

The Architecture and Implementation of Resource Space Model System*

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Abstract. Resource Space Model (RSM) is a semantic model to manage and share heterogeneous resources on the Internet. This paper focuses on the general architecture, physical implementation and application of RSM. The RSM system adopts Client/Server mode for users to utilize resource spaces through the Internet. The resource spaces are designed based on domain knowledge and stored as XML files in the server. The tool 3DBrowser provides a friendly interface with three-dimensional scene to display resource spaces, locate and operate on resources. Based on the architecture and tools, a Dunhuang RSM system has been developed as a collaboration platform to organize and share the resources of Dunhuang Culture Grid. The system provides an efficient resource locating way based on the classification of resources and improves the efficiency of research.

1 Introduction

The Internet is an open platform for data exchange and provides varied modes for users to share their information conveniently. Traditional information management methods are inefficient for the multifarious and disorderly resources on the Internet. Researchers have established several theories and prototypes to improve data organization on the Internet. Semantic Web focuses on representing information in a machine-understandable way by using markup languages and ontology-relevant mechanisms [1]. Computing grid tries to combine the computing abilities from the Internet into a universal platform with great power [2]. It involves the large scale and high-performance computing technology, but not the semantic issues. To manage resources effectively, discovering the rules that govern the future interconnection environment is a major challenge [12]. Semantic grid creates a new environment incorporating the

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Internet, sensor networks, mobile devices, and the interconnection semantics [3, 11]. Knowledge grid is an e-Science environment to support complex demands on knowledge mining and reasoning [4, 5, 8]. It includes three key problems: normal organization, semantic interconnection and intelligent clustering of resources.

Zhuge's Resource Space Model RSM is a semantic model to uniformly specify and organize resources on the Internet [6, 7]. The RSM aims at mapping versatile resources including information, knowledge and services into a uniform semantic space called resource space. A resource space uses a series of independent axes and coordinates to represent the classification of resources. A resource or a set of similar resources in a resource space is specified by a tuple of coordinates. The design of resource space is based on domain knowledge and consists of four main steps: resource analysis, top-down resource partition, design of two-dimensional resource space and join between resource spaces [7]. Users can locate resources in a resource space through their coordinates and operate on them. There are several normal forms and integrity theory to restrict and regulate resource spaces [9, 10]. They ensure the legal operations, classification semantics and concurrency of resource spaces.

This paper focuses on the key problems of implementation of RSM and its application in Dunhuang Culture Grid. It first describes the general architecture and the storage of resource spaces in XML files. The 3DBrowser is a tool with three-dimensional scene to browse resource space, locate and operate on resources. A RSM system has been developed to organize and share resources in Dunhuang Culture Grid.

2 General Architecture and Storage

2.1 General Architecture of the RSM System

An RSM system is an interaction and collaboration platform for users to normally organize and share resources based on RSM theory. The system adopts Client/Server mode consisting of a server and many clients connected through networks. The server, called RS server, stores resource spaces and provides portal and interface for users' access. The clients maintain resources and provide them for resource spaces. The users of RSM system are divided into three types: administrator, owner and customer. The administrators create, maintain and update resource spaces and operate the server. The owners, who provide resources for the system, manage their resources and usually operate the clients. The resources can be modified by their owners. If the modifications influence the resource spaces, the system updates them automatically. The customers are read-only users and can access the system through networks.

2.2 Storage of Resource Space and Representation of Resource

A resource space consists of the classified resources and n independent axes, where n is the space's dimension number. The storage of resource space should contain two parts: axes and resources. For uniform and convenient data exchange, XML file is chosen to store resource spaces. The XML file can also represent the hierarchy of classification conveniently because it owns a tree like structure. A uniform schema is adopted to store resource space. There are a couple of tags named `<RS_name>` to

define the name of resource spaces. The axes and resources are stored in the child nodes named <AXES> and <RESOURCES>, respectively.

Fig. 1 (a) shows an example resource space with two axes named FORMAT and CONTENT. CONTENT-axis owns two coordinates: *painting* and *statue*. *Video* and *graph* are the coordinates on FORMAT-axis. R_1 and R_2 are the identifiers of two resources in the space. Resource R_1 has a location as (*statue*, *graph*). That means R_1 is the resource whose format is graph and content is statue. The coordinates of resource R_2 is (*painting*, *video*). Fig. 1 (b) is the storage structure of the example in XML file. Every child node of <AXES> indicates one same name axis. The only element of axis node is a string combined with its coordinates, connected and separated by comma. The child nodes between the tags <RESOURCE> indicate the resources and are listed according to their coordinates. Its name is a combination of the coordinates connected one by one through underscores. The resources with the same coordinates are listed as child nodes named by their identifiers. The underscore and comma are the preserved characters in this schema. This schema can bring better access efficiency when locating resources according to their coordinates. The description of resource is omitted in Fig. 1 (b) and will be described in detail below.

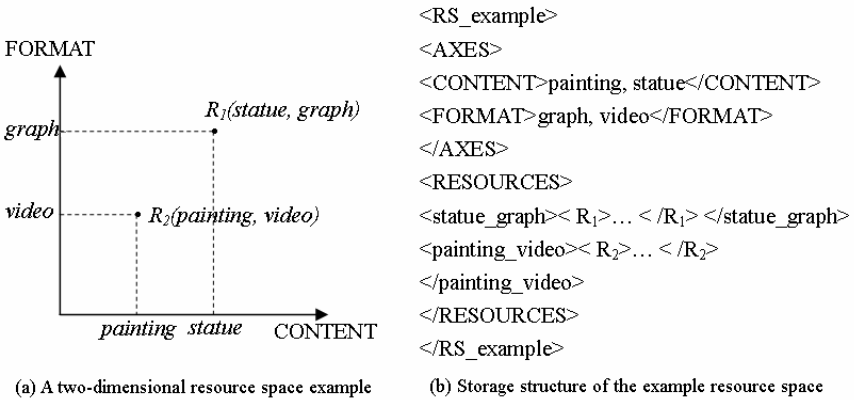


Fig. 1. An example of resource space and its storage structure in XML file

A uniform structure is needed to represent heterogeneous resources. In this paper, a resource is represented by a tuple of attributes as: {*identifier*, *location*, *abstract*, *physical-address*, *interface*, *author*, *owner*, *version*, *privilege*, *effective-duration*, *related-material*, *particular*}. The *identifier* is the unique name to distinguish one resource from others. The *location* accurately locates the resource through its coordinates in a specific resource space. Since resources are distributed on the Internet, the *physical-address* is necessary for users' access. It's unavailable for users but available for the system to guarantee the system's security. The *abstract* shortly describes the basic characteristics of a resource such as its content and functions. It helps the user to determine if this resource satisfies his/her demand. The *interface* shows the method to use the resource correctly. The *author* and *owner* show the person or organization that created the resource and provided it for the resource space, respectively. The

version indicates the different editions of a resource for user to choose. The *privilege* includes the permitted users and their available operations on a resource. The *effective-duration* is the period when a resource keeps effective. The *relate-material* is a list of materials relative to the resource such as other resources, web pages or files. The item *particular* holds the characteristic or original information of a resource. The details of resource R_1 , which are omitted in the example Fig. 1 (b), are shown as follows.

```

<R1>
<ABSTRACT> a graph that describes statue </ABSTRACT>
<PHYSICAL-ADDRESS>192.168.168.5/graph/r1.jpg</PHYSICAL-ADDRESS>
<INTERFACE> graph file </INTERFACE>
<AUTHOR> Academy </AUTHOR>
<OWNER> KG-ICT </OWNER>
<VERSION> 1.0 </VERSION>
<PRIVILEGE> all, read </PRIVILEGE>
<EFFECTIVE-DURATION> permanent </EFFECTIVE-DURATION>
<RELATED-MATERIAL>http://www.culturegrid.net</RELATED-MATERIAL>
<PARTICULAR><resolution>1024*768</resolution></PARTICULAR>
</R1>

```

The schema above shows the storage structure of a resource space and resources in XML files. It may cause low parsing and access efficiency to use one XML file to store resource space and resources together when there are large numbers of resources in the resource space. An alternative method is to maintain a smaller file to store the axes only. The resources with the same coordinates are stored in another independent file. This strategy can decrease the burden of parsing large XML file. However, it brings additional tasks to manage lots of files. Which strategy should be chosen depends on practical situations.

3 The Dunhuang RSM System

3.1 Dunhuang Resource Spaces

Dunhuang Culture includes the materials originally located in the caves near Dunhuang town and relative research area. All the digital files, web services and other relative materials are resources of Dunhuang Culture Grid. The classification criteria of Dunhuang resources include *format*, *content*, *dynasty* and *cave-number*. The format indicates the type of resources including graph, document, video, audio and service. The content includes four main types: architecture, wall-painting, statue and artifact. The dynasty indicates when the artifacts were created originally. The cave-number is a unique number to distinguish one cave from others. All the classification above combines the resource spaces of Dunhuang Culture Grid.

3.2 The 3DBrowser and the System Application

The 3DBrowser is a three-dimensional browser for users to browse resource spaces, locate and operate on resources. The interface is divided into two sub-windows

vertically, shown in Fig. 2. The right window lists located resources for user to operate. The left window shows a perspective of coordinates with three orthogonal axes. Every small transparent cube, composed of line frame, indicates the resources with same coordinates.

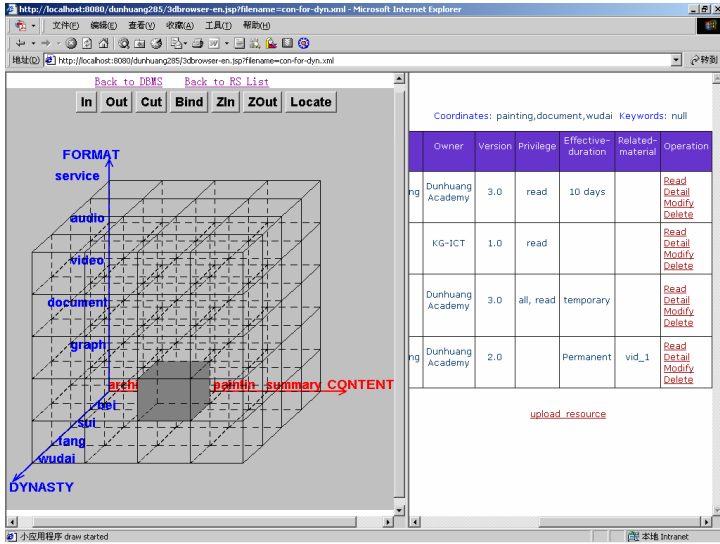


Fig. 2. The interface and appearance of locating resource in 3DBrowser

There is a gray cube called *focus cube* to show the current operable cube. The focus cube is changed along with mouse moving on the surface parallel to the screen. Two buttons named “In” and “Out” are to move the focus cube in the direction vertical to the screen. “Locate” button allows user to input coordinates to locate resources directly. During the locating procedure, user can click the right mouse button to observe current coordinates of focus cube through a popup window. There are also several functions and buttons to assist the users to browse resource spaces. User can click the “Cut” button to remove the top level cubes and observe the cubes behind, and the reverse operation is realized through “Bind” button. “ZIn” and “ZOut” buttons can zoom in and zoom out the space to get a whole and detailed scene, respectively. User can also move the whole scene through mouse drag. When the user reaches the target cube, he can double click the left mouse button to select it. Then the resources denoted by the cube are listed in the right window. User can observe the details of resources and operate on them. A simple query function based on keywords is also added into the system to get specific resources from located resources.

4 Conclusion, Problems and Ongoing Work

Based on Zhuge’s RSM theory, a semantic model to normally organize and efficiently share resources based on their classification, this paper discusses the key problems

about the implementation of RSM. The general architecture of system and the storage structure of resource space are proposed. A system based on them has been applied to manage and share heterogeneous resources of Dunhuang Culture Grid (<http://www.culturegrid.net>). The resource spaces have been created to represent the classification of resources. The resources are well organized and uniformly located in the resource spaces. By this classification, users can locate resources efficiently. In the system, the 3DBrowser provides a friendly interface for users to browse resource space, locate and operate on resources.

How to guarantee the efficiency and robustness is still unsolved here when large amount of users' access the system simultaneously. Some effort is focusing on the problem to extend the system for more users on the Internet. This system uses a lock strategy to solve the concurrent access. When a user accesses a resource, the strategy protects the resource from other users' operations. This guarantees the consistency of resources. A more suitable and flexible strategy will be studied to realize Zhuge's ideal: the future interconnection environment [3, 11, 12].

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