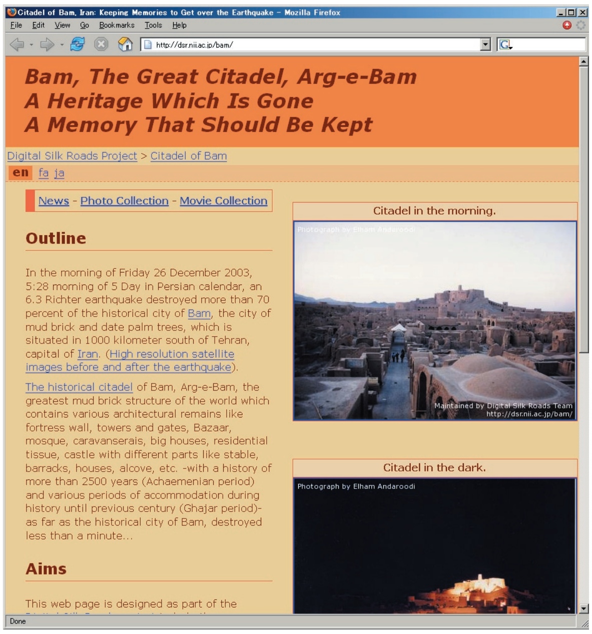


Fig. 5-3 Citadel of Bam Web site.

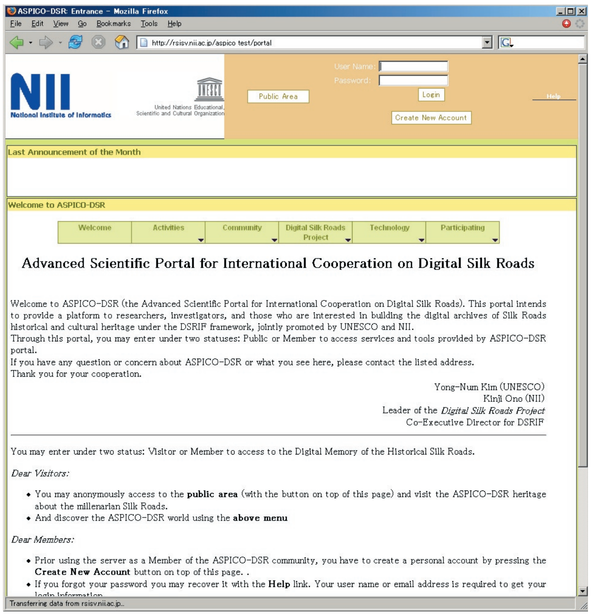


Fig. 5-4 ASPICO-DSR Web site.

ways to view its cultural contents (Figure 5-4). First, the Member Area provides researchers and experts with a work environment, named Work Space, in order to allow them to create contents and offer their expertise by writing interpretations and comments. On the other hand, the Public Area lets anyone world-wide accessing available cultural contents from member works, through a category-based search engine that uses comments to index resources.

5.3 Content Management System

5.3.1 Design Policy of DSR-CMS

All the contents, except for ASPICO-DSR, are maintained by a full-fledged content management system (CMS) developed by us for the DSR portal (hereafter called DSR-CMS). DSR-CMS was designed to reduce the overhead of content management while giving a uniform appearance to DSR contents. The DSR-CMS design policy has three main components - static generation, multilingual access, and awareness of information design.

1) Static generation

Static Web pages are generated in advance to avoid the dynamic generation of Web pages on request. This policy has two advantages. The first is the reduction of load on the web server, while the second is an organization that is friendly for search engine robots. The latter refers to the fact that static Web pages without troublesome URLs are preferred by search engine robots, hence those pages are more likely to be indexed and searched on major search engines, such as Google.

2) Multilingual access

All Web pages can be accessed at least in two languages, namely Japanese and English. Bam Web even provides contents in three languages, Japanese, English and Farsi (Iranian). The most reliable method for switching languages is through content negotiation, which is a function of HTTP (HyperText Transfer Protocol), by switching the language preference on the user agent (Web browser). Another convenient way to switch languages is to use the language links shown at the top of the page.

3) Awareness of information design

Usability is directly linked with the information design of Web pages. Many users nowadays have considerable experience using other Web sites, so following typical design rules can minimize users' overhead for learning how to use the DSR portal. We generally follow the best practices of information design which users are anticipated to be familiar with. One example of this is the breadcrumbs list, or topic path, we use to express the user's current location within the Web site.

5.3.2 Languages

The DSR-CMS uses the following five languages for content management.

– XML (eXtensible Markup Language) for content description.
– XSLT (XSL Transformation) for content transformation.

– Perl programming language for content processing.
– HTML (HyperText Markup Language) for content delivery.
– CSS (Cascading Style Sheets) for content rendering.

All contents are currently edited using standard text editors, as an integrated environment for content editing has not yet been developed. All the software, including the server software, is based on open source software, so extension of DSR-CMS can be done without restrictions.

5.3.3 Content Description

First, we identify the basic elements of information design. At present we still do not have a ready-made convenient standard for representing the information elements necessary for DSR-CMS, or for document structure generally, so we employ a bottom-up approach - identify important information elements through experience. An example of an information element is a page title, a section and its title, a paragraph, a list, and so on.

Second, we define an appropriate XML tag for information elements. For example, we use <section> for sections, <list> and <item> for lists and items, respectively. Sometimes we need to make decision as to whether to use a tag or an attribute for an information element, or how to define a hierarchy of information elements. At some point during development, we would like to identify the essential information elements and organize a more systematic definition of information elements using DTD (Document Type Definition) or XML Schema.

5.3.4 Content Transformation

The purpose of content transformation is to transform XML documents, which are best suited for content description, into HTML documents, which are ideal for content delivery.

Unfortunately, HTML has only a fixed set of tags, which specify the basic logical design of the Web page. We have hence decided to embed context-dependent information into the class attribute of each tag. For example, we transform the XML tag <section> into the HTML tag <h2 class="section"> to specify that it is not only a level-2 header, but also specified as a section in the original XML document.

5.3.5 Content Rendering

Content rendering uses information in CSS format. We define CSS properties for HTML tags with class information to change the appearance of tags in a context-dependent manner. For example, we define both the CSS for the h2 tag, and the h2 tag having the attribute “class” as “section.” In this way, we can differentiate the visual design of identical tags in an HTML document in accordance with the original intention represented in the XML document. Moreover, CSS is used extensively within the DSR portal to apply a uniform appearance to the whole site.

5.4 Navigational Aids

5.4.1 Problems of Conventional Navigational Aids

This section deals with the design of basic navigational aids for the DSR portal. Here we take Toyo Bunko Web as a case study, but the same design philosophy applies to other contents of the DSR portal.

Navigational aids are so important because they are the key point determining the usability of the system. To help users reach information that meets their needs, we need navigational aids appropriately designed for the digital archive. Cultural digital archives with poorly designed navigational aids are unfortunately common.

A typical example of a problematic navigational aid is one where users are requested to input appropriate keywords into multiple text input boxes associated with metadata, such as creator, title, and subject. Users can also select some choices from pull-down menus, on which are usually lists of highly technical terms. Then users can find information that exactly satisfies their needs, as long as they carefully specify all criteria. This method, however, expects users to input the right words into the right text box to match both their information needs and the system’s vocabulary.

This interface has several drawbacks, two of which are summarized as follows:

1) If the user is unfamiliar with appropriate keywords for the particular digital archive, the user sees only “not-found” messages and is unable to interact with the system. This drawback is especially apparent for non-experts or for first-time users of a Web site.
2) Users tend to search by a single criterion, not by multiple criteria. Hence the interface for setting multiple criteria is usually meaningless, since most users are interested in only a single criterion. As Google-style full-text search engines became popular, users are accustomed to work with a single text input box that accepts any kind of keywords, irrespective of the classification of metadata, such as the creator, title and subject.

5.4.2 Link-Centered Design

To solve the problems inherent in the text-input-box interface, we propose that Web pages provide enough information for users to choose the desired direction when navigating through the Web site. This leads to the idea of a link-centered design built around the idea that, as far as possible, it is better to provide a variety

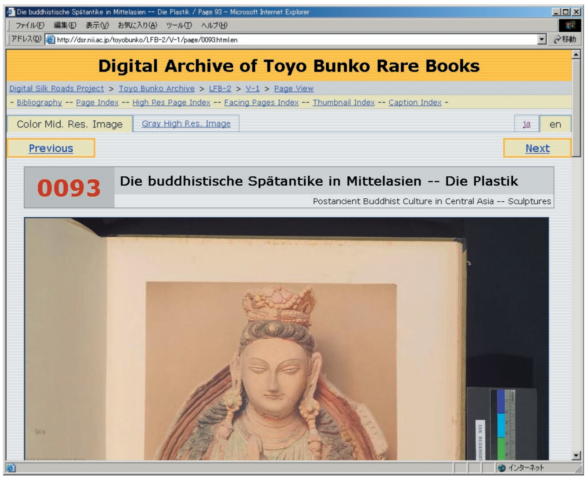


Figure 5-5 Navigational links on a Toyo Bunko Web

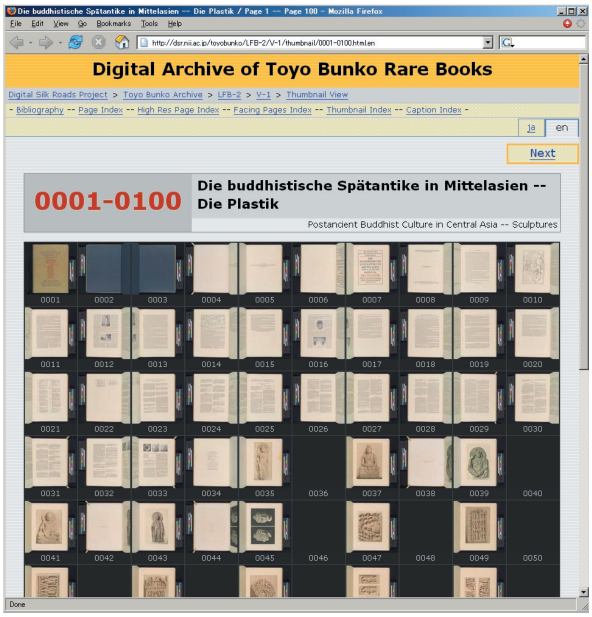


Figure 5-6 Index page for thumbnail

of links, with each link representing a distinct navigational path through the Web site. Here a set of links shows a list of system's vocabulary, and each link serves as narrowing down the database by a single criterion.

Let's look at a page of the site, as shown in Figure 5-5. At the top part of the page, links for navigation within books, such as "Previous" and "Next," and other links leading to the index pages, are listed. At the top we put a breadcrumbs list to show the current location within the Web site, as well as a few links to index pages of the contents that will be introduced in the next subsection. Below the breadcrumbs list and index links we put other navigational links for switching the format of images and for switching languages. Then we placed page links allowing the user to move to either the previous or the next page, and put additional page links at the bottom part of the page (not shown in Figure 5-5) for jumping directly to distant pages. Other links are also provided to further assist navigation through the Web site.

In the near future, we plan to give more advanced links semi-automatically to technical terms in the text that jump directly to entries of related terms and documents. With the help of dictionaries and ontologies that will be explained in Section 5.5, we can improve upon how users navigate through information within the portal. Such navigational aid can be easily implemented on the DSR portal via the modification of DSR-CMS. As we add more contents, we will need to implement more navigational aids within DSR-CMS, and the link-centered design based on the CMS may be the biggest difference between ours and other digital archives.

5.4.3 Index Pages

The presence of many links to jump to various pages facilitates users' navigation through the pages of a book. But, as users sometimes get lost in the web of hyperlinks, we need to introduce other navigational aids capable of showing the overall structure of the Web site at a glance. Index pages are designed for that purpose.

Figure 5-6 shows an index page that summarizes 100 pages in one table by using thumbnail images of each page. This index page is useful for searching pages with photographs, illustrations and drawings, because those pages can be easily identified via visual browsing of thumbnail images. Other types of index pages include those with book pages, book facing pages, high resolution images, and book captions. In the near future we also plan to have a table of contents that shows the logical structure of books, such as chapters and sections.

5.4.4 Full-text Search

A full-text search, which is a typical navigational aid for conventional cultural digital archives, is also provided on the DSR portal, as the only text input box interface left on the system. The search engine we use is called GETA.[1] It was developed by National Institute of Informatics and other organizations with support

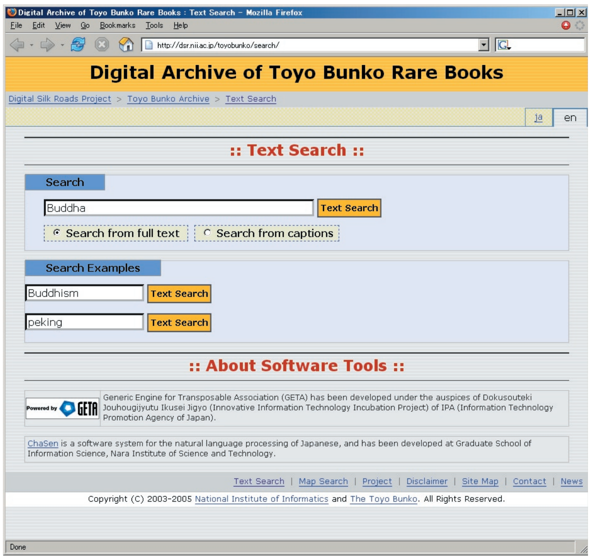


Fig. 5-7 Full-text search interface.

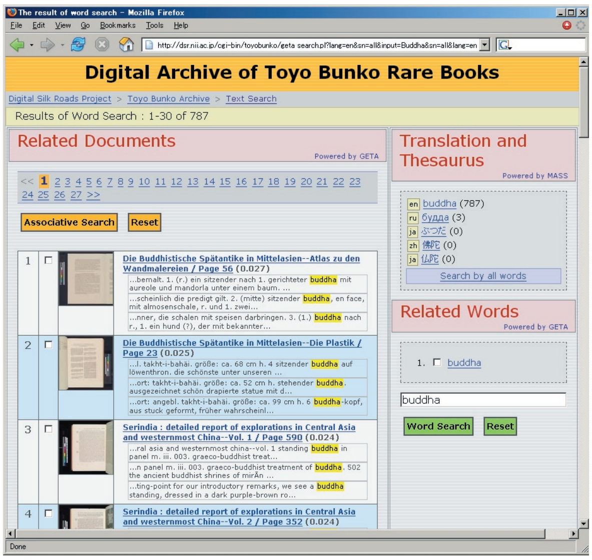


Fig. 5-8 Results of a full-text search.

from IPA (information technology promotion agency).

Figure 5-7 shows the interface for the keyword search. This interface supports exact-match-based full-text search only. A user first chooses the search target; either full-text or captions only. The latter is especially useful for searching images, illustrations and tables with keywords. Figure 5-7 shows an example when a user inputs the word “Buddha” to search for documents containing that word.

Figure 5-8 shows the results of a full-text search for the word “Buddha.” The left panel of the screen shows the list of documents containing the word; this result also supports KWIC (Keyword-in-Context) by showing the text around the searched-for keywords. The system shows three occurrences of the keywords starting from the first instance, so users can understand the context in which search keywords are being used.

In the top right panel of Figure 5-8, keywords translated into other languages are shown, along with the number of documents containing the translated keywords. This translation is carried out by MASS (Multilingual Annotation Support System), introduced previously in Section 3. If search keywords match one of the records in MASS, the system applies a query expansion for multilingual search. Thanks to this method, users are only required to input keywords in a language they are familiar with, while still being able to search for documents written in languages they cannot write simply by following links provided.

Finally the bottom right panel of Figure 5-8 shows the list of keywords related to the list of documents in the left panel. The usefulness of this feature is explained in Section 5.4.5.

Referring back to the left panel of Figure 5-8, clicking one of links takes you to the page containing the keywords, as shown in Figure 5-9. This page shows the image of the original book at 900x900 pixels, and below the image it shows the OCR (optical character recognition) text extracted from the image. When users reach this page through the full-text search, they will find that search keywords are highlighted on the OCR text as shown in Figure 5-10. From a practical viewpoint, this highlighting function significantly reduces users’ burden in locating keywords within OCR text.

This search system also supports basic stemming and stop-word elimination. For Japanese language in particular, a morphological analysis tool called ChaSen[2] is used for splitting words into meaningful segments in standard word form. Indexing of documents is done in Unicode (UTF-8) for all languages in order to generate a single index for all documents.

5.4.5 Associative Search

The uniqueness of GETA search engine is better demonstrated by the “associative search” for searching documents similar to the queried documents. The advantage of an associative search is that users do not have to input keywords, instead simply picking documents for which to find similar documents based on similarities between word frequency statistics. Figure 5-11 shows an example list of associated documents

1 http://geta.ex.nii.ac.jp/

2 http://chasen.aist-nara.ac.jp/

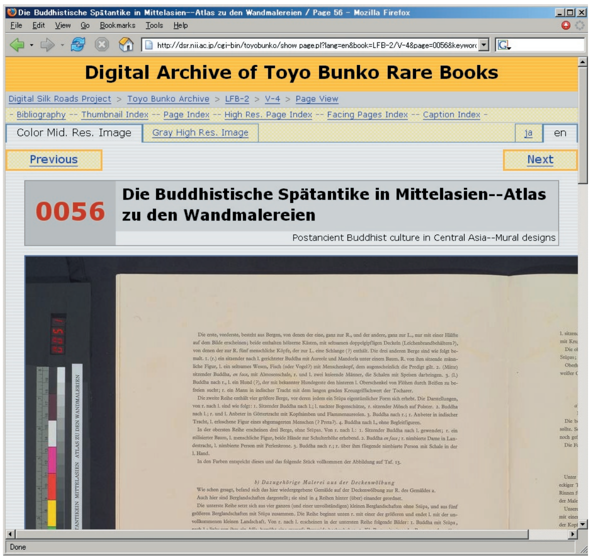


Fig. 5-9 Page view of full-text search

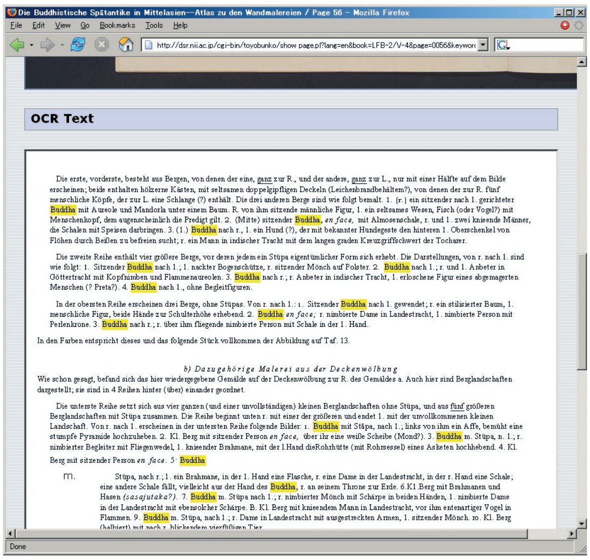


Fig. 5-10 Page view of full-text search (OCR

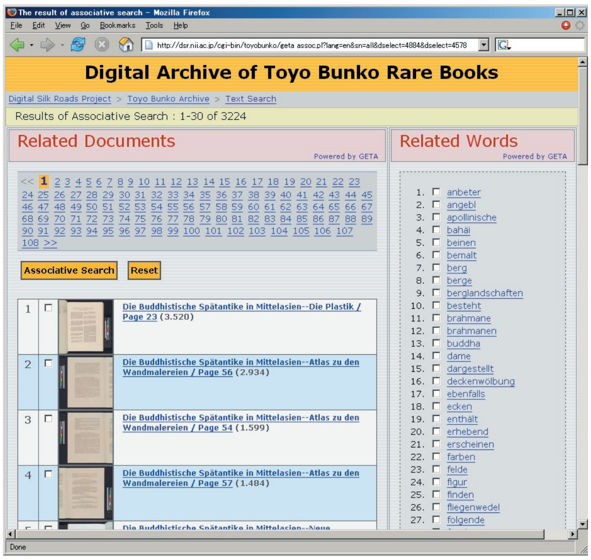


Fig. 5-11 Results of an associative search.

and important keywords automatically chosen for searching associated documents. Note that similar documents are chosen from multiple books. Following those links, users can navigate across books for related information.

5.5 Knowledge Representation

5.5.1 Metadata

The metadata used in the DSR portal includes basic information such as title, creator, description, publisher, date, format, identifier and language. Those elements are taken from the Dublin Core Metadata Element (DCME) Set[3], which is used as the de facto standard for representing basic bibliographic metadata. The extension of DCMS is also required on the DSR portal, however, in terms of multilingual metadata and domain-specific metadata. One metadata that cannot be ignored for the digital archiving of rare books is the binding information of the book. Western books have bindings opposite those of Chinese books. Other page numbering features also vary by book, so we need a metadata to describe such information. These metadata are described in XML with standard metadata tags as well as special tags defined by us. Then those metadata are processed on DSR-CMS in order to process HTML documents embedded with metadata.

5.5.2 Ontology

Ontology is used to represent the relationship of concepts in a hierarchy, thesaurus and other forms [22]. It is a key concept for the semantic management of contents, because it can be used to create relationships between cultural resources on a conceptual level. Concepts and relationships between concepts, however, vary by domain. Hence it is important for the DSR portal to have good ontologies in the related domains of the natural sciences and the humanities. Good ontologies have already built in some areas, but in most areas there are no such ontologies so we need to develop them ourselves. The building of ontology is not a trivial task, so we start with a simple ontology for a restricted domain, and build up a large ontology combin-

3 http://dublincore.org/documents/dces/

ing multiple smaller ontologies. We are also building special tools, called Open Ontology Forge (OOF), to support the management of ontologies.

5.5.3 Combining Knowledge with Search

Knowledge represented in the way above can be integrated into advanced search mechanism. One example is a concept-based navigation and multilingual search. The former is related to an ontology, while the latter is linked to a multilingual dictionary. As illustrated in Figure 5-8, a basic form of multilingual search has already implemented - a searching mechanism indispensable for cultural digital archives that straddle multiple languages and periods.

5.6 Current Status

The number of accesses to this Web site is measured by the number of page views for the top page, excluding internal and erroneous accesses. As of January 2005, the page view of the DSR top page has reached about 38,000 (since December 2003), the Toyo Bunko Web top page, 20,600 (since April 2004), and the Bam Web top page, 12,400 (since January 2004). The number of actual page views by visitors is difficult to measure, because a considerable number of accesses are from search engine robots, which are not meaningful as user-request statistics.

5.7 Future Directions

5.7.1 Challenges

The DSR portal is not yet fully developed; we need to solve the following challenges to make the DSR portal more powerful for researchers and non-experts alike.

1) A steady increase in the amount of digital cultural resources

The first challenge is to increase the amount and variety of digital cultural resources available. Variety is especially important because an integrated information resource like the DSR portal has more value when connected to information from multiple sources, such as books, papers and photographs.

2) Effective integration of multiple resources

An increased variety of cultural resources will require effective linking across cultural resources. Knowledge representation such as ontology can be used as glue to connect multiple resources. Another possibility is to use research papers as a hub for linking multiple cultural resources with academic descriptions.

3) Sustainable evolution of databases and users

We need to have a strategy for the evolution of the digital archive. This means that knowledge collected in the digital archive should not be static but should be dynamically evolved via collaborative work by a variety of experts and non-experts. One way is to collect opinions, comments, and follow-ups on cultural resources from motivated individuals; we are planning to set up another portal for this purpose. This kind of collaborative work is necessary for the sustainable evolution of digital archives, and we hope that motivated individuals can also learn from participatory collaborative work.

As stated, it is important for the DSR portal to increase the amount and variety of contents; we plan to include the following two resources into the DSR portal in the near future.

5.7.2 The Global Database of Buddhist Caves

“The Global Database of Buddhist Caves” will be an integrated multimedia database with information on Buddhist caves around the world. The purpose of this database is to build a portal site for Buddhist caves that provides textual information about the caves as well as related information such as research papers and photographs. Ontology may be especially important in the creation of this database. The structure of the different cave sections - walls, ceiling, statues, and murals - follows the concepts of Buddhism, so the representation of the structure requires a systematic knowledge representation method. Hence domain ontologies are required for a number of academic fields, such as archaeology, art, history, and architecture. This database is expected to allow researchers to compare caves across different sites and countries, studying them to discover commonalities and differences between them.

5.7.3 The Database of Silk Road Studies

“The Database of Silk Roads Studies” will be a collection of research papers, academic reports, and other research references related to Silk Roads Studies. This is in some sense an extension of Toyo Bunko Web, which archive only books. Research papers and academic reports provide detailed descriptions of specific topics, and add a good deal of knowledge that cannot be found in books. The design of this database will allow users to search papers that are related to a cultural resource, or cultural resources that are related to a paper. In this sense, papers can be used as a hub to connect multiple cultural resources. Those resources can also be linked with ontologies and dictionaries to support instant lookup of important technical terms on the DSR portal.

6 ASPICO Portal for International Collaboration

6.1 Overview

This chapter describes ASPICO-DSR (Advanced Scientific Portal for International Cooperation on Digital Silk Roads), a Web-based portal that aims at hosting international and multidisciplinary experts to create a digitized cultural heritage of the Silk Roads. This solution features services through a standard Web browser to collect or upload multimedia resouces, comment them (metadata), and search them such that resources provided by members are, finally, viewable by the public. In addition, ASPICO-DSR eases and fosters members' collaborative studies by providing communication tools and shared workspaces.[15][16]

6.2 ASPICO-DSR: Architecture and Metadata Management

DSR was established to protect the heritage of the Silk Road by utilizing the raft of new technologies being developed within numerous fields of research. NII and UNESCO pledged to support this tremendous work via a development of the ASPICO-DSR Web-based portal .

1) Architecture

The functional architecture of ASPICO-DSR is laid out in Figure 6-1. The portal entrance leads to one of two different areas depending on the status of the users, namely whether the user is a visitor or a member.

The Public Area is freely accessible by visitors interested in the Silk Roads. Users can first browse pages about various topics, ranging from the ASPICO-DSR project to underlying technologies and partner initiatives. Users can also search for multimedia resources available from the Digital Silk Roads Database through the portal, and view the comment from Silk Roads experts accompanying along these resources.

The Member Area relies on workspaces to encourage collaboration among expert members and allow members to manage cultural resources. Each member can access a private domain, namely called 'My Workspace,' to manage his/her own resources and work. Ad-

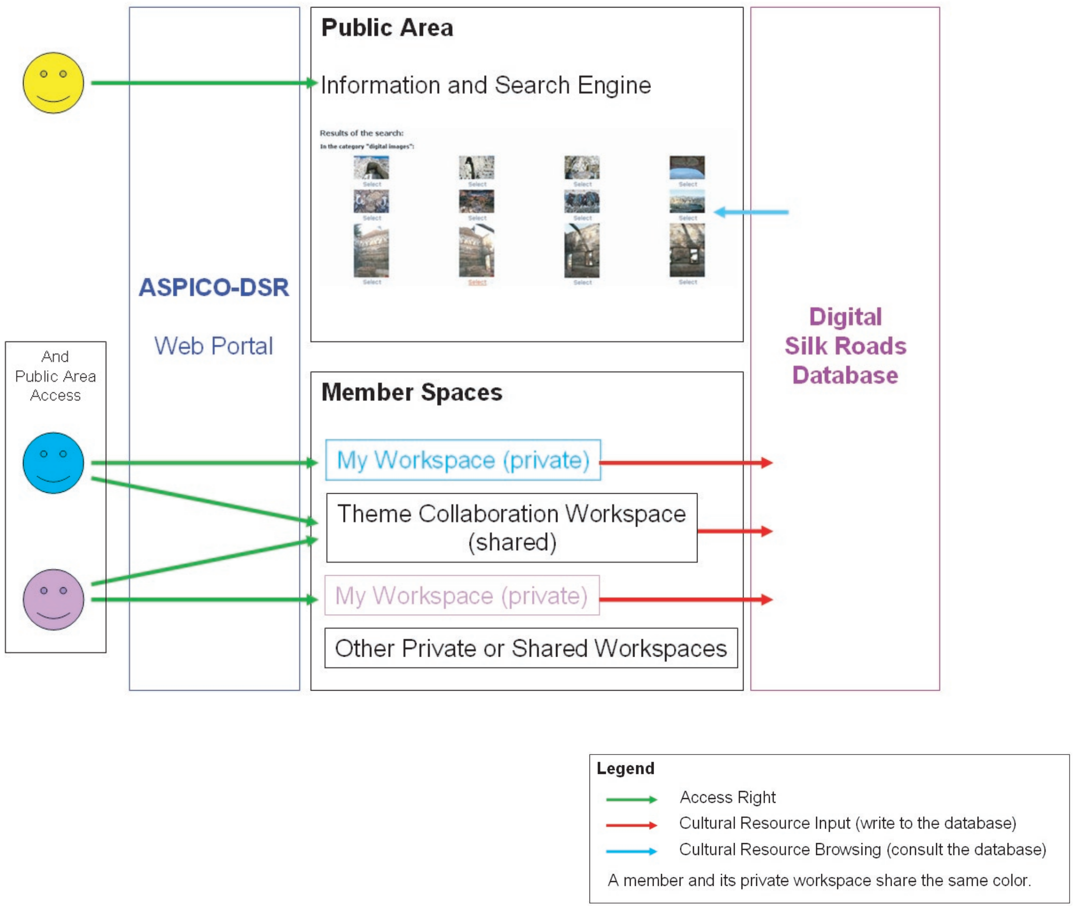


Fig. 6-1 Functional Architecture of ASPICO-DSR

ditionally, members may freely join work groups that share a 'Collaboration Workspace.' In this space, members can manage common resources, work, and also collaborate with others in the work space via the available communication tools.

The Public and Member Areas rely on mostly multilingual interfaces in order to foster international cooperation among members. In the end, the overall work and data from member studies is stored in the the Digital Silk Roads Database to serve the Public Area and support ongoing endeavors to build and improve the contents of the portal.

2) Metadata Management

The central function of this architecture is the management of resources and their comments. Comments are provided to visitors along with resources, and they are categorized as metadata for those resources. This second point of reference allows resources to be directly searched by means of their comments, as shown in Figure 6-2.

In this example, the search request is the keyword ' Buddha'. The engine retrieves a set of results that includes the image in Figure 6-2, since its comments include a reference to the keyword. Requests 2 and 3 will also retrieve this resource, but the other resources in their respective result sets will differ from those for Request 1.

The current metadata schema of ASPICO-DSR for classification of resources relies on four separate standards to create the base of its cultural heritage ontology model. Those standards are Dublin Core (DC), Object ID, the Categories for the Description of Works of Art (CDWA), and Visual Resources Association (VRA). ASPICO-DSR builds its schema from them by exploiting their standard vocabulary. The following Tree 1 shows a part of the current structure of the schema.

Terminal leaves of the tree are categories that can be selected as the final classification point for resources (for instance, videotapes, or post-cards). Branch nodes can be customized through ASPICO-DSR to dynamically represent new categories.

Beyond the creation of metadata, management includes ensuring the quality and correctness of comments that become available in the Public Area. In this regard, the design specifies three states for resources, temporary, clean, and validated, which are assigned on the status and quality of the corresponding metadata, as shown on Figure 6-3.

Temporary Resources are isolated files without any associated metadata. They require comments from Silk Roads experts for further exploitation (discussion and publication). Such data is only accessible from Private or Shared Work Spaces. Clean, or Commented Resources consist of sets of data with associated comments. Such Resources must be reviewed by the committee before being open to the public. They are still only accessible via member's Private or Shared Work Space. Finally, a Validated Resource is one which has been reviewed by the ASPICO-DSR quality committee and is available in the Public Area.

This three step process ensures a collegial decision and validates the quality and relevance of submitted

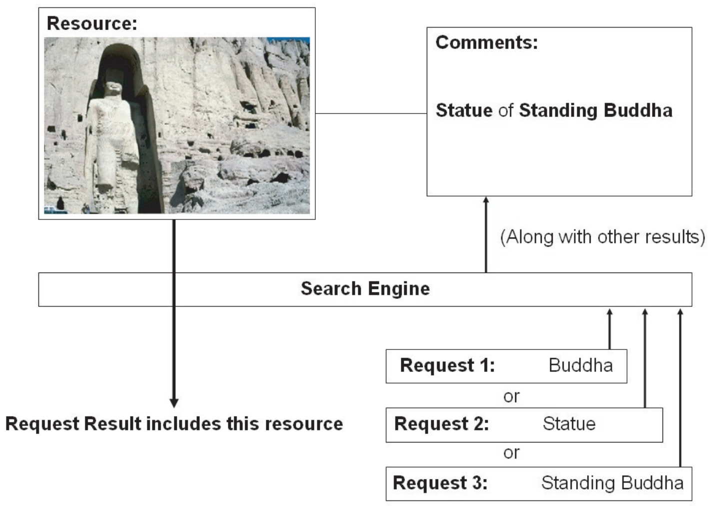
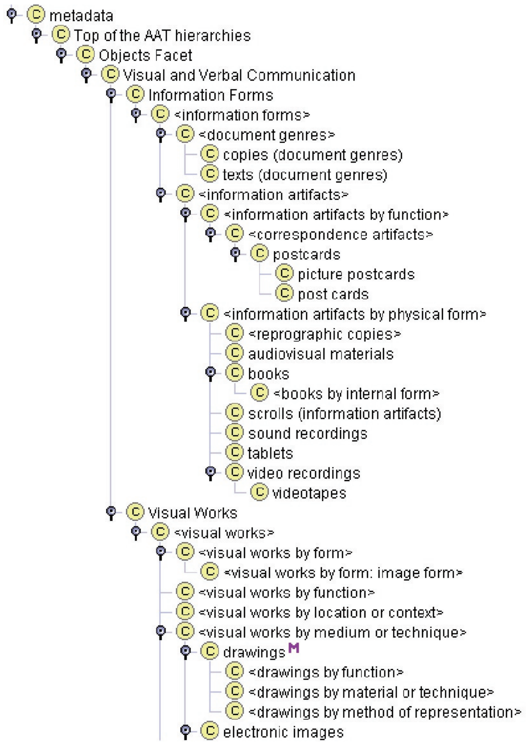


Fig. 6-2 Comments are also search keywords (image from the Bamiyan Collection)



Tree 1 Partial Metadata

resources before they reach the Public Area.

6.3 Description of the ASPICO-DSR

The current implementation of the ASPICO portal relies on open-source software and is built on top of the Comprehensive Collaboration Framework (CHEF) from the University of Michigan running in Java[41]. This section describes the mainl tools of ASPICO-DSR, namely the primary simple search engine, work

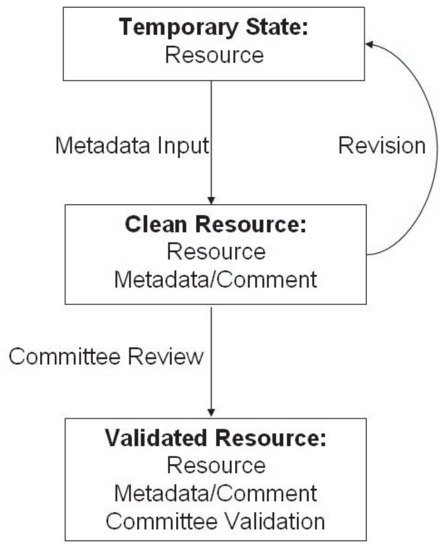


Fig. 6-3 -Resource States

space, communication and collaboration tools, the metadata editors, and the quality committee function.

1) Basic Search Engine

On the entrance page of ASPICO-DSR, detailed information about the project, related technologies and related activities is accessible through the front menu. At the top of the page, shown in Figure 6-4, the 'Public Area' button leads to the Silk Roads digital heritage search engine.

The current search engine provides for only basic operation; after it is proven to be conceptually sound, additional function will be added. At present, searches may only be performed by categories of resources (media type, object type), such as paintings or books.

Fig. 6-4 Top of the entrance page

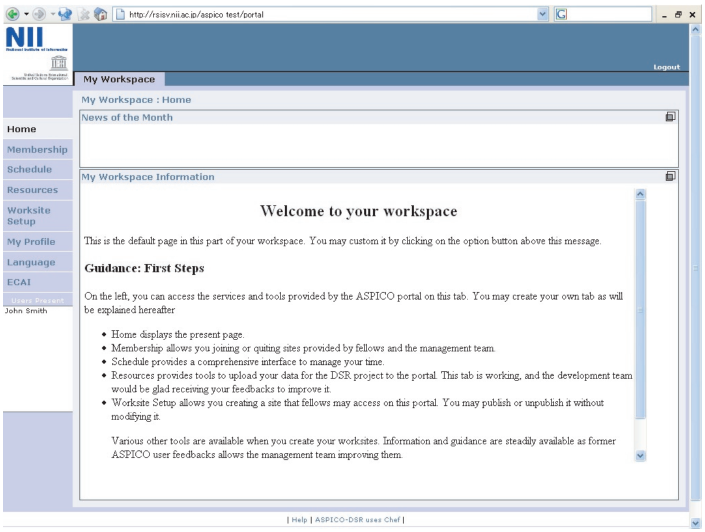


Fig. 6-5　My Workspace (private area)

For instance, only request 2 (‘statue’) from Figure 6-2 is currently supported as a mean to search for resources.

When a category is selected, the corresponding available resource list is displayed and visitors are able to choose objects of interest. When an element is clicked on, it is magnified and information provided by experts appears alongside it. Comments are mostly descriptive, and situate the resource in time and space when possible (Title, Location, Era, Comments, Dimensions, Relation to the Silk Roads, etc). All authoring information presented conforms to the UNESCO policy on ASPICO-DSR contents.

2) Workspaces

ASPICO-DSR divides workspaces into two two types to allow members to make full use of the services available in each. This infrastructure relies directly on the CHEF model and exploits its capabilities within the context of the Silk Roads.

Each member receives a private workspace upon creating an account. Figure 6-5 shows a typical workspace area. This home page allows each member to manage personal information such as their profile, membership status in shared spaces, and schedule, and engage in resource and metadata management.

At the top of the page, tabs may be available for swapping among spaces. The default tab is always set

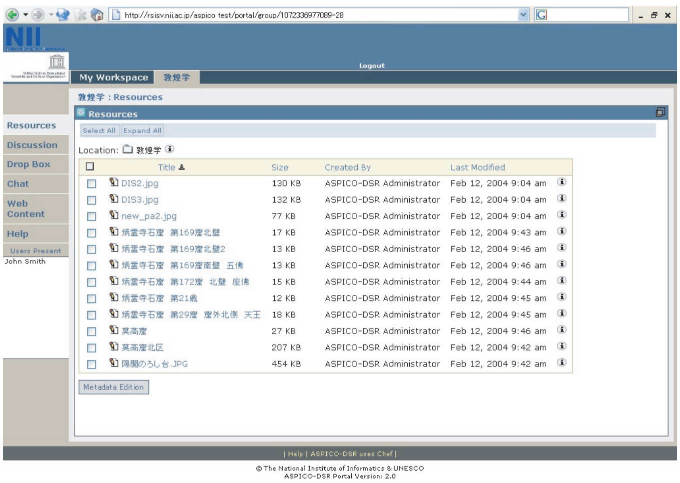


Fig. 6-6　Shared Workspace example

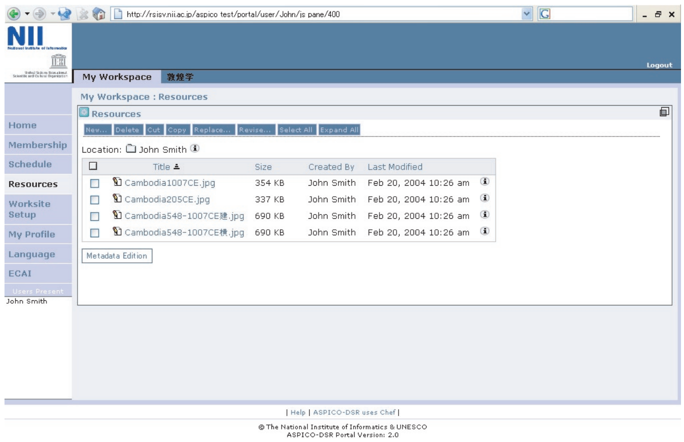


Fig. 6-7 Resource Management and Metadata Creation

to the private ‘My Workspace,’ and, after entering a working group by applying using the ‘Membership’ tool (on the main menu to the left), a new tabs becomes visible at the top to represent the workgroup. In the example in Figure 6-6, two work groups are presented, ‘Silk Weaving’ and the Japanese ‘敦煌学’.

Figure 6-6 shows an example of one of these shared spaces, with the Japanese ‘敦煌学’ tab selected.

The layout is similar to ‘My Workspace,’ so members should be familiar with the interface. However, the left menu and colors can vary depending on the creation options.

To create and control shared spaces, the left menu in ‘My Workspace’ has a button named ‘Worksite Setup.’ The creator is the owner of this shared space, and may choose to grant any simple access or full maintenance rights to all who request it, or manually select members to allow to participate. Furthermore, as shown in Figure 6-6, the owner may freely modify colors and menus to suit the purpose of workgroup. The ‘Help’ link at the bottom of the portal page details the sequence to create and customize a complete workspace.

The main advantage of these shared workspaces is the ability to share resources and communicate directly with fellows and peers. The following section describes these optional communication and collaboration tools.

3) Communication and Collaboration Tools

In shared workspaces, members may exploit ASPI-

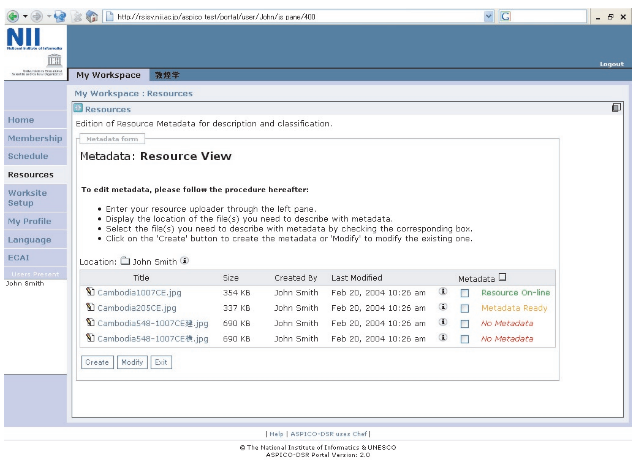


Fig. 6-8 Metadata Editing Tool

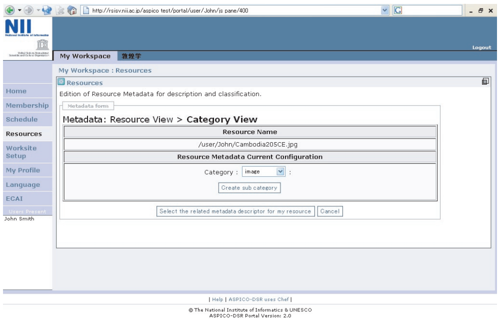


Fig. 6-9 Metadata Class Selection (category)

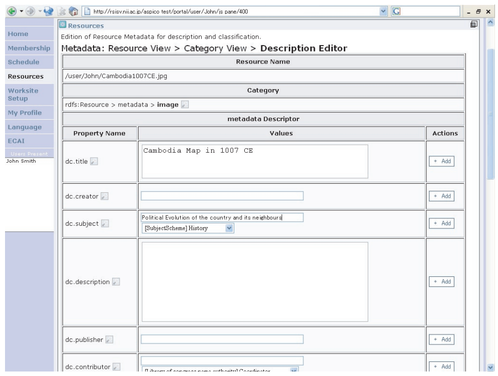


Fig. 6-10 Properties list for the selected category

CO-DSR communication and collaboration tools. From the original CHEF platform, the portal provides a discussion forum, integrated instant messaging (chat), and a drop box, i.e., access to personal folders for peer to peer file exchanges. A tool is available in a shared workspace when its name appears in the menu at the left. Members may submit request to the administrator of the space for access to tools dynamically using the 'Worksite Setup' function.

The discussion forum uses a format similar to most systems widely available on the Internet. Members can create new discussion threads and messages or reply to posts from fellow workspace members. Similarly, the integrated instant messaging system (chat) closely resembles popular versions of such tools used on the Internet. As users chatting in several workspaces simultaneously may lose the thread of some conversations and not be able to participate meaningfully, the chat program is only permitted to be open in one workspace at any given time. Finally, the drop box is aimed mainly at allowing members to exchange working documents from person to person through the portal. This system has two main advantages: first, it avoids a problem common in email, where a large file attachment causes an email to be rejected and go undelivered-there are no restrictions on file size for the drop box: second, privacy is ensured, as the data never leaves the ASPICO-DSR servers .

4) Metadata Editing Tool

The main tool for ASPICO-DSR is that used for managing and commenting resources provided by members. In technical terms, this means it uploads data and creats associated metadata along the ASPICO-DSR cultural heritage logics (a proper schema relying on standards such as Dublin Core). On member spaces, the 'Resource' button on the left menu leads to the screen in Figure 6- 7.

The initial screen shows the current list of resources provided by the member. The top menu of the central panel in Figure 6-7 contains a row of buttons that group gather the most often used resource management functions, such as new resource, deletion, and copy and paste options. These buttons lead to separate screens to complete the desired function and return to the screen shown in Figure 6-7 after completion of the function. The creation of a new resource requires a file name and the acceptance of one UNESCO license, either for full donation to UNESCO, or for limited rights (under definition).

At the bottom of the central panel in Figure 6-7, the 'Metadata Editing' button leads to the metadata management tool, the typical layout of which appears in Figure 6-8.

The list of available files is displayed once more displayed, together with metadata related information. A color code is employed as an easy way to show the status of resources, with red, orange, and green corresponding to temporary, clean and validated states respectively. The green state means the resource is online and available in the Public Area, whereas red and orange states are still local to members.

To create comments, members select one or more resources (in the latter case, all resources have the same metadata) and start the process. First a category is required (metadata class), as shown in Figure 6-9, and then the corresponding properties can be filled in to describe and comment the resource, as shown in Figure 6-10.

The Figure 6-9 also makes aparent the possibility of creating a subcategory before selecting a category selection. Indeed, members may not find an appropriate classification in the list. As Silk Roads experts, members can add one or more subcategory in their field of interest and then select the one appropriate for the described resource. For example, one root category is ' Books Containing Illustrations,' which may seem too abstract to properly describe a member's book about

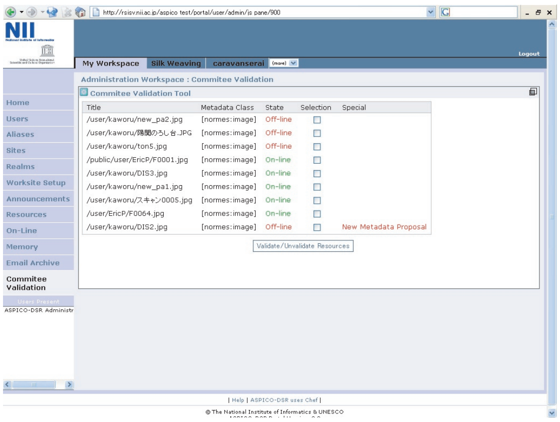


Fig. 6-11 Committee Validation List

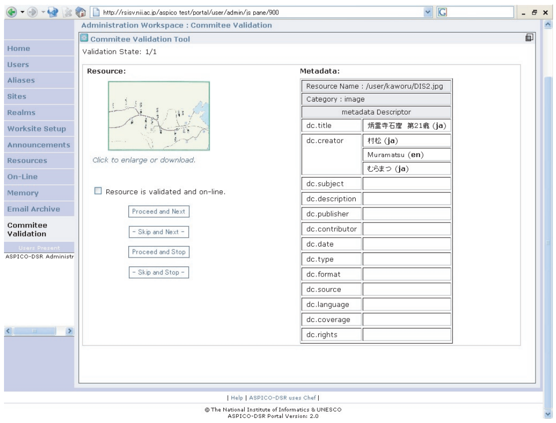


Fig. 6-12 One resource and comments

pottery. The member can then create a subcategory ‘ Pottery along the Silk Roads’ that will then serve all books on the subject.

On completion of the creation process, the resource change status, switching from red state to orange. Modification processes can then be applied to revise or complete the input information. From the orange state (clean), one additional step is required to publish the resource in the Public Area and make it accessible by the search engine. This step is only able to be carried out by the ASPICO-DSR committee, in order to ensure the quality and correctness of contents.

5) Content Quality Tool: Metadata Validation by the ASPICO-DSR Committee

The ASPICO-DSR Committee is in charge of the portal to ensure that the information available in the Public Area is of a high level of quality . Elected members have access to a special tool in the left menu of their personal workspace. The current implementation only allows the portal leader to access this tool. Figures 6-11 and 6-12 show this tool and its functions.

Resources of either a clean or validated states are shown in the list on Figure 6-11. The color code is simpler here as only two states are used: red means the information is offline and green means the information is online. The committee member can select resources to review. Special warnings appear when online re-

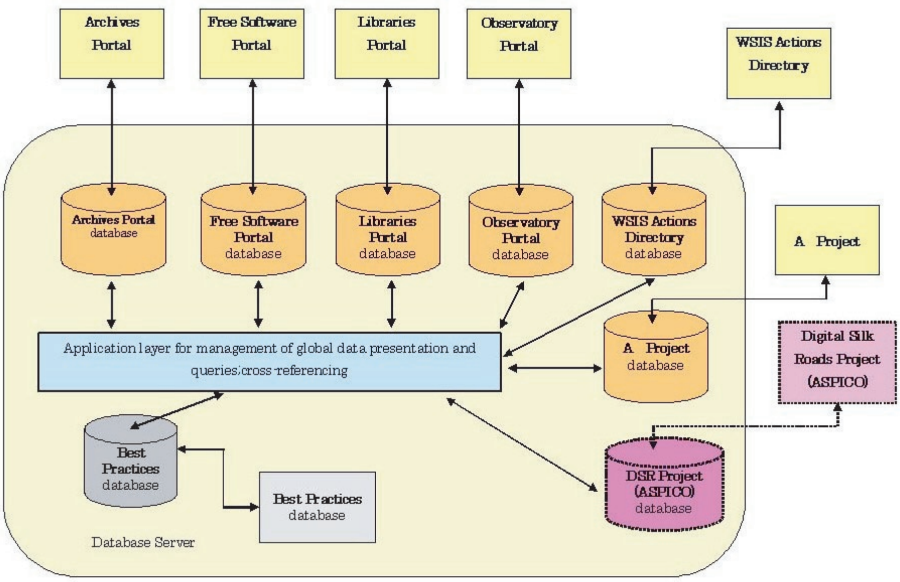


Fig. 6-13 Possible Integration of ASPICO with the UNESCO Web Portal

sources are modified by their original creator, usually to make improvements or suggestions.

Figure 6-12 shows the typical reviewing screen when resources are selected. The resources displayed are accessible by simply clicking on them. Comments are compiled in the table on the right, and buttons provide options for validating or canceling the process. Once validated, updated resources are searchable through the engine in the Public Area.

6) Integration of ASPICO with the UNESCO Web Portal

ASPICO-DSR will be open not only to the Silk Roads community but also to the public, via the Internet. To harness ASPICO as the DSR community's tool for daily cooperation and assistance as well as a platform for information dissemination , we are trying to integrate ASPICO with the UNESCO Web Portal.

Figure 6-13 shows a possible method of integration.

6.4 Conclusion

This chapter presents ASPICO-DSR in its current state of implementation, and describes future developments that are being pursued with a view toward its evolution. The architecture of the system fulfills the requirements for support of the international Silk Roads community set forth by UNESCO via a set of services allowing for the upload and commenting of multimedia resources before publication in the Public Area. After publication, it makes the resources accessible by anyone around the globe with a standard Web browser.

ASPICO-DSR presently fulfills the initial requirements set forth in DSR project. This first version, however, needs improvements to meet member needs in a real-life usage environment. For this reason, we are considering implementing an advanced resource interface to ease resource and metadata management.

For the future, we are also discussing interlinking different systems around the world to build a comprehensive set of independent cultural heritage databases. ASPICO-DSR allows these databases to be searched individually or collectively from a common portal.

7 Annotation and Knowledge Management of Cultural Resources

7.1 Introduction

In this report, we present the lastest development of an open-source collaboration tool dedicated to semantic management of cultural content, a new type of WWW-based collaboratory for cultural heritage information sharing and cooperative exchange for research and education purposes. Professional domain experts are able to use the system to analyze, evaluate, and collaborate on the interpretation and indexing/annotation of multimedia documents. The metadata hereby provided are managed via an advanced XML-based content manager and an intelligent content- and context-based retrieval system.

The ASPICO system not only provides the functions of a traditional digital library, but on top of that it employs a comprehensive approach as an aid in the development to collaborative knowledge derived from cultural sources, i.e. supporting users in their analysis, interpretation, and evaluation of the sources as well as the creation of new knowledge as a result of this work with the material. Therefore, the system and its components are adaptable to heterogeneous cultural domains.

From the ASPICO Approach to a Scoper-based Approach

Designed as a content- and context-based knowledge work environment for distributed user groups, the initial system, called "ASPICO" (Advanced Scientific Portal for International COoperations), supports both individual work and collaboration among domain experts who are analyzing, evaluating, indexing, and annotating the material in the multimedia data repository. It continuously integrates the user knowledge thus derived into its metadata repositories, and on this basis can offer improved content-based retrieval functionalities within the information system. Users can therefore both access and create valuable knowledge about various cultural contexts, which in turn allows other end-users to better retrieve, compare, and interpret the materials. The two major features of the ASPICO system are:

(1) Direct access to cultural heritage knowledge is provided by a content-centric, user-driven information system and collaborative working environment over the internet.

(2) Feebacks of the professionals' actual usage of the collaboratory are analyzed and documented for different tasks and user groups so as to implement new user requirements and improve the system functionalities. The usages from various cultural cooperations strongly influence the evolution as an, iterative, dynamic platform.

The first prototype of the ASPICO system was provided at the end of March 2004 under the Digital Silk Roads project[1][2][15], allowing for formal cataloguing, content-based indexing and annotation of digitized text documents, and document exchanges. A newer version called "myscoper" incorporates advanced document preprocessing modules for automatic metadata analysis and indexing of multimedia data in collaborative scopes and points of views, and especially more support of collaboration between users based on a collaborative and point-of-view based task model. As a prerequisite for collaborative work, any digital material is analyzed, indexed, preliminarily translated, annotated, and interlinked by experts. "myscoper"provides them with appropriate task-based interfaces for in-depth indexing/annotation and other tasks as well as with supporting knowledge management tools (indexing aids and special control vocabulary lists). End-users can input valuable information through annotations. In this way, a growing body of metadata is emerging over time. The system exploits the digital nature of the data by employing advanced XML-based content management and advanced retrieval methods. The online version of "myscoper" will integrate cutting-edge document processing and management facilities, e.g., XML-based document handling, digital watermarking, and semi-automatic segmentation, categorization, and indexing of digitalized contents.

By combining the results from the manual and automatic indexing procedures, elaborate content-based retrieval mechanisms can be applied. This helps users find what they are actually looking for according to various points of views.

7.2 The Platform Architecture

The "*myscoper*" system introduces the following innovative features:

– practicable methods of content and knowledge processing for isolated document collections
– a new concept of content-based organization, handling, and presentation of historical materials
– a user-friendly online working environment to share the expert knowledge of professionals via annotations.

The dynamic accumulation of annotations requires new data structures to be both scaleable and extensible. In order to capture these dynamics we chosed XML as a de facto standard for the encoding of generic documents and metadata representation schemata. The use of XML guarantees the interoperability, since these schemata can then be enriched and tailored to additional sources and knowledge incorporated into our system without any need for re-modeling the whole system. In addition, XML allows the integration of knowledge processing methodology and retrieval functionality within the system. Therefore as a result, the system is capable of capturing the dynamics of collaboration without neglecting the necessary flexibility of scaleable and extensible representation schemata.

The platform architecture (see Figure 7-1) is based on open-source components including a storage layer (Dspace[1]), an ontology-based metadata management program, query interface and resource entry services, and a multi-resolution resource viewing tool. The storage layer can support various types of digital data, ranging from scanned-in text documents to multimedia data and the accumulated annotations related to one or more of these original data sources\. The system limits the access to data according to the users' rights set to indoor users (Intranet), outdoor users (Extranet), and to the Web users. The Collaborative Task Layer allows a wide variety of user types to access, manipulate, and annotate the digitized material. Some of these tasks can be performed collaboratively, e.g., collaborative inspection and interpretation of source materials. A collaboration model has been developed and offers context-dependent interface functions for collaboration between users.

Support of collaborative work goes beyond contemporary groupware products, offering innovative functions such as:

– collaborative interpretation of sources, e.g., tagging, annotating document sources and annotations made by other colleagues
– support of specific tasks in scholarly work where individuals or groups contribute to a common information space

7.2.1 Ontology-based Metadata Management

In order to organize the stored data in a way that supports the complex knowledge-intensive tasks users perform, suitable tools for metadata management are being provided. The knowledge structures, which are represented by specific XML schemata, constitute the Domain Model. These knowledge structures, a key feature of our system, are managed as multilingual ontology-based metadata support. Our platform follows a promising research approach based on the usage of metadata and ontologies. Metadata is any information which characterizes instance data, and which describes relationship between those instance data. Metadata is used to provide an effective use of data, in order to facilitate any data management, any data access, and data analysis[43].

An ontology is an explicit specification of the conceptualization of a domain[44]. Ontologies enable domain experts to create an agreed-upon vocabulary and semantic structure for exchanging information about that domain. Ontologies facilitate the cataloguing and sharing of knowledge, as domain experts are able to contribute to a shared, worldwide, but well-organized knowledge base of technical information. We considered a metadata management architecture and designed multi-layer ontologies to classify and describe

1 MIT's Dspace: http://www.dspace.org

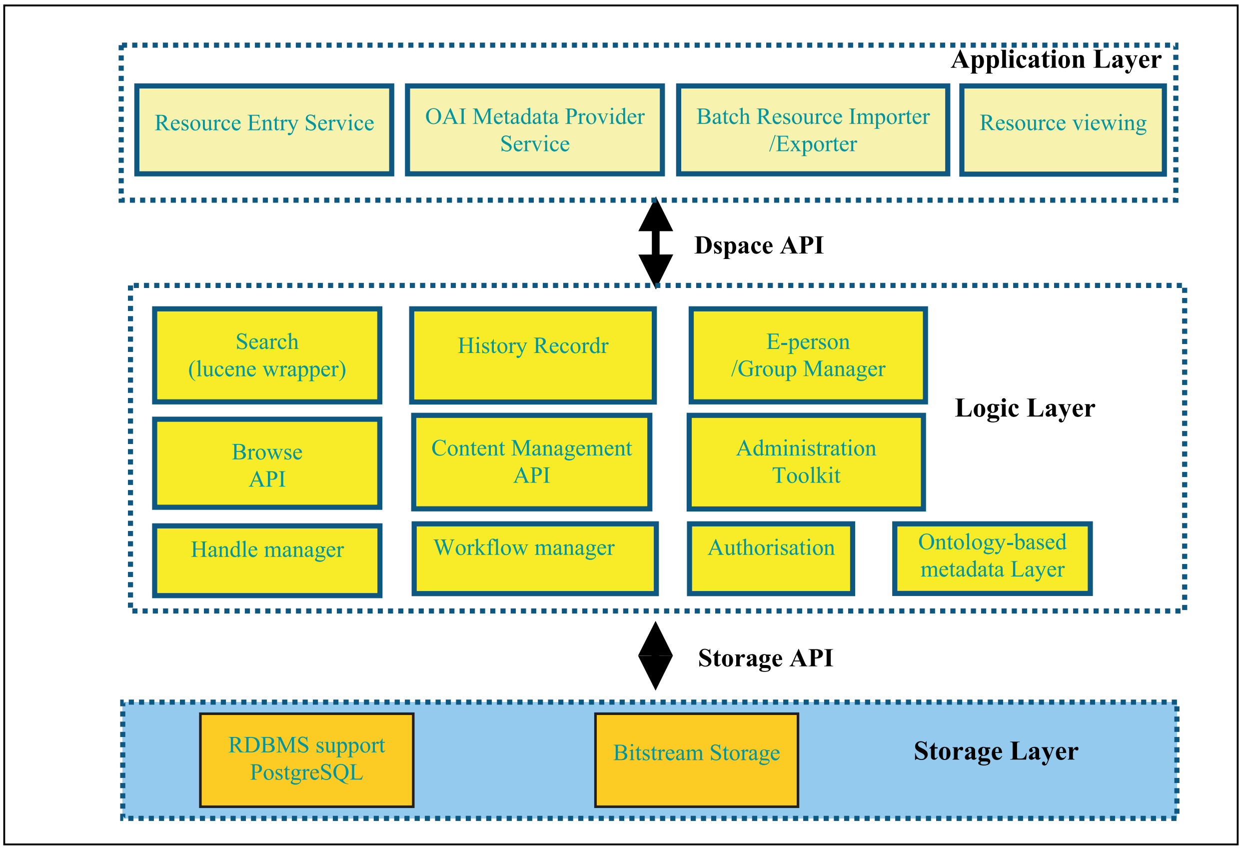


Fig. 7-1 Architecture of the myscope platform

resources. It is based on Protégé 2000 where each ontology is related to one field such as history, geography, architecture, and art, etc... However, the system included the possibility for overlapings, as different ontologies may have equivalent concepts, or may contain subsets of separate ontologies within themselves.

This problem of ontology integration has been solved by classifying and reorganizing ontologies in a logical and semantic sense according to metadata. Our approach points to a need for a formal model for ontology-based metadata management. Ontology is the formal and explicit conceptualization of a particular domain. It includes a set of concepts and their relationships. Based on Protégé 2000, we defined our ontology structure as a 6-tuple:

$O := \{C,P,A,H^C,prop,att\}$

where C represents a domain-based set of concepts, P a set of relation identifiers, and A a set of attribute-value relations. HC is a *Hierarchy of Concepts* that are linked together through relations (e.g. specialization, generalization). H^c is a directed transitive relation $H^c \subseteq$ CxC called *concept taxonomy*; function prop: P->CxC relates two concepts non-taxonomically; function att: A->C introduces the relationship between concepts and literal values.

Example. Let us consider a subset of our ontology structure related to spirituality C:={SPIRITUALITY,RELIGION,LANGUAGE,OBJECT,LANGUE,BOUDDHISME},

P := {EXPRESS,CREATE} , and A defines the relations EXPRESS(RELIGION,LANGUAGE) and CREATE(RELIGION,OBJECT).

7.2.2 Resource Entry

Resource entry is also performed via a Web browser interface similar to that used for querying. Users who wish to enter some resources first need to log on. Write, modification, and suppression rights can be assigned and controlled by the system administrator for each user; the availability of some predefined types of users provides community and group management abilities.

Information such as the identification profile of the user and the date of the entry are automatically filled in by the system. To maintain the integrity of the resource being entered into the system, the controlled lists of relevant vocabulary within the thesaurus are used for each translatable field. When uploading a resource via the web interface, users are required to enter some preliminary metadata related to the resource. When a resource is saved in the main database, the metadata is translated into a language-independent code representation. The creation of the metadata profile is done according to some metadata categories such as structural metadata, content metadata and contextual metadata to avoid overlaps between attribute sets,

7.2.3 Query Interface

Queries are performed via a web browser-based interface. New interfaces for simple or advanced queries can be easily created and the fields to be included and customized by the system administrator. In addition, date or numeric size fields can be searched by specifying a range of dates or sizes between which searches are to be performed. Users are able to select the working language and the domain of interest as well as the number of results to be returned and whether resource results are shown. The interface is divided into three parts:

1- Historical and material resources related to artifacts;

2- Technical or management information related to photographic resources;

3- Technical or management information related to document resources;

Where applicable, the user can choose technical terms from a list of relevant terms ordered alphabetically, the user can type something in his own search terms. Ontologies in 21 languages will be able to be consulted online. Full-text searches can be made within each domain.

The format for display or the output format of the results (e.g., HTML, XML, plain text, formatted tabular, list of images, graphical or statistical analyses, etc.) is independent of the storage structure in order to optimize the delivery process. The format generation typically follows a methodology based on context-dependent cultural resource accesses [25].

7.2.4 Multi-Resolution Resource Viewing

Another key component of the resource management system is the capability to remotely view multi-resolution resources, including high-resolution images of both 2D paintings and 3D objects. Each image resource is stored as both a JPEG thumbnail for rapid previewing and in tiled pyramidal TIFF format for high-resolution viewing. A java applet acting as an interface for the storage layer permits multi-resolution viewing. This viewing system is based on the Internet Imaging Protocol. The viewer works by requesting only the tiles at the appropriate resolution required for viewing a particular part of the image. The requested tiles are then dynamically JPEG encoded by the server and sent to the applet. In this way, images of any size can be viewed quickly across Internet.

7.2.5 Multilingual Ontology-based metadata

Multilingual support is becoming of critical importance in the cultural domain. This can be accounted for by: (1) the increasing amount of cultural contents accessed over the Internet, (2) efforts to develop standards for cultural data from diverse fields for the purpose of digital archiving and research sharing, and (3) the increase in the use of tools to extract semantic data from cultural digital data. Furthermore, a multi-lingual Ontology-based metadata approach enables searching by both semantic and by contextual content, as it relies on multi-lingual annotated documents and features extraction processes. Each set of ontologies is based on object-identifier bridge between mono-lingual Unicode (UTF-8) encoding ontologies.

Controlled lists of technical terms (e.g., Art and Architecture Thesaurus AAT, Library of Congress Authorities) from each ontology as well as the free text information fields (such as the titles) have been translated with the support of domain experts. Providing content- and context-based access to the data repository is a crucial feature of “*myscoper*”. “*myscoper*”’s users directly enrich the document repository through new sources and successive annotations and indexation. Annotation as a multifunctional means of in-depth analysis can be done individually but also collaboratively, for example in the form of annotations of annotations, or collaborative comparisons of documents. As a result, a large amount of value-added information is provided in addition to the digitized documents.

7.3 Ontology-based metadata compliant to the Open Archives Initiative Metadata harvesting Protocol

The Open Archives Initiative (OAI) consortium is dedicated to solving problems of digital archive interoperability via the establishment of standard protocols. A major accomplishment of this consortium is the definition of a protocol for metadata harvesting (OAI-PMH). This is a protocol to transfer metadata from one archive to another. “Data Providers” refers to entities that possess data/metadata and are willing to share this data/metadata with others (internally or externally) via well-defined OAI protocols (i.e., Any WWW-based system that can be accessed through the well-defined interface of the Open Archives).

Table 7-1 Dublin Core Elements

No	Element	Description
1	Title	Name of the object
2	Creator	Author(s) of the written document
3	Publisher	The agent or agency responsible for making the object
4	Subject	The topic addressed by the work
5	Description	The contents of the resource
6	Type	The genre of the document (such as novel, poem, etc.)
7	Format	Electronic format
8	Identifier	String or number used to uniquely identify the object
9	Source	Information about a second resource
10	Language	Language of the intellectual content
11	Relation	Relationships to other objects
12	Coverage	The Spatial location and temporal duration
13	Rights	The management, statement for the resource
14	Contributor	Any entities responsible for making contributions to the contents of the resource
15	Date	The date of publication

Table 7-2 ECAI-Specific Metadata Elements

No	Element	Description
16	ECAI.Team	The ECAI team responsible for collecting the dataset or overseeing its incorporation into ECAI.
17	ECAI.Theme	The thematic domain(s) covered by the dataset.
18	ECAI.Notes	Additional information about the resource being described.
19	ECAI.UseRestrictions	Defines the level of access permitted to the data through the ECAI data browser
20	ECAI.Content	Describes the nature of the material available in the dataset.
21	ECAI.Expert.Commentary ECAI.Expert.InternalNotes	Authoritative comments for public viewing written by the ECAI team editor or other ECAI expert on the quality, validity, usefulness, etc. of the resource. Authoritative notes from the ECAI team editor or other ECAI expert on the quality, validity, usefulness, etc. of the resource. For internal use only.

7.3.1 The OAI Data Provider Service

Our digital archive is composed of many separate collections. Each collection has records in different metadata formats. We have developed tools for displaying collections based on the metadata formats of the records contained in those collections. The Collections include metadata contents organized as XML files and database files. All the metadata required for a particular format is in the database.

Our OAI Data Provider is based on OAICAT provided by OCLC. OAICat is a Java Servlet web application providing an OAI-PMH v2.0 repository framework. The framework has been customized to work with arbitrary data repositories by implementing some Java interfaces. Multilingual support has been added to the oaicat.properties file. All the implementation aspects of the Data Provider that deal with the database are captured in this file. Using the software requires familiarity with writing SQL queries and java. This software is currently undergoing testing.

7.3.2 OAI Metadata Support

Our implementation of the OAI protocol uses unqualified Dublin Core (DC) with the metadata prefix oai_dc. The Dublin Core Metadata Element Set contains 15 attributes, shown in Table 7-1.

Moreover, the OAI-PMH has changed the current status of unqualified Dublin Core from *mandatory* to *recommended*. As such, we have implemented a richer metadata protocol using the ontology-based metadata hierarchy of metadata sets.

7.3.3 OAI Extended to support ECAI

The Electronic Cultural Atlas Initiative (so called ECAI) Metadata is an extension of Dublin Core (DC). It includes data which catalogues the content and spatial and temporal ranges of datasets. ECAI has added custom ECAI extensions that enable access to the data resource via software such as TimeMap. The metadata focus on the data collection as a whole rather than the individual items in the collection. The TimeMap metadata extensions describe attributes such as

a) where the data is located on the network and
b) where the spatial and temporal information is stored within the data.

For example, ECAI metadata requires that the extent of the resource or dataset be defined by a bounding box (or "space-time cube") consisting of minimum and maximum longitude (x) and latitude (y) values, and a minimum and maximum time/date (t).

The core-based implementation of OAI has been extended based on the metadata prefix oai_dc.ecai.

The ECAI-Specific Metadata Elements are given in table 7-2.

7.4 Conclusion

The *myscoper* system is a scientific and education portal collaboratory tool supporting exchanges of cultural document information between users via innovative task-based interfaces for content indexing and annotation.

8 Spatial-Lexical Knowledge Model for the Silk Roads caravanserais -Multilingual Domain Ontology for Advanced Systematic Classification-

8.1 Motivation

Management of cultural heritage information systems especially those dealing with Silk Roads content will face the sheer volume and variety of the multidisciplinary databases of both tangible and intangible heritage.

The main challenge is how best to represent and share such large databases of cultural heritage systematically while bridging the knowledge gap between info-base providers and users accessing the system via the Internet (Fig.8-1).

Implementation of a separate knowledge model for each homogeneous field is of key importance in the conceptualization of the content, and representation of technical domain knowledge. Such models need to follow relevant standards to allow data interoperability between different information systems and communities, and to facilitate information gathering, integration, and distribution over networks.

In a general schema it can be noticed that such a knowledge model is the core of data management for advanced digital documentation of cultural heritage especially in a collaborative way, with contributions from domain experts like architects, historians, archeologists, etc. and computer scientists and IT experts, through related Web sites and portals; such kind of model is one of the targets of the Digital Silk Roads.

8.2 Statement of Problem

As a subset of the cultural heritage of the Silk Roads, information on architectural assets - as well as our case study, Caravanserais of the Silk Roads - reflects the main characteristics of historical buildings, the three-dimensional forms and spatial organization of it as a whole, which varied during different historical periods. A technical domain-based knowledge model including spatial dimensions is required to efficiently manage such visual 3D information and related annotations.

A new question arises here: What are the theoretical studies on the development of such knowledge models for the selected corpus of historical architecture within the described general schema (such as the Digital Silk Roads project)? Which technologies should be implemented? How can the proper theory, concept and technology be implemented using new information and communication technologies and how can the knowledge in the domain, i.e., architectural science, be supported by such a knowledge model?

To propose of some solutions for the above-stated problems, this research, as part of a multidisciplinary Ph.D. study in informatics with an architectural engineering backdrop, focused on a Spatial - Lexical Knowledge Model for Caravanserais of Silk Roads, Multilingual Domain Ontology for Advanced Systematic Classification[1] .

The following parts of this paper contain discussion on selected corpus and objectives of this knowledge model , development of domain ontology of selected corpus, design process and enhancement of available methods and the tool and software support. Finally, it concludes with the future plan of the study to reach to innovative knowledge model and cover the spatial attributes of architectural content of caravanserais.

8.3 The Focused Corpus and Objectives

Due to the varied content of information within the domain - as reflected in typological differences based

1 The supporting projects for this research, which is done in cooperation with Ecole d' Archtecture Paris Val de Seine (EAPVS) in France, are "Digital Silk Roads Initiative Framework" (DSRIF) from NII and UNESCO, and "Inventory of Caravanserais," from EAPVS and UNESCO.

Fig. 8-1 A graph showing examples of cultural heritage data over vast scope like Silk Roads and challenge for data management

on time, environment, and space - it is necessary to choose a special corpus of architectural heritage of the Silk Roads to be able to focus on its characteristics, i.e., information management, semantic annotation, and data access, and understand it as a system.

The corpus is an important subset of the cultural heritage of the Silk Roads, caravanserais[2]. Their main function was to support caravans during their journey [27]. Caravanserais were built in a chain in such a way that, as Robert Hillenbrand said, "They punctuated the major historic overland routes at intervals of a day's journey" [28]. Caravanserais of the Silk Roads are spread almost all throughout these historical roads - in the East, through China and India; in the Middle East, from Iran westward to Europe; in Venice; and even in North Africa and the Sahel. But within this general area, they are concentrated mainly in three countries: Iran, Turkey, and Syria [30].

Based on the available researches, especially the UNESCO project on caravanserais[3], Iran is considered to be the mother country of caravanserais, with more than thousand samples of different typologies. In accordance with this huge number of cases and based on background research on caravanserais [46], the area of this research focused on caravanserais of east-west Silk Roads in Iran, excluding samples of city typology.

The information of this corpus contains different types of visual information reflecting characteristics of this typology of historical buildings, based on various features such as location, style, historical period, and environment (Fig 8-2).

The objectives of this research focusing on the selected corpus are as follows:

(1) To define a method for advanced knowledge-based management and systematic documentation of data on the cultural heritage of the Silk Roads involved in a case study of caravanserais using NTIC, with architectural science support.

(2) To create a spatial-lexical model in order to conceptualize and to represent the knowledge of historical architecture found in the corpus of caravanserais. From this step, an advanced systematic classification system may be created.

(3) To scientifically recognize caravanserais through an analytic study of their components and relationships between components used to form the architectural space as a whole.

(4) To study and develop domain ontology for enhanced semantic access to visual data, especially via the Internet.

(5) To propose a cooperative joint research to cover the multilingual needs of users of the corpus of Silk Roads by extending the content to other languages[4]

2 The supporting projects for this research show the important role of caravanserais in studies along the Silk Roads

3 The UNESCO project is entitled "Inventory of Caravanserais," with participation by 9 countries in Central Asia and under the general coordination of Professor Pierre Lebigre from EAPVS

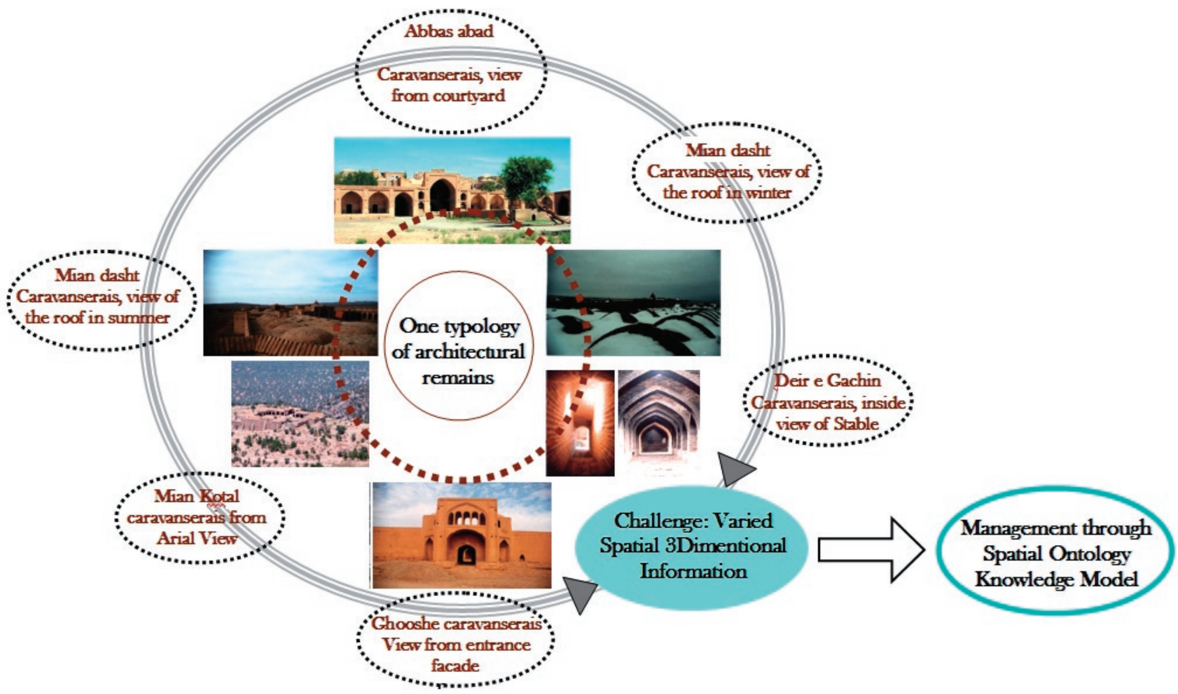


Fig. 8-2 Different typologies of caravanserais of Silk Roads in Iran and challenges ahead the management of their databases.

8.4 Study, Design and Implementation of the Selected Concept, Domain Ontology

This research focuses on ontology as a proper model to visualize and to represent spatial data of the selected corpus through study on theory and development of a spatial-lexical multilingual specification of caravanserais.

Ontology is originated from philosophy and is the study of the kinds of things that exist. However, the definition given by Gruber to ontology, "as a specification of a conceptualization" [31] focuses on its role in knowledge management. It represents a declarative model of the terms and relationships in a domain [5] and provides a lexical knowledge-base. Domain ontology focuses on the conceptualization of specific domain data, like the selected corpus of this research.

This research started with the study of visual modeling technologies related to knowledge management - mostly with a focus on ontology as the selected concept - and the available state-of-Art, domain knowledge models and ontologies, especially those in the field of cultural heritage [32][33], in a comparative way and study of their shortcoming. Furthermore it focused on studying the theory and implementation of new methodologies, using domain knowledge and architectural science to enrich the ontology (as compared with the studied samples) and to create a new, compatible systematic knowledge model to ensure that a common semantic understanding of spatial information was shared among multilingual users.

As a practical implementation, a prototype of an ontology model for caravanserais was developed. One typical application of ontology models which is to help solve stated problems, especially those involving semantic data access, search and retrieval of visual data of the selected corpus over the Internet is going to be reviewed (in a parallel research) and tested as part of the Layout Learning Ontology tool.

8.5 The Process and Innovative Enhancement

The main interest of this research is to cover the spatial features of the corpus in order to conceptualize the semantic structure of the content, developing multilingual domain ontology through the following processes:

(1) Designing a lexical model through:

(a) Data acquisition, component-recognition, and completion of a multilingual term-set of technical components of caravanserais (Fig.8- 3) [12]

4 Part of this multilingual support is provided by a UNESCO expert team in the field of Silk Roads field

5 Poli-Roberto, Framing ontology-second part http://www.formalontology.it/Framing_second.htm

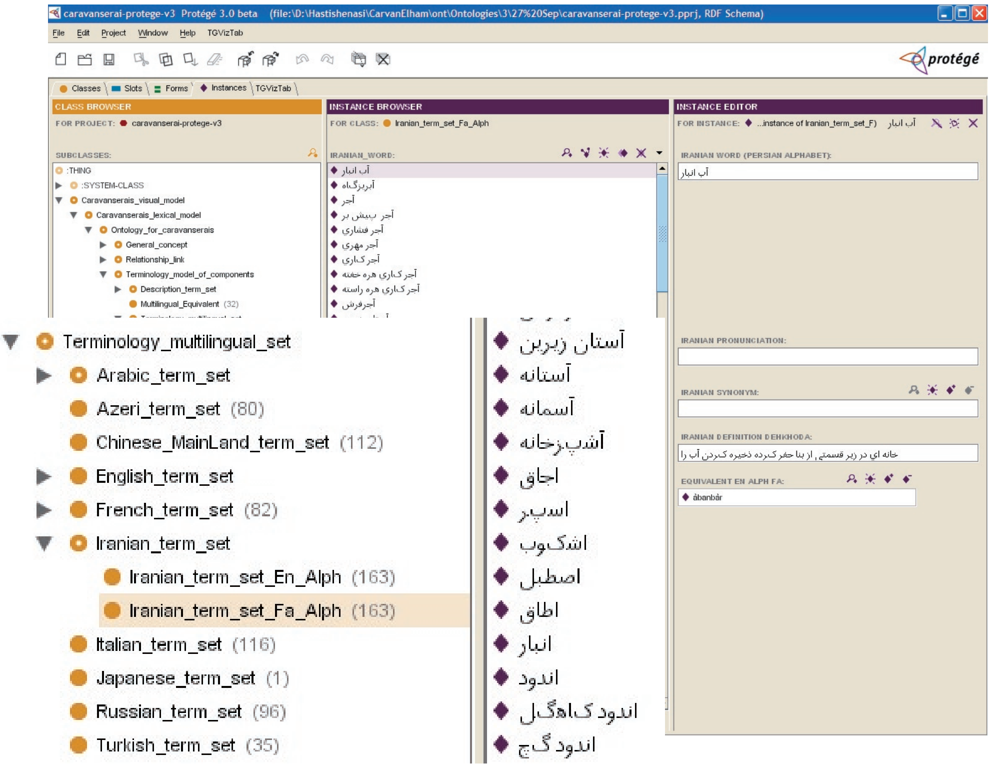


Fig. 8-3 A snapshot of multilingual terminology designed in Prot_g_ tool for caravanserais and Iranian term-set

(b) Designing a lexical terminology model including both lexical and linguistic data by mapping from available lexical databases or dictionaries such as Oxford [34], WordNet [35], Pappillon [36], and General Ontology for Linguistic Description (GOLD) [47].

(c) Designing a taxonomic lexical model mapped with each monolingual term-set using thesauri, such as Art and Architecture Thesaurus for the English term-set (Fig8- 4) [37].

→ This lexical model helps in conceptualizing the evolution of technical architectural vocabularies through time. It also disambiguates the function of spaces within the hierarchical structure of the thesaurus. The main challenge of this process was to design the lexical model, with lots of interrelated information, in a clean way compatible with the languages and tools of ontology development (protégé, and RDFS), with classes, subclasses, and properties of classes as slots and instances of each class having a mono-linked ID.

(2) Adding relationships between terms based on the spatial organization or structural features of components within the overall architectural concept of caravanserais (Fig.8-5).

Parts of these relationships are mapped from the available domains, such as upper-level relationships (like generalization or specialization) [38] or distance, orientation, and topology relationships provided by systems of qualitative representation of space [39] or part-whole relationships defined in mereology [48]. Finally, new relationships based on architectural characteristics were added.

→ This process represents an innovative enhancement of available ontology models, using architectural domain science to cover spatial attributes and their development through time in historical architecture.

(3) Defining a shape grammar for developing spatial model of components based on their form, shape, and location within the space of a caravanserai and its dimensions. Such models are mainly based on algorithms that understand and create designs directly through computation of shapes, rather than indirectly through computation of text or symbols [40].

→ Shape grammar provides a shape-based knowledge representation and attempts to define the scale, proportion, and spatial organization of a three-dimensional space. Here architectural science tries to enrich domain ontology by covering the gap between the verbal description of a space and the formal representation of it in visual tools.

(4) Adding domain knowledge to the software application process of Layout Learning Ontology as part of

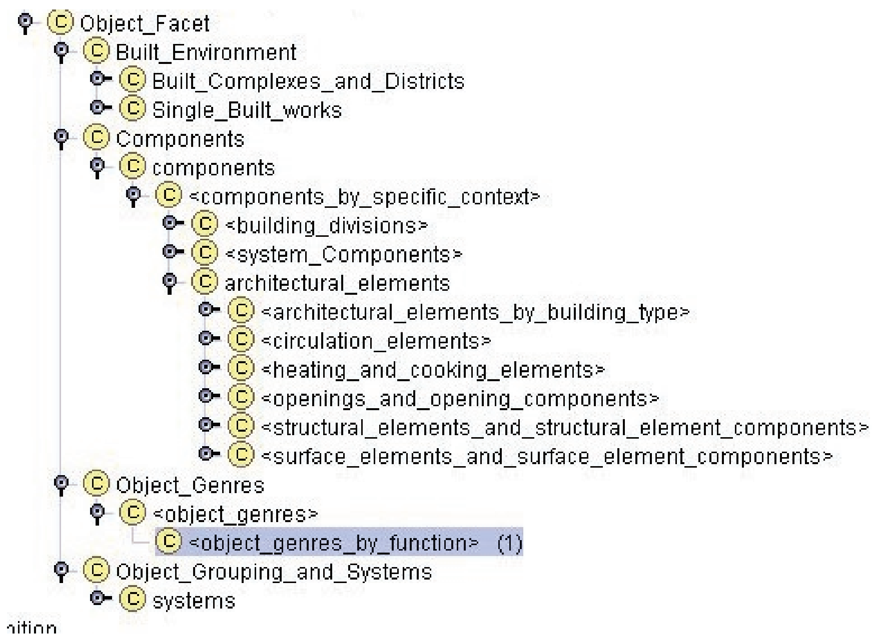


Fig. 8-4 A snapshot of hierarchical structure given to English term-set by using Art and Architecture Thesaurus

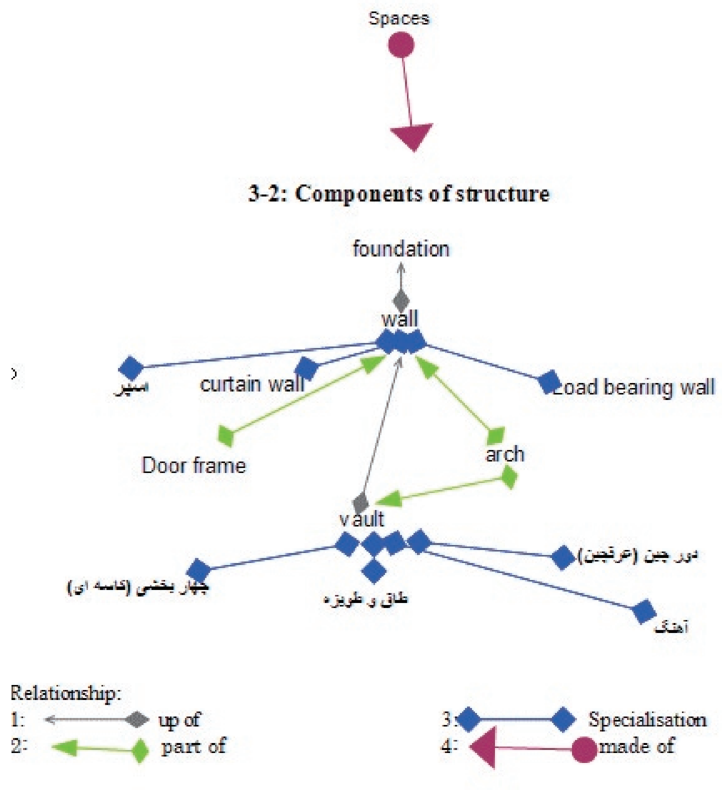


Fig. 8-5 A sketch of visual model of terms and their relationship, an example of defining relationship to complete the model caravanserais components

semantic access and distribution of data via the Internet.

8.6 The Tool and Software Supports

Protégé, a knowledge-base editing environment, was used to develop the ontology which has enabled us to combine a multi-lingual multimedia ontology with Web standards for knowledge representation, as required by semantic webs such as RDFS and OWL.

Protégé supports construction of ontologies in a frame-like fashion, using classes and slots [49]. Classes can define hierarchies - which are term-set, AAT hierarchies and relationships set in our ontology - and slots can contain values or information for each instance of a special class.

8.7 Conclusion

Cultural heritage information deals with multi-disciplinary, multilingual content of various technical specifications. Architectural heritage adds the three-dimensional properties of historical buildings to info bases with spatial ambiguity in how data is accessed, especially knowledge-level semantic annotation and retrieval. This research focuses on the conception and development of a knowledge model through domain ontology, enhancing available methodologies through the use of architectural science. This paper presented a general overview of the spatial-lexical knowledge model and multilingual ontology, focusing on the caravanserais along the Silk Roads in Iran, excluding typology of city samples, as a case study.

Within the proposed research plan the following tasks have been achieved:

(1) Reviewing the state of Art in knowledge management-ontology applications;

(2) Completing the multilingual terminology for caravanserais;

(3) Study and design of a lexical description model proper for historical architecture terminology;

(4) Study and definition of relationship links based on properties of historical architecture.

The future plan of this research and expected results are as follows:

(1) Formalization of content-base and constraint-base relationships for architectural properties within a caravanserai by moving from RDFS language to OWL;

(2) Study and definition of Shape Grammar Language for selected corpus with IT input tool;

(3) Discussing with domain experts regarding the completed prototype of ontology in collaborative work over the Internet to reach a consensus among the network of experts of supporting projects.

(4) Supporting the parallel research on testing the application's ontology in the Layout Learning tool;

(5) Studying the possibility of generalizing the research to other typologies of architectural remains or cultural properties.

9 Conclusion

This article reported the progress of the Digital Silk Roads project, being conducted at NII in cooperation with UNESCO, over the past 4 years.

The main objectives of the project are to develop a virtual museum or library of Silk Roads cultural and historical heritage and to provide a uniform platform for international and multidisciplinary collaboration.

New technology should be utilized so that it will bring the maximum benefit to mankind, not only in terms of the economy but also in terms of enriching our lives and cultures. We believe that utilizing advanced information technology to preserve historical and cultural heritage will certainly serve this goal.

Digital archiving technology, for example, allows heritage materials and sites thought to be beyond saving to be restored, enabling us to pass on such assets to the future generations. The Digital Silk Roads project will provide us with a new paradigm of collaboration in the digital age, establishing a rout for digital information exchange among the countries along the Silk Road and encouraging the creation of a new cultural form, just as the Silk Road did throughout their history.

The DSR project will enable people to freely explore and experience some of the world's greatest cultural assets without actually visiting them, which had been merely a dream for many centuries. There is no doubt that the DSR project will have a significant impact on the enhancement of cultural diversity around the world.

We plan to make the entire system accessible via the Internet, so that users around the world can share and utilize these precious cultural resources. Furthermore, we are currently working to develop a system to store related information and documents together with the images and videos so that such information can be referred to quickly and easily. This will allow researchers to fully share available resources, which seems sure to lead to further development of the Silk Road studies.

At the moment, the most urgent task is to resolve intellectual property rights issues and accumulate cultural heritage contents. In an effort to obtain appropriate contents, the project will make the most of the Digital Silk Roads Initiative Framework (DSRIF) under the

MOU between UNESCO and NII. Researchers and experts from around the world are expected to contribute to the development of the Digital Silk Roads on their own initiative through the network collaboration system: ASPICO-DSR.

We believe that our effort will set a new direction for study of the Silk Road in the 21st century

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