Profiling and Visualizing Metadata for Geo-Referenced Multimedia Information in a Geospatial Portal

— A Case Study for the Cybercartography and the New Economy Project

By

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ABSTRACT

With more and more applications of multimedia data emerging in geospatial contexts, researchers have recognized that the combined use of multimedia data and geospatial data can offer good solutions to solve problems in both social and physical science domains. A new concept "cybercartography" has been proposed in the geography community to integrate digital cartographic products with multimedia data such as photographs, videos, still images, audios, texts, virtual reality and even multisensory data on the Internet. This study will present research methodology and key findings on profiling metadata for geo-referenced multimedia data in a geospatial context.

The Cybercartography and New Economy project is developing two atlases based on the concept of "cybercartography". An OpenGIS compliant catalog will be developed to enable the access, sharing and reuse of large amounts of multimedia data, through metadata. Since multimedia data is a relatively new scientific data type in the geography community, there is no metadata standard that is readily available for describing it. This paper will introduce a new approach of developing a metadata profile by a combined use of different metadata standards for the purpose of making multimedia data more manageable, accessible, shareable and reusable in a geospatial context. Metadata information visualization of a geospatial web portal will also be discussed as an efficient means of facilitating efficient data access and retrieval.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIXES

CHAPTER 1

INTRODUCTION

1.1 CONTEXTUAL BACKGROUND

Geography is a science that studies the geospatial component of various phenomena on the earth. Over the past few decades, an increasing amount of digital geospatial data, for both physical and social phenomena, has become widely available to the geography community. It has been estimated that 80% of the digital data collected today has a geospatial component (Andersen, 2003). There are many reasons which can help to explain the rapid growth and wide use of digital geospatial data, with the major reason being attributed to the fact that technologies on data collection and management have significantly advanced in this information era. The wide spread of geographic technologies such as Remote Sensing, Global Positioning Systems (GPS), and Geographic Information Systems (GIS) has made it a much easier task to collect and manage scientific geospatial data in a modern environment. In the meantime, data gathered over the years using older techniques, equipment and formats are being converted into modern digital formats that are easier to duplicate and store, more accessible and shareable.

Multimedia is another important type of data that has experienced rapid growth, with more and more multimedia data such as images, videos and audio clips/tracks/files being available from all sources in the geography community. In addition to the same factors that cause the rapid growth of digital geospatial data, the growing popularity of multimedia data is also the result of the wide use of digital cameras or camcorders allowing scientists and researchers to utilize multimedia objects to record phenomena on earth. This growth has also been accelerated by the development of devices and tools such as scanners, Macromedia flash, ArcScene, and 3D tools which make it easy to create multimedia data for geographic analysis. As more and more people recognize the fact that multimedia data in GIS can offer a good solution to various problems by representing qualitative spatial information, it has become an important trend in GIS to integrate multimedia data with geospatial data (Camara et al, 2000).

The growing popularity of digital geospatial and multimedia data is not limited to the geography community. It has found its way in many other theoretical and applied areas such as mobile systems, transportation systems, health care, communications, education and utility systems which have utilized geospatial information. In this information rich era, on one hand, there are a large number of end users from various disciplines who are now interested in using data that others have collected; on the other hand, there are many providers who are willing to share their data. The key question is how to make this large amount of data, including both digital geospatial data and multimedia data, more manageable, shareable, reusable and easily accessible among data providers and end users. It is to this fundamental question that this thesis research hopes to make a contribution.

1.2 RESEARCH QUESTIONS

The advances of technology in GIS and Internet offer an opportunity to enable the sharing of a large amount of data. An increasingly popular solution is to develop geospatial portals (or GIS portals). A portal is a web site that acts as a gateway to provide a single access point to multiple resources:

"A geospatial portal is a human interface to a collection of online geospatial information resources, including data sets and services" (OGC, 2004: 1).

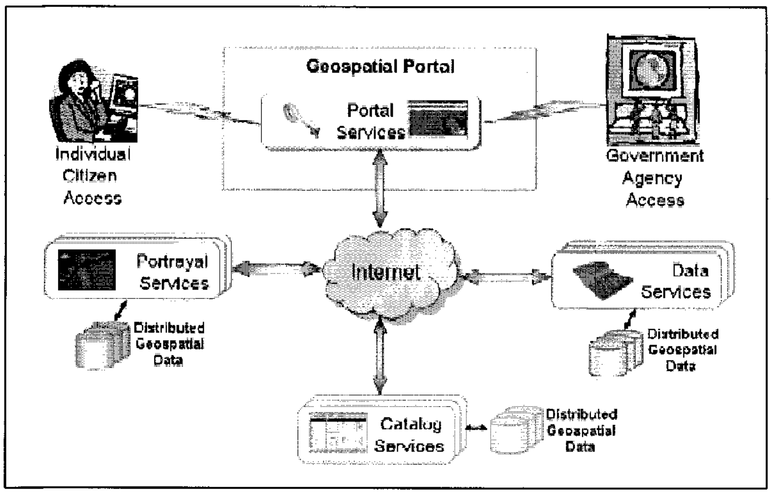


Figure 1.1: Reference Architecture of an Example Geospatial Portal

Source: From OGC (2004), Geospatial Portal Reference Architecture, Rose, C. L. (Editor), v0.2

Figure1.1 shows the reference architecture of an example geospatial portal, which includes portal services, portrayal services, catalog services and data services. Catalog service is one of the four class services in a geospatial portal. It supports the ability of publishing and searching collections of descriptive information (metadata) for data, services, and related information objects. Users can search data or services from distributed catalogue services through a geospatial portal, which can be a spatial data clearinghouse, a spatial digital library or any other metadata catalogue systems.

A National Spatial Data Infrastructure (NSDI) is one kind of geospatial portal that comprises of a distributed series of Internet sites (or metadata catalogues). More than 100 nations around the world are developing or have developed Spatial Data Infrastructures (SDI) for geospatial data sharing, accessing, and retrieving. For example, the Canada Geospatial Infrastructure (CGDI) has developed the Geoconnections Discovery Portal (GDP) to deliver geospatial information from federal agencies, provincial and territorial governments, the private sector and academia over the Internet (See Canada GDP: http://geodiscover.cgdi.ca). Likewise, the Federal Geographic Data Committee (FGDC) in the United States has developed the NSDI to facilitate the exchange of information about digital geospatial data (See FGDC: http://www.fgdc.gov/apps/glist.new/index.php). There are also many other geospatial portals such as NASA's (National Aeronautics and Space Administration) Global Change Master Directory (GCMD) (See GCMD: http://gcmd.gsfc.nasa.gov/) and the National Geophysical Data Center (NGDC) (See NGDC: http://www.ngdc.noaa.gov/).

However, most of the existing geospatial data portals only distribute, access and portray digital geospatial data. A data portal system that will be used in the Cybercartography and New Economy Project (CANE), a collaborative research project that aims to distribute large amount of data from multiple stakeholders in multiple formats over the Internet, will be involved in distributing, accessing and displaying multimedia objects. Unlike other geospatial portal systems, Cybercartography is a new concept and a new theoretical approach to cartography. The portal for the CANE project will integrate spatially-referenced digital cartographic products with different types of multimedia data such as videos, still images, audios, graphics and text etc. It will be developed to deliver these data and products through the Internet for user access in an interactive, dynamic, multimedia, multisensory and multidisciplinary way that has never been done before.

Despite the diversity of portals, the fundamental search or access process is the same, that is, to look for data by searching their metadata from metadata catalogues. Metadata, or data about data, in catalogues represent characteristics of data resources that can be queried and presented for human evaluation, and further processing by both humans and software. Great efforts are being made by many international, national and federal organizations to develop metadata standards, with the aim of linking all geospatial data together in a standard way, which can enable geoprocessing interoperability. That means to make it possible to exchange heterogeneous geographic information content and share a wide variety of geospatial servers on the Internet (OGC, 2004). As a result, many metadata standards such as NZLAN (New Zealand Metadata Standard), DIF (Directory Interchange Format), FGDC (Content Metadata for Digital Geospatial Standard) and ISO19115 (International Organization for Standardization Metadata Standard) have emerged and become available from both national and international levels for geospatial data and services.

However, all these metadata standards were designed and developed for distributing digital geospatial data or services through geospatial portals. There are some key questions that remain unanswered regarding how to make multimedia data manageable, accessible and reusable in geospatial portals. What metadata are needed for multimedia data in a geospatial context? Can the existing geospatial metadata standards be used to describe multimedia data in a geospatial context? These are important questions to be addressed in this research, which will use the CANE project as the case for studying these key research questions. The ultimate goal of the research is to integrate multimedia data with geospatial data and to make multimedia data manageable, shareable, reusable and accessible through a geospatial portal.

Given the large amount of data available to geospatial portals, it is very likely that a simple metadata query will return hundreds or even thousands of "hits". A long list of metadata query results could be very confusing to users, or even turns users away. This is a problem that can happen to any geospatial portal that enables users to search data through metadata catalogues. How to display metadata in query results in an efficient and innovative way so that it becomes easier for users to understand and interpret the retrieved metadata information from a metadata catalogue is another important question to be explored in this thesis research.

1.3 RESEARCH OBJECIVES

This thesis aims to develop a new approach to metadata to help make the growing amount of multimedia data more manageable, shareable, reusable and easily accessible in a geospatial context. There are two main objectives in this research.

In order to ensure information interoperability, to allow data sharing between different servers, to ensure data query and access by users and software, as well as to facilitate data management and maintenance by providers, the first objective of this research is to review some existing metadata standards, analyze needs and requirements and finally develop a multimedia metadata application profile which can be used to organize and construct metadata of multimedia data in a geospatial context in a standardized way. The capability of the ISO19115 geospatial metadata standard for documenting multimedia data in a geospatial context will be closely examined while developing the metadata application profile.

Research has shown that even if data are available on the Internet, this is not enough in itself. Poor access functionality could still prevent users from retrieving data. A usability test of the Canada GDP indicates one out of five visitors found "all" the information they were looking for, and only 26% found "all" or "most" information. It indicates "Those who found "all" or "most" of what they were looking for were more likely to be frequent visitors to the site." (GDP, 2004: 49) while "The majority of those who could not find information they were looking for were first-time visitors." (GDP, 2004: 58). This will cause the loss of potential users because users will most likely not visit the web site again if they could not find the information they wanted during their first visit. It is important to find an efficient way of displaying metadata query results so users can easily understand the retrieved information and find data more quickly. The second objective of this research is to explore information visualization as a new method of presenting metadata information to users in facilitating data access and retrieval.

1.4 METHODOLOGY

There are two main tasks for this research: the first one is to develop a community metadata profile for multimedia data, and the second is to explore information visualization as a tool in facilitating data access. The relevant methods are as follows.

1.4.1 Developing a Metadata Application Profile for Multimedia Data

The main existing metadata standards including multimedia metadata standards, geospatial metadata standards and other standards are briefly reviewed in order to find out their capability of describing multimedia data in a geospatial context. As the key metadata standard, the ISO 19115 is studied in detail. Needs and requirements are the keys for developing any metadata application profile. An analysis of the needs and requirements of multimedia data used in the CANE project is conducted and some potential functional scenarios for defining application requirements are also collected in this research. Based on the review of metadata standards and analysis of needs and requirements, a multimedia metadata application profile is developed.

1.4.2 Exploring Information Visualization

Information visualization is considered to be an effective method in facilitating data access and retrieval. This thesis research study aims to explore information visualization as a means for efficient data access and retrieval. A literature review of information visualization and its applications in information access and retrieval is conducted in this research. This research uses the Antarctic Master Directory (AMD) as an example to present ideas of information visualization to help users quickly grasp the meaning of metadata query results and find relevant data by visualizing metadata query results. As a result, the information visualization ideas introduced in this research is further researched by a collaboration team that has been formed for the information visualization work in the CANE project.

1.5 CHALLENGES AND SIGNIFICANCE

Recently, people have been paying increased attention to metadata. There are two reasons, one is that "people need better ways to find and evaluate information on the Internet and on corporate Intranets"; the other is that "knowledge management systems need integrating information from multiple sources and applications need to be easier to search and maintain" (Graef, 2004: 1). In the geospatial community, metadata are described as one of three components (spatial information, attribute information and metadata information) of geospatial data. Metadata are being paid more and more attention in this community and geospatial metadata standards are becoming mature. Likewise, in the multimedia community, metadata for management of multimedia objects is not a new thing. Many organizations or groups have been working or doing research on the use of metadata in managing the large amount of multimedia objects. Overall, the use of metadata for the management of either geospatial data in a geospatial community or multimedia data in other communities can be found in both research and application areas.

It is indicated that the combined use of multimedia data and geospatial data will offer efficient solutions to solve problems in the real world, while the advancement of the Internet offers us a solution to combine them using the Internet technology. The OpenGIS catalog specification, which is adopted as a standard interface for the geospatial portal, has the potential to provide standardized catalogue services to manage, publish and search metadata for data, services, and related information objects including multimedia data.

However, one challenge is how to describe these multimedia data used in the geospatial context in a standard way. No published research related to the use of metadata in documenting multimedia data in a geospatial context has been found. With the emergence of more and more multimedia data applications, this kind of research will become increasingly important in the geography community. The other challenge is how to make large amounts of multimedia data easily accessible once they are on line. Information visualization of text form metadata could be a potential solution. There is inadequate research on the documentation of multimedia data with metadata in a geospatial context and information visualization of metadata, especially metadata query results, to facilitate data access. Improvements are required, which is what this thesis research aims to achieve.

1.6 THESIS OUTLINE

This thesis is organized into eight Chapters. The outline of the thesis follows:

Chapter 2 provides background knowledge about metadata and briefly discusses the ways of storing and organizing metadata; multimedia and various types of multimedia data are also introduced. The potential of multimedia information application is discussed.

Chapter 3 introduces the case study — The Cybercartography and the New Economy Project (CANE). It gives an overview of the CANE project. The relevant issues and challenges in the CANE project for this research study are discussed.

Chapter 4 presents a review of metadata standards including both multimedia metadata standards and geospatial metadata standards. An analysis of the potential capability of metadata standards applied for geospatial information of multimedia data is carried out. The conclusion presents an approach — to develop a multimedia metadata application profile.

Chapter 5 focuses on analyzing the needs and requirements of developing the multimedia metadata application profile for the CANE project through four aspects:

- Multimedia data management
- Multimedia data reuse
- Multimedia data accessibility and retrievability
- Media specific information

Chapter 6 presents the multimedia metadata application profile developed according to the analysis discussed in chapter 5. It also outlines the limitations of using the ISO19115 geospatial metadata standard in describing multimedia data in a geospatial context.

Chapter 7 explores information visualization as a means of making data more accessible and retrievable in geospatial web portals. After introducing and reviewing information visualization and its application, ideas of information visualization for the AMD (Antarctic Master Directory) query results are displayed and limitations from the view of this research study are stated. Further research work for information visualization is pointed out.

Chapter 8 presents the conclusions of this research and points out future research directions.

CHAPTER 2

BACKGROUND OVERVIEW

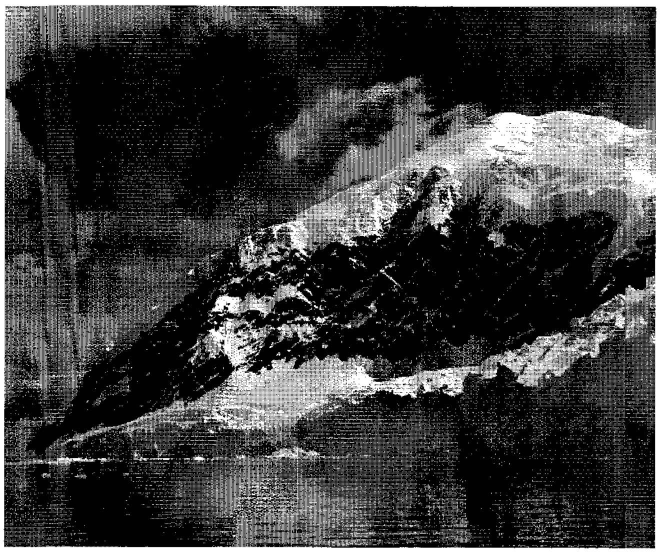
2.1 METADATA

2.1.1 What are Metadata

Metadata usually are called data about data or information about data. The term "meta" comes from a Greek word, denoting something of a higher or more fundamental nature (Lillywhite, 1991). Broadly speaking, metadata can refer to any data that are used to describe the content, quality, condition and other aspects of data for humans or machines to locate, access and understand the data. General metadata can provide users with the following information:

- What is the content of the data
- Who created the data
- Why were the data created
- When were the data created
- Where are the data located

All of the above metadata information can help users to get an overview of the data. Figure 2.1 shows an example of some metadata contents for an image file. The image itself tells nothing more than the plain fact that it is a picture of a mountain view with snow. Without reading the associated metadata, it is impossible for a user to know the properties of the image such as what the image is about; who took the picture; when and where the picture was taken; what is the resolution of the picture etc, all of which are important information that can help to determine the fitness of the image for a particular application before the user makes a decision to use the data.



Metadata for the image

Photographer: I. Bajewskey

Time: 2002-12-21 T 18:00

Description: Mountain view from Neko Harbour

Photo Number: DSCN 7767

Latitude: S64° 50' 34.6"

Longitude: W62° 31' 23.6"

Elevation: 1 m

Orientation: NW 332°

Resolution: 2048 X 1536

Year: 2002

Figure 2.1: An Example of Metadata Contents

Source: Ingrid Bajewsky of Nipissing University, Taken During the 2002 Students on Ice Expedition

Actually, the concept of metadata is not new even though the terminology is more recent. To put it to a real-life perspective, a person's identification card can be viewed as some kind of metadata of the person. Traditional library catalogs are one kind of bibliography metadata for the library collections. The library catalog index card is a simple and classic example of metadata application. The individual fields such as publication date, author, title, publisher, etc., are called metadata elements, which usually follow a clearly defined metadata schema or standard — a list of metadata elements with defined structure and relationships. Users can search a library catalog to get the specific information on the subject they are interested in and fetch the materials from the library shelf according to the information they get from the catalog.

In this information era, metadata are generally applied to electronic (digital) resources and referred to "data" in the broadest sense (scope), including data sets, textual information, web pages, images, videos, graphics and any other digital data. Today, metadata are commonly used on the Internet. For example, some search engines use catalogs to structure web pages. If no information (metadata) is available about these web pages, users cannot easily get information they need through the search engines.

All of these perspectives on metadata are important in the development of networked digital information systems in this information era. However, different people have different perspectives about metadata based on their particular application purposes:

- **Producer's perspective:** Metadata are bibliographical information of the resource data, such as author, title, creation date, data format, use limitation etc.
- **Service providers' perspective:** Metadata are described as information needed for data accessing, retrieving and sharing. For example, in a distributed GIS system, the providers will think of metadata as a vehicle for data distribution and data sharing in an interoperable way.
- **User's perspective:** Metadata can enable users to get suitable data. Metadata provide not only content information about data but also quantity and authority information, such as data quality, data fitness, data liability, data origin etc.

All of these perspectives can lead to a very broad conception of metadata. In order to understand this conception better, metadata usually are broken down into distinct categories. Gilliland-Swetland (2000) presents some categories including administrative, descriptive, preservation, use, and technical metadata which reflect key aspects of metadata functionality. Table 2.1 explains each metadata category with examples of common functions that it might perform in a digital information system.

Category	Definition	Examples
1 **Administrative**	Metadata used in managing and administering information resources	- Acquisition information - Rights and reproduction tracking - Documentation of legal access requirements - Location information - Selection criteria for digitization - Version control and differentiation between similar information objects - Audit trails created by recordkeeping systems
2 **Descriptive**	Metadata used to describe or identify information resources	- Cataloguing records - Finding aids - Specialized indexes - Hyperlinked relationships between resources - Annotations by users - Metadata for recordkeeping systems generated by records creators
3 **Preservation**	Metadata related to how a system functions or metadata behave	- Documentation of physical condition of resources - Documentation of actions taken to preserve physical and digital versions of resources, e.g., data refreshing and migration
4 **Technical**	Metadata related to how a system functions or metadata behave	- Hardware and software documentation - Digitization information, e.g., formats, compression ratios, scaling routines - Tracking of system response times - Authentication and security data, e.g., encryption keys, passwords
5 **Use**	Metadata related to the level and type of use of information resources	- Exhibit records - Use and user tracking - Content re-use and multi-versioning information

Table 2.1: Different Categories of Metadata and Their Functions

Source: From (Gilliland-Swetland J. A. 2000), Defining Metadata

Some metadata are created based on a user's or provider's perception about the data. They can be changed when perception changes, even if the data itself remains unchanged. Descriptive metadata are one good example of this. Some other metadata cannot be changed after being created or captured, such as technical metadata. Metadata of multimedia data usually involve both types.

"The World Wide Web has created a revolution in the accessibility of information. The development and application of metadata represents a major improvement in the way information can be discovered and used" (NISO, 2004:12). Metadata are becoming increasingly important in the production, management, and application of data by providing key information such as the location information of data, technical information of data, data quality information, data history, data contents, etc. Metadata is the key to ensure that resources will survive and continue to be accessible into the future (NISO, 2004). Recognition of the benefits of using metadata has helped push the research and wide use of metadata in different disciplines.

2.1.2 How to Store and Organize Metadata

Depending on the application, metadata can be applied to a resource in different ways. Metadata can be embedded in a digital object or they can be stored separately. Some metadata are often embedded in a "metafile" or "header" of a digital object, such as the header of a HTML file, the "metafile" of an image file, or even as digital watermarks in digital images or videos to protect a resource's integrity or ensure its authorship. The benefit of storing metadata with its object is to ensure that the metadata are not lost, avoid potential problems of linkage between data and metadata, and help ensure that the metadata and object will be updated together. The disadvantage is that it is difficult to manage data such as indexing, searching and retrieving. It can simplify the management of the metadata itself and facilitate search and retrieval data if metadata are stored separately. Therefore, it is a common practice to store metadata separately in order to manage a large number of objects.

Metadata are commonly stored in a database system and linked to the objects that are described by those metadata. One of the best ways to make a wide array of data easily accessible on the Internet is through metadata catalog services which support the ability to publish and search metadata for data. Through metadata catalogue services, users or application software are enabled to find information that may exist anywhere in a distributed computing environment. A catalog is a collection of metadata, or information repositories, about the other information (e.g. data objects or operators) (Peng et. al, 2003). A catalog service provides a mechanism for data and service providers to list and advertise the availability and types of data and services and also to allow users to search for catalogs first before getting to the data repositories. The OpenGIS Consortium (OGC) has defined an OGC catalog specification which specifies the interfaces, bindings, and a framework for defining application profiles required to publish and access digital catalogues of metadata for geospatial content, services, and related resource information. This OGC catalogue specification is applicable to the implementation of interfaces on catalogues of a variety of information resources.

2.2 MULTIMEDIA

Since the early 1990s, extensive research on multimedia communications and the advances in Internet networking and computing have helped introduce a new era of multimedia information applications. What is multimedia? A literature review indicates that there is an absence of a clear definition of multimedia. Dion (2001) pointed out that this is partly due to various types of individuals who make up the multimedia industry define multimedia from different perspectives.

This study is going to adopt a definition of multimedia by Acab:

" Multimedia involves any combination of two or more of the following elements: text, image, sound, speech, video, and computer programs. These mediums are digitally controlled by a computer(s). In order to get an idea across, one can use multimedia to convey their message. Multimedia enhances the information for better communication and understanding. " (Acab,1996: 1)

In his book "Being Digital", Negroponte (1995) stated that "multimedia will someday be as subtle and rich as the feel of paper and the smell of leather" (Mason, 2000: 1). Smell, haptic and virtual reality are some examples of emerging multimedia types. However, so far there is no tangible smell and haptic data available in this study. The types of multimedia data that are consistent with the above definition are presented briefly in this section. They are described in the following sequence: text, hypertext, hypermedia, still image, video, audio, animations, graphics, atlas content model and virtual reality.

(1) Text

Text is the simplest media type and the major form of interaction between computers and humans. Text can appear as unformatted or formatted. Unformatted text is text where the character set is fixed and the form and style are basic and limited. Formatted text is text where the character set is richer with few limitations of form and style.

(2) Still images (or pictures)

Image files can be classified into two main groups: bitmaps or vectors. Bitmaps represent an image as a regular grid of pixels; Vector graphics use mathematical equations to describe an image as lines and curves. A vector format image display requires it to be rendered to a bitmap format by the graphic adaptor. Still images can be scanned from images or be captured by digital cameras in the real world. Different kinds of still image-formats exist including compressed or less compressed. JPEG (Joint Photographic Experts Group), PNG (Portable Network Graphics), TIFF (Tag Image File Format) and GIF(Graphic Interchange Format) are the most commonly used image formats.

(3) Video (or moving images)

Videos are also known as moving images. Video exists as a sequence of still images. Almost all media players have their own video formats. Some of them are AVI (Audio Video Interleave), WAV(Windows Wave), MPEG1(Moving Picture Experts Group) and MPEG2 (Moving Picture Experts Group), ASF(Advanced Streaming Format), WMV (Windows Media file with Audio and/or Video) etc. Video is the most challenging multimedia form to deliver via the Internet. One second of uncompressed NTSC (National Television Standards Committee) video, an international standard format, requires approximately 27 megabytes of disk storage space.

(4) Sound (Audio)

Audio can be further divided into speech, music and all other kind of sound from the real world, captured in digital form, such as, synthesized, mechanical and natural sound. The most frequently used audio formats are AVI (Audio Video Interleave), WAV(Windows Wave) and MP3 (MPEG-1 (or MPEG-2) Layer 3 Audio Encoding) .

(5) Graphics

Graphics are objects computed or constructed by a computer. A graphical drawing consists of objects like a line, a circle, a square, etc. Graphics are not scanned from the real world, as distinct from a still image. Example formats of graphics are WMF (Windows

Metafile), EMF (Enhanced Metafile), EPS (Encapsulated PostScript) and DXF (Digital eXchange Format).

(6) Animation

Animation is produced by sequentially rendering a number of graphic frames. When graphics are pixel-based, their animation is considered to be the same as videos; When graphics are vector-based, the animation can be regarded as graphic images with a temporal dimension that indicates the frame or time the graphic elements appears (Lu, 1999). Graphic images can be created from artificial sources, such as computer-generated graphics. The leading animation format used on web pages is Macromedia's flash. Flash is an animated vector-graphic format that offers the advantages of dynamic images without requiring the large file sizes of true video.

(7) Hypertext

Hypertext is formatted text which contains links to other texts. The term was invented by Ted Nelson around 1965. Hypertext is therefore usually non-linear (as indicated below)

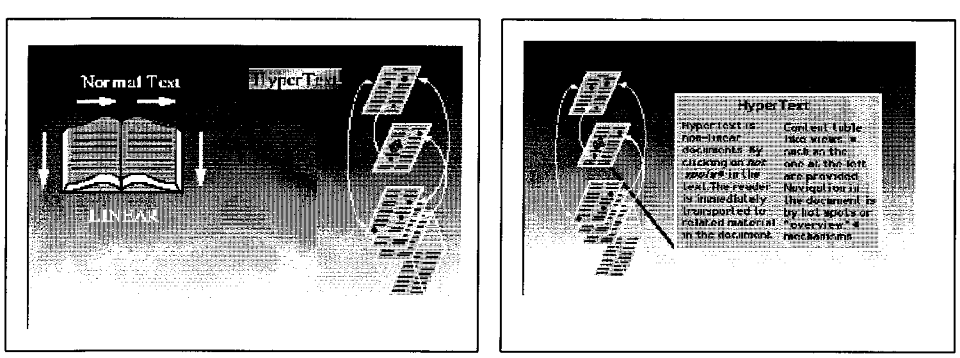


Figure 3.1: A Definition of Hypertext

Source: Marshall, D., 1999

(8) Hypermedia

Ted Nelson was also the first person to use the term hypermedia. Hypermedia includes not only text but also other types of multimedia, e.g., graphics, images, audio and video. The World Wide Web (WWW) is good example of hypermedia application. The term hypertext and hypermedia are usually considered synonymous. Nominally hypertext refers to relating textual elements, while hypermedia includes relationships among elements of any multimedia type. (Bieber, 2000)

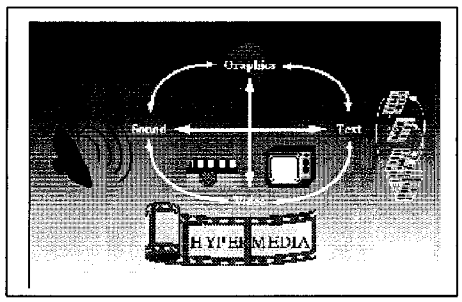


Figure 3.2: A Definition of Hypermedia

Source: Marshall, D., 1999

(9) Atlas content model

An atlas content model is a combined use of map products with different types of multimedia data on the Internet to disseminate information about a specific theme, e.g. life science, climate change and tourist industry. Content of the modules are well structured and source data may come from different servers.

(10) Virtual reality

Virtual reality is "a computer simulation of a real or imaginary system that enables a user to perform operations on the simulated system and shows the effects in real time." (See Dictionary.com: http://dictionary.reference.com/search?q=virtual%20reality). To "enter" a virtual reality, sometimes a user needs to wear special gloves, earphones, and goggles, all of which receive their input from the computer system. In order to keep a real-time interactive effect, "virtual reality technology must be supported by high performance computers, the associated software and high bandwidth network capabilities. Virtual reality also requires the development of new technologies such as displays that update in real-time with head motion; advances in sensory feedback such as force, touch, texture, temperature, and smell; and intelligent models of environments" (See PC AI Magazine: http://www.pcai.com/web/ai_info/virtual_reality.html). Due to the requirements of extremely expensive hardware and software, currently virtual reality systems are confined mostly to research laboratories. It is pointed out that "the term virtual reality is sometimes used more generally to refer to any virtual world represented in a computer, even if it's just a text-based or graphical representation" (See ISP glossary: http://isp.webopedia.com/TERM/V/virtual_reality.html). According to this definition, a game is defined as a virtual reality in this research.

2.3 METADATA FOR MULTIMEDIA DATA

An effective and widely applied solution to handle and manage multimedia data with a traditional database management technique or other techniques is by using metadata. Metadata are becoming an important part of multimedia data.

2.3.1 Metadata are Needed by the Characteristics of Multimedia Data

An important problems faced by the application of multimedia data is how to handle large amounts of multimedia content. Multimedia data have two distinctive characteristics. First of all, multimedia data, especially audio and video are large in volume; secondly, they are stored in specific formats without obvious semantic structures. In particular their distinctive characteristics make them difficult for computers to automatically recognize or retrieve multimedia content information using the exact-matching techniques, a typical data management technique. Furthermore, it is inefficient to execute queries on multimedia databases. However, indirect retrieval and processing of multimedia data by utilizing metadata seems to be an appropriate approach to improve querying and processing. Therefore, there is a need to explicitly capture content information in the form of metadata, to provide additional information about multimedia objects such as the administrative, descriptive and technical information about the data.

2.3.2 Metadata are Used to Manage and Represent the Inherent Complexity of the Multimedia Objects

In the digital world it is not difficult for a single multimedia object to be modified or integrated into other multimedia objects or into a new type of multimedia object. The relationships among some multimedia objects are very complicated. Because of the easy modification of multimedia objects, the reliability and authenticity of the multimedia objects become a serious issue. Metadata plays a critical role in documenting and maintaining those relationships, as well as indicating the authenticity and reliability information about multimedia objects.

2.3.3 Metadata Enable the Creation of Dynamic Web Pages on the Internet

Metadata can enable the building of pages with dynamic multimedia objects included, instead of building static web pages in which all the multimedia objects have to be "hardcoded" with the names and locations of the multimedia objects in the HTML files.

2.4 MULTIMEDIA INFORMATION APPLICATIONS

The application of multimedia information has become one of the most fascinating and fastest growing areas in the field of information technology because the use of multimedia data can help users interact with and navigate through information. Multimedia data are widely used in many areas such as health care, entertainment, museum exhibits, digital publications, education and training, trade and communications, arts and culture for information representation and dissemination (Dion, 2001).

With the advent of multimedia authoring tools like Macromedia's Flash, AuthorWare and Director, a multimedia application is only limited by our imagination. A modern computer can not only store multimedia data for reuse but also has the ability to reuse a variety of multimedia data in a combined way. That means the extensive variety of types of multimedia data such as text, images, animation, videos and sound can be seamlessly combined together, in forms ranging from simple slide shows to interactive presentations or hypermedia, to a virtual reality simulation. The content in multimedia can be manipulated in the same way as other computer files. It can be copied, resized, reformatted, backed up and distributed over networks. Multimedia applications on the Internet are becoming mature and their potential can be more fully implemented. With the adoption of hypertext markup language (HTML) on the Internet, the web evolved from a limited document exchange among a particular community into a worldwide-adopted medium. The advance of technology, especially the dropping cost of storage, efficient compression algorithms, and intensive transmission speeds makes it easier to put multimedia data on the Internet. One major problem for distributing audio and video files through the Internet is that these files are often too big in size to be transferred in the normal way, even when using efficient compression algorithms. Usually, users cannot review (or preview) the data until the entire file has been downloaded. The streaming media techniques offer an ideal solution for solving the problem. Streaming allows very large, audio and video files to be played across a network or the Internet and to be viewed immediately without having to wait for the content to be downloaded completely from the server. All these advances make it possible to put multimedia data on the Internet as easily as text for many different applications.

Multimedia can provide an emotive, powerful and effective means of building environmental awareness (Arkive, 2004). Although currently the application of multimedia in a geospatial context is still in its early phase, people have recognized its importance in communicating geospatial and cartographic information. Multimedia data are usually found described as an important part of geospatial information systems. As Bodum (1999) pointed out, combined use of multimedia, such as text, audio, 2D and 3D graphics, animation, and video can be a new visual representation format for communicating geographical information instead of maps, a traditional metaphor for communicating geographical information. When integrated with digital map products on the Internet, multimedia can be widely used in spatially relevant fields such as earth science, urban planning, environment management, education, transportation management and tourism. With the advance of technology, more and more multimedia will be produced and used in the geography community and spatially relevant applications.

Many researchers have presented ideas of integrating map products with multimedia data on the Internet. Kraak et al (1997) provided the concept of "hypermap" which is defined as geo-referenced multimedia system that can structure individual multimedia data with respect to each other and to the map. According to Kraak et al's definition, a hypermap will let users navigate multimedia data sets not only by theme but also by spatial location. Later Peinel et al (2001) presented a new brand of information portal, which is built upon the concept of smart maps. In their concept, smart maps serve as a navigational hub by indicating the existence of information for specific location, by relating distributed multimedia information to a location on a map of interest and by categorizing information for easy orientation in subjects.

2.4 SUMMARY

All the applications of multimedia information in a geospatial context mentioned above are limited to the use of a small number or single type of multimedia data, or are just proposed as ideas. The Cybercartography and the New Economy (CANE) research project not only involves the theoretical proposal of the application of multimedia data but also the implementation of a large amount of various multimedia data in its two atlas products, using metadata catalogue services. Metadata become critical important for multimedia data management, reuse, sharing, and disseminating in the project.

CHAPTER 3

A CASE STUDY — THE CYBERCARTOGRAPHY AND THE NEW ECONOMY PROJECT

3.1 THE CYBERCARTOGRAPHY AND THE CANE PROJECT

3.1.1 The Definition of Cybercartography

"Cybercartography is a new way of looking at the role of cartography in the 21st century and in particular at cartography's contribution to the new knowledge-based economy" (Taylor, 2005:2)

There are seven elements defined for Cybercartography. It is cartography that (1) is multisensory (e.g., touch, sound, smell, sight and potentially taste); (2) uses multimedia information objects (e.g., animation, 3D scientific visualization, and webcams, etc.); (3) is interactive and engages the user in new ways (e.g., flight simulation, gaming, etc.); (4) is applied to topics of interest to society (e.g., international trade and Antarctic research); (5) is an information/analytical package that will integrate geo-referenced digital information objects with the use of open-source and interoperable systems (e.g., photographs, films, videos, still images, audios and texts, OGC, MapServer); (6) is a cartography that is compiled by teams of individual researchers from different disciplines; and finally (7) partners including the users are part of the development of products (Taylor, 2002).

3.1.2 Introduction to the CANE Project

CANE is a four-year project funded by the Social Sciences and Humanities Research Council of Canada (SSHRC), with a multidisciplinary research team developing a new paradigm that will research and apply the seven elements of Cybercartography. It will integrate spatially-referenced digital cartographic products with many types of multimedia data such as photographs, videos, still images, audios, text, virtual reality and multisensory data such as smell and haptic data. These products will be delivered through the Internet for data access in an interactive, dynamic, multimedia, multisensory and multidisciplinary way by developing a catalogue system. These multimedia data in the CANE project may be stored in various formats on a wide variety of platforms, and metadata may be described in different ways, or these multimedia data maybe collected by individual researchers or scientists. A catalogue system which is compliant to the Open GIS catalogue specification for geospatial data and multimedia data will be developed in order to make them manageable and accessible to users and software.

Besides a variety of expected research results from many research disciplines, another research result for the project is the creation of two atlas products, Canada's Trade with the World and the Cybercartographic Atlas of Antarctic. In these two atlases, multimedia data and geospatial data will be integrated by using a metadata catalogue service and other web application service technologies, such as web map services, web feature services and web coverage services. The potential users of the atlases will be able to interact with geospatial and multimedia data together on the Internet.

3.2 ISSUES AND CHALLENGES

Since Cybercartography is a new concept and new theoretical approach to cartography, the CANE project will involve many new ideas and new approaches. There are many new challenges that need to be tackled in the project. One challenge is to develop an efficient infrastructure. The priority of this challenge is how to choose a metadata standard before developing any metadata repositories or catalogues. There are two types of data, spatial data and multimedia data in the project. In the geography community, metadata for geospatial data are well developed but what metadata standards can be used for multimedia data in the CANE project is unknown. There are some relevant issues and challenges which need to be addressed.

3.2.1 Geo-referenced Multimedia Data

The ISO19129 (imagery, gridded and coverage data framework) standard defines geo-reference as "the reference of a data set to a location on the earth." (Kresse et al, 2004: 99). Geo-reference is the rationale of geographic information. It can be applied to imagery, gridded and coverage data. A typical geo-reference example is to establish the geo-reference of an imagery data set by either an image reference method or a sensor reference method. Both of these methods could be very complex. Multimedia data in the CANE project are usually geo-referenced. This is the key to integrating multimedia data with the digital map products in the CANE project. However, the geo-reference of multimedia data is different from those geo-references of imagery, gridded and coverage data. Geo-referenced multimedia data means that the data can be associated with one or more locations on the surface of the earth. In the CANE project, a geo-referenced multimedia object maybe associated with one or more identifiable features on the earth. These features could represent a tangible thing on the earth, for example, a state, river, mountain, island or lake. The relationship between geo-referenced multimedia data and geographic features is not a simple one-to-one relationship. A geographic feature can have multiple multimedia data associated with it, while some multimedia data may be associated with multiple geographic features. For example, there can be hundreds of images and texts about a mountain feature. Or an image can contain many features, such as a lake, a river or an island. In order to use multimedia data in a geospatial context, the geo-reference information of an individual multimedia object needs to be captured in the form of metadata. The first challenge faced by this research is how to model this geo-reference information in the form of metadata in a standardized way.

3.2.2 Multimedia Data Management

As discussed in chapter 2, a metadata system is a sound solution for multimedia data management. Metadata protect the investment in data, promote data sharing and help minimize the costs incurred by data loss or re-creating data that already exist. It is an effective way to manage multimedia data by providing critical information for archiving and maintaining multimedia data. A scientific or an academic community will benefit considerably if the data and collected materials are maintained and archived by using metadata during the process of geo-scientific research (NAP, 2002).

But scientists are not taking maximum advantage of the information era. Researchers usually do not maintain and archive their data and collected materials during and after their research. A survey of SSHRC-funded researchers indicated that "only 7% of the researchers said that they deposit any of the data with an archive, while the 93% of the other researchers did not deposit data at all" (SSHRC, 2001:21). From a technical perspective, in the information era, documenting data, archiving data, locating appropriate data sources, and transferring data among computer systems are issues that still require solutions and participation by the scientific community (Peng, 2003). As a multidisciplinary research project funded by SSHRC, the CANE project will involve a large amount of data including geospatial data and multimedia objects (or artifacts) which will be modified or adopted from other sources or created based on other sources during the process of developing the two atlases. However, the information about multimedia data, that is, metadata, are scattered among individual researchers or from different sources. If they are not collected and documented well with standardized metadata, the multimedia data or their value will be lost because of the lack of adequate documentation in the future. A second challenge faced by this research is to find out information needed to be documented in order to ensure the management of geo-referenced multimedia data in the CANE project using standardized metadata.

3.2.3 Multimedia Data Reuse

Like geospatial data, multimedia data can also be reused. There are two aspects when considering reuse: one is that multimedia data can be downloaded or copied by final users for their specific purposes; the other is that a multimedia object can be used in different applications in the CANE project in different contexts or topics. A multimedia object can be reused to combine with a new multimedia object, such as web pages and atlas content modules for the CANE project. The combined multimedia object will also be presented to end users. In any case of reuse, users need reliable and authentic information about multimedia data to be certain that the reuse is appropriate. The other challenge faced by this research is to find out what metadata needed to record or extract information from multimedia data for the purpose of proper use.

3.2.4 Multimedia Data Access

Once data are available on the Internet, data accessibility becomes a big issue. Data access is actually a common issue frustrating almost all information domains. In a geospatial context, geospatial data are usually available on different web portals. Users can search geospatial data by searching their metadata. The CANE project will use a similar approach to make geo-referenced multimedia data available on the Internet. Then, the question is what metadata information could be used as search criteria for multimedia data. Is there any innovative way of helping users to have easier data access by searching their metadata? The latter question initiates another objective of this research, that is, to explore a new approach of information visualization in order to make data easily accessible.

3.2 SUMMARY

Based on the above analysis, two challenging questions related to metadata of multimedia data raised from the CANE project in this research:

- What metadata information should be chosen and constructed for a variety of types of geo-referenced multimedia data?
- Is there any innovative way to help users with easier data access when searching their metadata from a geospatial portal?

This study will focus on geo-referenced multimedia information from the Antarctic atlas in the CANE project to answer these two questions.

CHAPTER 4

REVIEW OF METADATA STANDARDS

In order to find out what metadata can be used to describe the large amount of multimedia data in the CANE project, a review of metadata standards both in the multimedia community and the geospatial community is conducted in this chapter.

4.1 METADATA STANDARDS

The reasons for developing metadata standards are related to long-term interoperability and economics. There is growing awareness of the importance of using existing metadata standards (Hill, 1995). In any community, if metadata are documented but not documented in a standardized way, the data usability will be limited. They will only be available to a small group of people rather than to the whole community. In a distributed system like the Internet or a web portal, if data are not described based on existing metadata standards, there will be many different ways of describing data, which will result in many problems related to data exchange, data sharing and make the goal of searching and accessing distributed information resources more difficult. Multimedia data in the CANE project will not only be used by the primary community but also be used on the Internet through a distributed system – a web portal system. Therefore, it is critically important that the metadata for the CANE project should follow metadata standards for the purpose of making the search and exchange of information more possible across distributed systems.

4.1.1 Metadata Encoding Standards

A metadata standard outlines the characteristic properties to be recorded, as well as the values that the properties should have (Geoconnections,1997). Usually, a metadata standard includes sets of metadata elements designed for specific purposes. For example, a typical metadata element is a "description" which is usually used to describe the content of a particular information resource. The definition or meaning of the elements themselves is known as the semantics of the standard. The values given to metadata elements are known as the content (NISO, 2004).

The two most important aspects of interoperability about metadata standards are semantics and syntax. Semantics is about meaning and syntax is about form of metadata. General metadata standards specify the names of metadata elements and their semantics. In order to encode, format, express and exchange metadata and content in a standardized way on the Internet, most metadata standards have also defined syntax rules for the elements in addition to their content semantics. Only agreement about both semantics and syntax can ensure the sharing and exchanging metadata among different communities (Duval et al, 2002).

The two most popular metadata encoding standards are Extensible Markup Language (XML) and Resource Description Framework (RDF).

(1) XML (Extensible Markup Language)

XML is a markup language developed by the World Wide Web Consortium (W3C). It separates data from presentation to make data easily exchangeable and processable, especially in heterogeneous systems. XML is quickly becoming the industry standard for publishing and sharing data across the Internet. The XML format looks like HTML (HyperText Markup Language), but it was designed to describe data and to focus on what data is, while HTML was designed to display data and to focus on how data looks (www.w3c school.com). An xml file is usually formalized or validated by an xml DTD(Document Type Definition) or XSD (XML Schema Definition) file which defines legal elements and syntax of corresponding xml files. Many software vendors have adopted XML and many metadata standards, such as MPEG-7 and ISO19115, use XML to describe the syntax of their metadata.

(2) RDF (Resource Description Framework)

RDF, Resource Description Framework, as its name implies, is used as a framework for describing and interchanging metadata. XML is machine readable, but not machine understandable. Due to the structure of XML, it is impossible for machines to interpret the relationship between different XML tags in a document. RDF was developed to solve such problems, with the main goal of describing resources and their relationships through three parts of records (Resource, Property, value). RDF documents are usually implemented in XML. The resources of RDF are any objects that are uniquely identifiable by an URI (Uniform Resource Identifier). Using RDF will allow the description of semantically enriched data and therefore allow the management of information sharing between different information communities.

4.1.2 Metadata Standards in the Multimedia Domain

Different metadata standards have been developed in different domains for their specific needs. This section will introduce a general review about metadata standards in the multimedia domain.

There are two different types of multimedia metadata standards. The first type is called encoded metadata standard which is devised for a particular media format. These metadata are usually stored inside a multimedia object to describe detailed technical information etc. Some examples of these encoded metadata standards are Joint Photographic Experts Group (JPEG), Tagged Image File Format (TIFF), Moving Pictures Expert Group 2 (MPEG-2) and Moving Pictures Expert Group 4 (MPEG-4), Portable Network Graphics (PNG) and

Digital Video (DV). The second type of metadata standard is devised to describe various types and formats of multimedia data. The most representative metadata standards are Dublin Core, DIG 35 (Digital Image Group), Moving Picture Experts Group (MPEG-7), as well as the Adobe Extensible Metadata Platform (XMP) metadata standard. Because the CANE project will be involved the application of various types of multimedia data, the second type of metadata standard for multimedia data is the targeted standard of this research. A brief review of each of the multimedia metadata standards that falls within the second category follows.

(1) Dublin Core

The Dublin Core Metadata Element Sets (Dublin Core) were originally agreed upon at a workshop convened by the Online Computer Library Center (OCLC) and the National Center for Supercomputing Applications (NCSA) in Dublin, Ohio in March 1995. The standard has been maintained by the Dublin Core Metadata Initiative (DCMI), an organization with the mission to make it easier to find resources using the Internet (Dublin Core, 2003).

The Dublin Core metadata standard consists of 15 elements (See appendix 1). It includes primary metadata for resource description and discovery, so it is becoming a widely accepted standard for discovery metadata, particularly for web applications. It is also widely used for simple description (eg. description, coverage) in different domains such as library collections, digital learning objects, digital documents, multimedia objects, web pages or other Internet resources. Because the simple Dublin Core metadata elements satisfy the primary metadata requirements of many applications, it can be used as the starting point for the creation of more complex metadata for any specific application. This is why Dublin Core can be mapped to a variety of metadata standards from different domains. For example, it can be mapped to geospatial metadata standard ISO19115 (See

Appendix 2) or multimedia metadata standard MPEG-7 (See http://www.metadata.net/harmony/video_appln_profile.html).

One advantage of Dublin Core is that it is repeatable and extensible. All of the 15 elements in Dublin Core can be used and repeated as many times as necessary and they can be modified by qualifiers. A qualifier might be used to refine or extend the content or format of a particular element. For example, the element "coverage" can be assigned to describe either the spatial information or the temporal information of an object. When it is used to describe spatial information of an object, it usually means a location related to a place name or point location (in geographic coordinates). Becker et al (1997) also extend it to describe a polygon location by using a qualifier.

Dublin Core is simple, and easy to use and interpret. However, it is insufficient to adequately describe the content and context of many sources. For example, it has limitations in describing the responsible party who contributes to a source. It contains two elements "creator" and "publisher" for describing responsible parties. However, different communities of practice require creators' information specified at different levels of detail. As Duff (2001) pointed out, these two elements might meet the needs of bibliographic items but are not sufficient for many information objects because they blur the different creator roles such as editors, translators, illustrators and composers etc. It is also difficult to specify the owner and rights owner(s) of an item.

(2) MPEG-7 (Moving Pictures Expert Group)

MPEG-7, formally named "Multimedia Content Description Interface", is a standard for describing multimedia content in multimedia environments. This standard was released by the Moving Pictures Expert Group (MPEG), a working group of the International Organization for Standardization/the International Electrotechnical Commission (ISO/IEC). The goal of this standard is to provide a set of standardized tools and methods to enable both human beings and machines to generate and understand audiovisual descriptions which can be used to enable fast and efficient retrieval from digital archives (pull applications) as well as the filtering of streamed audiovisual broadcasts on the Internet (push applications). MPEG-7 can describe audiovisual information regardless of storage, coding, display, transmission, medium, or technology. It addresses a wide variety of media types including still pictures, video, graphics, 3D models, audio, speech and the combination of these (MPEG-7, 2003).

The MPEG-7 metadata standard has three main components. 1) A core set of descriptors (Ds) that can be used to describe the various features of multimedia content; 2) Description Schemes (DSs), which are pre-defined structures of Ds and their relationships, and 3) a Description Definition Language (DDL), which allows the creation of new DSs and Ds, and the extension and modification of existing DSs.

The MPEG-7 was designed to take into account all the viewpoints under consideration by other multimedia metadata standards from the multimedia industry such as TV Anytime (a metadata standard for television) and Dublin Core. (Austerberry, 2004). Therefore MPEG-7 is a complicated standard. It provides data types and description elements to describe audiovisual content including low-level features in the content (colors, textures, sound timbres, melody description), but does not offer applications that recognize audiovisual content like search engines and filter agents. In the literature, MPEG-7 is mostly used as an audio-visual metadata standard.

One of MPEG-7's goals is to make the web as searchable for multimedia as it is for text today. If it is expected that future search engines will be able to retrieve songs from a whistled stanza, or to identify a criminal from a face captured by a surveillance camera, then Mpeg-7 is the promising candidate metadata standard (Austerberry, 2004).

(3) DIG 35 (Digital Image Group)

DIG35 is a metadata standard for digital images. It is defined by the Digital Image Group, a not-for-profit imaging industry consortium founded by Adobe, Canon, Eastman Kodak, Fuji Photo Film, Hewlett-Packard, IBM, Intel, Live Picture and Microsoft. It has a well-defined structure and includes element types for photography such as collecting, content searching, linking, and information/copyright preservation. This standard defines five metadata blocks, including 1) basic image parameter metadata; 2) image creation metadata; 3) content description metadata; 4) history metadata; 5) intellectual property right (IPR) metadata; and 6) fundamental metadata types and fields (DIG 35, 2001). The aim of the DIG 35 standard is to promote interoperability between various digital image devices. It has well-defined metadata for handling copyright information. However, it is not applicable for the all variety types of multimedia objects; it is a metadata standard designed to be used in image devices.

(4) XMP (Extensible Metadata Platform)

XMP was developed and released by Adobe in 2001, aiming to provide a standardized method for creating, processing and interchanging metadata for multimedia objects (See http://www.adobe.com/products/xmp/main.html). One characteristic of XMP is that it uses RDF as a syntax rule for its interchange representation. XMP standardizes the definition and creation of metadata, and defines an extensible representation that allows applications and tools to access and understand metadata about documents that they manipulate. XMP defines a core set of metadata properties (schemas) that are relevant for a wide range of applications including all of Adobe's authoring and publishing products, as well as for applications from other vendors. The schemas are included in XMP are:

- Core Schema
- XMP Media Management Schema

- XMP Support Schema
- XMP Basic Job Ticket Schema
- XMP Rights Management Schema
- Adobe PDF schema
- Dublin Core Schema

XMP also provide some proposed schemas for particuluar media types, including:

- XMP Graphics Schema
- XMP Graphics: Image Schema
- XMP Dynamic Media Schema
- XMP Dynamic Media: Video Schema
- XMP Dynamic Media: Audio Schema
- XMP Text Schema
- XMP Text: Paged-Text Schema

XMP provides a file embedding mechanism to embed semantic metadata directly in media files. This can allow applications to easily locate metadata in files by simple scanning, rather than needing to parse a specific application's file format. XMP is a promising metadata standard which will be applied widely in the publishing industry on the Internet. At present, there are not many applications found using the XMP metadata standard.

4.1.3 Metadata Standards in the Geospatial Domain

Geospatial metadata standards usually mean metadata standards which are used to describe geospatial data or servers. The most well known geospatial metadata standards are Content Metadata for the Digital Geospatial Standard (FGDC) and International Organization for Standardization metadata standard (ISO19115). Other geospatial metadata standards include Directory Interchange Format (DIF) metadata standard, Australia and New Zealand Metadata Standard (ANZLIC).

ISO 19115: 2003(E), formerly known as ISO 15046-15, is one of the significant international metadata standards developed by the International Organization for Standardization Technical Committee (ISO/TC 211) which developed a series of geographic standards (the ISO 19100 series) to help facilitate the description and management of geographic information. The ISO19115 metadata standard proposes a series of conceptual specifications which were developed partially based on the 1994 FGDC standard. The standard provides more than 400 elements for describing data sets and data servers interpreted in 14 UML (Unified Modeling Language) packages (See figure 4.1).

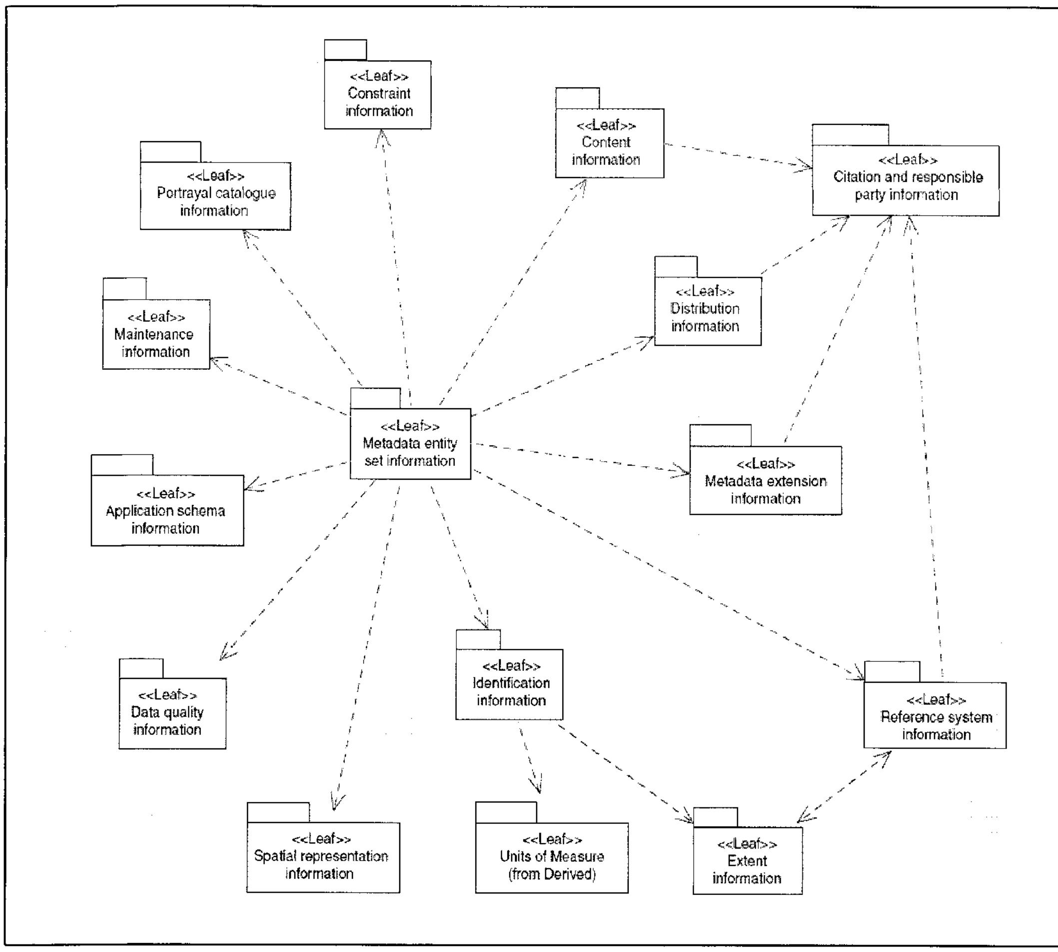


Figure 4.1: ISO 19115 Metadata Package UML Diagrams

Source: ISO/FDIS 19115 Metadata Standard Final Draft

This metadata standard provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data (ISO 19115, 2003). The standard also defines mandatory and conditional metadata sections, metadata entities and metadata elements; the minimum set of metadata (core elements) required to serve the full range of metadata applications (See table 4.1). Optional metadata elements to allow for a more extensive standard description of geographic data are also provided for specific requirements. In order to satisfy all potential requirements, it also includes a method for extending metadata to fit specific needs.

Dataset title (M) (MD_Metadata > MD_DataIdentification.citation > CI_Citation.title)	**Spatial representation type** (O) (MD_Metadata > MD_DataIdentification.spatialRepresentationType)
Dataset reference date (M) (MD_Metadata > MD_DataIdentification.citation > CI_Citation.date)	**Reference system** (O) (MD_Metadata > MD_ReferenceSystem)
Dataset responsible party (O) (MD_Metadata > MD_DataIdentification.pointOfContact > CI_ResponsibleParty)	**Lineage** (O) (MD_Metadata > DQ_DataQuality.lineage > LI_Lineage)
Geographic location of the dataset (by four coordinates or by geographic identifier) (C) (MD_Metadata > MD_DataIdentification.extent > EX_Extent > EX_GeographicExtent > EX_GeographicBoundingBox or EX_GeographicDescription)	**On-line resource** (O) (MD_Metadata > MD_Distribution > MD_DigitalTransferOption.onLine > CI_OnlineResource)
Dataset language (M) (MD_Metadata > MD_DataIdentification.language)	**Metadata file identifier** (O) (MD_Metadata.fileIdentifier)
Dataset character set (C) (MD_Metadata > MD_DataIdentification.characterSet)	**Metadata standard name** (O) (MD_Metadata.metadataStandardName)
Dataset topic category (M) (MD_Metadata > MD_DataIdentification.topicCategory)	**Metadata standard version** (O) (MD_Metadata.metadataStandardVersion)
Spatial resolution of the dataset (O) (MD_Metadata > MD_DataIdentification.spatialResolution > MD_Resolution.equivalentScale or MD_Resolution.distance)	**Metadata language** (C) (MD_Metadata.language)
Abstract describing the dataset (M) (MD_Metadata > MD_DataIdentification.abstract)	**Metadata character set** (C) (MD_Metadata.characterSet)
Distribution format (O) (MD_Metadata > MD_Distribution > MD_Format.name and MD_Format.version)	**Metadata point of contact** (M) (MD_Metadata.contact > CI_ResponsibleParty)
Additional extent information for the dataset (vertical and temporal) (O) (MD_Metadata > MD_DataIdentification.extent > EX_Extent > EX_TemporalExtent or EX_VerticalExtent)	**Metadata date stamp** (M) (MD_Metadata.dateStamp)

Table 4.1: Core Metadata of Geographic Data Sets (Note: O- optional; M- mandatory; C- conditional)

Source: ISO/FDIS 19115 Metadata Standard Final Draft

The objective of the ISO19115 metadata standard is to provide a structure for describing digital geographic data. There are many benefits of implementing this standard by data producers (ISO 19115: 8):

- *"To provide data producers with appropriate information to characterize their geographic data properly.*
- *To facilitate the organization and management of metadata for geographic data*
- *To enable users to apply geographic data in the most efficient way by knowing its basic characteristics.*
- *To facilitate data discovery, retrieval and reuse. Users will be better able to locate,*

access, evaluate, purchase and utilize geographic data.

- *To enable users to determine whether geographic data in a holding will be of use to them."*

4.2 EVALUATING THE CAPABILITY OF METADATA STANDARDS FOR DOCUMENTING GEO-REFERENCED INFORMATION OF MULTIMEDIA DATA

One important and distinguishing characteristic of multimedia data in the CANE project is that they may have geo-referenced spatial information. An important question raised is how to describe and model the spatial information of multimedia data by using metadata standards. This section aims to analyze the potentiality of different metadata standards be used for describing geo-referenced information of multimedia data.

4.2.1 Multimedia Metadata Standards

Multimedia metadata standards have included spatial metadata elements (usually coverage, location or place) in a more or less detailed way. For example, the DIG 35 standard has defined place metadata with the following spatial metadata elements:

- **Coordinate location:** Specify the exact longitude, latitude and altitude of an object ;
- **GPS location:** Specify the location information received from a GPS receiver;
- **Address location:** Specify an object using an address coordinate location.

A test was performed to describe the exposure location information of the image in figure 2.1 by using DIGF 35's GPS location metadata (See table 4.2).

DIG35 BLOCK	DIG 35 Metadata Elements	Metadata Value
Camera_Location	GPS Latitude Reference	S
	GPS Latitude	64° 50' 34.6"
	GPS Longitude Reference	W
	GPS Longitude	62° 31'23.6"
	GPS Altitude	1
	GPS Image Direction	332°

Table 4.2: Exposure Location of the Image (in figure 2.1) Described by DIG 35 GPS Metadata

The test shows that the GPS metadata of DIG 35 are sufficient to describe exposure location information of an image. A further review of some image metadata standards indicates: GPS location metadata in DIG 35 has been consistent with GPS location metadata in the EXIF (Exchangeable Image File) metadata standard which is widely used by digital cameras (Adobe, 2004). Adobe's XMP has adopted TIFF metadata standard as part of its image metadata standard with EXIF embedded in the TIFF metadata standard, so these GPS metadata can be also found when editing an image in Adobe Photoshop. The coordinate location in DIG 35 has the potential to be used to describe the geographic coordinate point location.

MPEG-7 also has a descriptor called Place DS (descriptors) that is used to describe existing, historical, and fictional places. This same DS can be used to describe places depicted in the content, such as the setting and places in the real world where the content was filmed. As the GPS location in DIG 35, EXIF and XMP, the DS also includes a position location metadata type named geographicPointType DS, which describes a geographic point using coordinates in GPS.

The sections above show that the spatial metadata elements in multimedia metadata standards can be readily used to describe the point location information of multimedia objects. Yet the location information of many multimedia objects in the CANE project are not only limited to points. They can be non-point locations, such as continued point locations, line locations, bounded polygon locations or rectangle locations. For example, a video clip could capture a helicopter flying over Antarctic Dry Valleys from place A to place B. In order to ensure this video clip to be found in an area of interest (AOI) on a Dry Valleys area map, a simple way is to encode the flight route of the video (a segment location) in metadata form (See Figure 4.2). However, the spatial metadata elements in multimedia metadata standards are not sufficient to describe a segment location which is needed by this video clip.

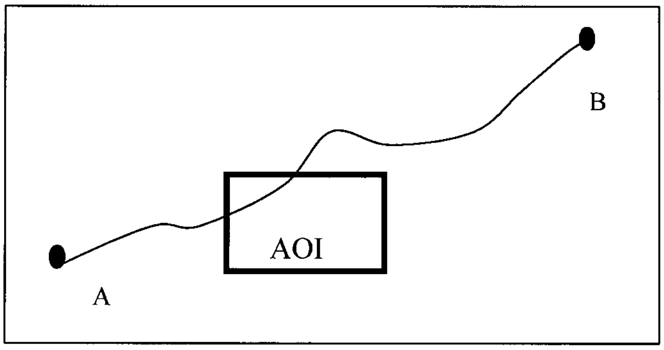


Figure 4.2: A flight Route of a Helicopter in a Video

4.2.3 The ISO 19115 Geospatial Metadata Standard

The ISO19115 geospatial metadata standard has an "EX_Extent" class metadata for representing coverage information of a data set including spatial and temporal. In a recent discussion on the metadata mail-list (2005/05/04), a group of metadata researchers, concludes that the coverage can represent extent of study area or extent of data in study area. Therefore, the "Ex_Extent" is very flexible in describing coverage information. (See figure 4.3).

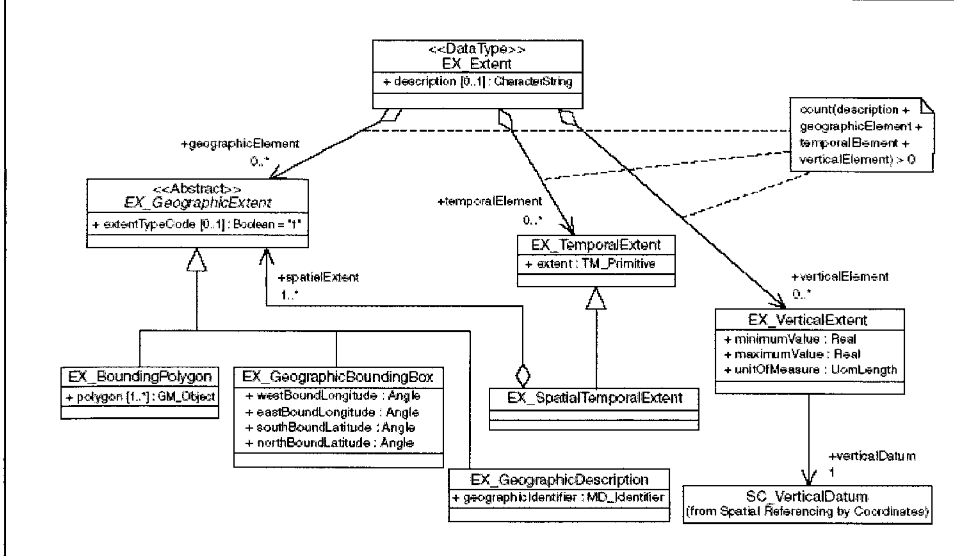


Figure A.15 — Extent information

Figure 4.3: Extent Metadata Information Defined in ISO19115

Source: ISO/FDIS 19115 Metadata Standard Final Draft

The spatial coverage can be represented by a geographic co-ordinate bounding box including longitude and latitude information without projection. Or in a more accurate way, it can be represented by a bounded polygon with projection. However, the ISO 19115 metadata standard provides information (in its content information metadata class) about what is the geometric representation form of features in a data set, such as point, line or polygon, but it has no definition of how to encode the feature geometry information in metadata forms. So the feature geospatial information of the geo-referenced multimedia data needs other ways to be encoded. There are many standards in the geospatial domain that can be used for encoding geospatial feature information. GML, also called as ISO 19136 by ISO/TC211, has stood out among many different geospatial feature encoding standards and become the world's leading standard for geographic information encoding especially delivery over the Internet. Although the ISO/TC211's version of GML is still a committee draft, GML is becoming the most widely supported open specification for construction and representation of geographic (spatial and location) information.

4.2.4 GML (Geographical Markup Language)

GML is an XML based encoding standard but it makes use of RDF concept by using an object-property approach to describe geographic objects. The latest version GML defines XML encoding for the transport and storage of geographic information, including features, co-ordinate reference systems, geometry, topology, time, units of measure and generalized values. In GML, those real-world objects are called features. GML is used to encode those features which have properties including geometry properties and non-geometry properties. Obviously, GML has the potential to be used as a metadata standard for encoding geospatial feature information of multimedia data.

4.3 SUMMARY

For the CANE project, a general consensus has been reached that ISO19115 will be used as the metadata standard for geospatial data. The main reason is that it is envisioned that in the future all existing spatial metadata standards will converge through the ISO initiative (ANZLIC, 2001). Indeed, most of the existing geographic metadata standards already have a great deal in common, and a robust international discussion has ensured that the ISO standard has accommodated most international requirements. Furthermore, the ISO standard is developed by 29 nations including organizations such as United States Federal Geographic Data Committee (FGDC). Mapping between other spatial standards and ISO 19115 standards have been developed to ensure the interoperability between them by some organizations and communities.

However, it remains an open question as to which metadata standard should be used for multimedia data in a geospatial context. The ideal solution is to use one metadata standard to describe both geospatial data and multimedia data. In fact, the accuracy, reliability and authenticity such as use constraint, lineage, and responsible party information are well defined in ISO19115 geospatial metadata standard but it lacks the particular technical metadata and other specific metadata for multimedia data types. For multimedia data, the three major metadata standards appear to be Dublin Core, MPEG-7 and XMP. Dublin Core has been better developed and deployed in the area of bibliographical metadata on web resources, particularly when qualified Dublin Core is exploited. The MPEG-7 metadata standard is usually considered for describing audiovisual materials. It has more details on metadata for the contents of audio and video, which is partly why MPEG-7 become such a complicated metadata standard. Hunter (2002), an expert on MPEG-7, proposed a metadata application profile by combined use of Dublin Core (for the high level) and MPEG-7 (for the fine level) for simple video description. XMP as a metadata standard aims to be used in digital publications on the Internet. It has well defined metadata for digital content management, workflow and distribution processes. It has also provided some information such as “ContainedResources”, “ContributorResources” and “history” for managing media objects. But this is not sufficient for describing multimedia objects in a geospatial context which need more detailed information about source data and contributors. XMP also lacks a geospatial and temporal context information which is critically important for geo-referenced multimedia data. Furthermore, the relevant XML schemas of XMP have not been found being published online. The conclusion of this review is that no metadata standard is readily available for describing the multimedia data in the CANE project. There is a need to look for other solutions.

In a conclusion, there are two potential solutions to describe geo-referenced multimedia data in the CANE project: either to extend existing metadata standards or to build a multimedia metadata application profile by adopting elements from existing metadata standards and standardizing a multimedia metadata profile to be used in a community context. Given the fact that the second solution is easier to implement, it has been recommended to develop a multimedia metadata application profile for the CANE project. A metadata application profile consists of metadata elements drawn from different metadata standards for a particular application. It can be considered as a data-model created by taking elements from different metadata standards. Any metadata element in an application profile will have an associated name space which supports the definition of a unique identifier in a relevant XML schema. A metadata application profile can be a high quality metadata format for exchange of information resources and to improve data accessibility on the Internet by specifying the permitted schemas, values of elements, or sometimes by refining and extending the definition of the elements.

CHAPTER 5

NEEDS AND REQUIREMENTS ANALYSIS

A good metadata application profile should strive for simplicity, and at the same time, satisfy as many potential needs as possible. Therefore it is important to find out the critical needs and requirements in defining a multimedia metadata application profile for the CANE project (This will be hereafter referred to as the metadata profile). There are four general purposes in developing the metadata profile:

- To make multimedia data and metadata manageable;
- To provide information for the reuse of multimedia data;
- To ensure that multimedia data are accessible and retrievable; and
- To provide metadata information for media specific requirements.

The following sections aim to analyze the four main purposes for the development of the metadata profile and to discuss some specific sets of potential needs that are consistent with each purpose. Based on this, a metadata profile will be developed in Chapter 6.

5.1 THE MANAGEMENT OF MULTIMEDIA DATA

The primary purposes of developing the profile are to ensure and facilitate multimedia data discovery and reuse through a web portal with integrated map products. The efficient management of metadata and data is the precondition to fulfill all of the purposes.

Related to the management of multimedia data and metadata in the CANE project, there are three important questions that need to be answered. First of all, how to provide general administrative information; secondly, how to make all the relationship information among multimedia data available and traceable; and finally, how to provide as much information as possible, related to long term management of multimedia data, to help preserve multimedia data.

(1) Administrative Information

In order to facilitate the management of multimedia data and metadata, it is necessary to provide metadata related to information such as identification, custodianship and acquisition. Some of the key administrative information is:

- Who is the originator that created the multimedia object?
- Who is in charge of the accuracy for the contents of multimedia objects?
- Who provides the metadata and what is the contact information?
- What is the unique identifier of the multimedia object?

(2) Relationship Information

Many multimedia application projects need to manage only one type of multimedia data such as images or videos. One of the challenges faced by the CANE project is that it needs to handle and manage many different types of multimedia data. In order to satisfy different application goals, one multimedia source may be represented in many different types and formats. For example, the Human Oriented Technology (HOT) lab research team in the CANE project presents a need to give users the option of listening to the audio of a lecture, or reading the text scripts of the lecture. In this case the content of the same lecture needs to be represented in both audio and text forms. The relationships among different multimedia objects can be very complicated. One multimedia object can be represented in different formats, each of which can have different versions. Furthermore, one multimedia object can come directly or be derived from one or more source objects; some multimedia objects may be referenced by, and be combined into, new multimedia data. For example, an atlas content module will include a variety of multimedia objects in facilitating information dissemination. In order to ensure long-term data management, metadata elements defined in the profile should ensure the "traceability" of all relationships among all data components.

Despite the fact that multimedia data will be used in many different ways and for many different purposes, and that there are many different types of multimedia data with complex relationships among them, multimedia data in the CANE project can be classified broadly into two categories based on their characteristics:

- **Generic multimedia data**, including text, image, video, audio, animation and graphics.
- **Combined multimedia data**, including atlas content models, image collections, interactive graphics, hypertext, hypermedia, virtual reality.

The relationships between the two categories of multimedia data are complicated. A combined multimedia object can contain or refer to generic multimedia objects and also can contain or refer to other combined multimedia objects (Figure 5.1).

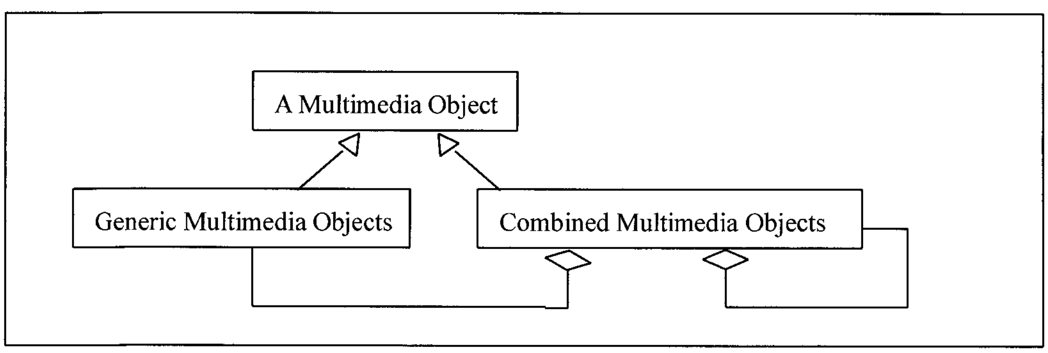


Figure 5.1: Multimedia Data Categories

Table 5.1 lists some relationships among multimedia objects proposed by Agnew et al (2001) as a Dublin Core "relationship" qualifier. These relationships can be used as the reference relationships for multimedia data in the CANE project.

Relationship	Description
Is a Version of	The multimedia object is a version, edition or historical state of other multimedia objects
Has Versions	This refers to other alternative available versions of this multimedia object.
Is Part of	This multimedia object is part of a combined multimedia object.
Has Part	This relationship uses to refer component parts of a combined multimedia object.
Is Referenced by	This multimedia object is referred by other multimedia objects
References	Can be used to identify multimedia objects referred by the combined object
Is a Format of	The multimedia object is the same version/edition, but is in a different format from other multimedia objects.
Has Format	Reference to other multimedia objects in different format but have the same version.

Table 5.1: Relationships among Multimedia Objects

(3) Preservation Information

Data produced in the past may not be usable today because of obsolete data formats or the obsolete equipment being used to create data. For example, in the 1970s, the consortium of Texaco, Humble (now Exxon), Unocal, Mobil, and Shell, called THUMS, in Long Beach, California stored seismic data collected for the Wilmington oil field on 1,600-bpi tapes. In 1995 when THUMS staff tried to integrate these data with new three-dimensional seismic survey data, the old format tapes were not readable any more (NAP, 2002). Another example is the BBC Domesday Project in 1986 which aimed to conduct a modern-day equivalent of William's survey 900 years after the publication of the Domesday Book. Over a million people took part in data collection. Thousands of maps, still photographs and central statistical data, written and visual information were collected to reflect British's life around 1986. All these data were stored in two discs: the Community Disc and the National Disc. These discs contain such a large amount of data that it would take a person over seven years to look at everything on the discs. These discs were available to users as a package together with the necessary hardware at a cost of nearly £4,000. Unfortunately, because of the fast change pace of technology, the data storage media used in 1986 became obsolete. These discs are now unreadable on a modern PC. Expensive rescue work and research have been ongoing to in an effort to rescue and preserve the project (Domesday, 2005).

In this digital era, one potential solution for avoiding the loss of data like the above examples is through preservation management of digital data in which preservation metadata become essential in supporting and facilitating the long-term retention of digital data. Preservation metadata can provide preservation information to enable long-term preservation, accessibility and dissemination of data. They can help to address the following functional requirements (NLNZ, 2003: 3):

- " *To provide sufficient knowledge for taking appropriate actions in order to maintain a digital object's bit stream over the long-term; and*
- *To ensure that the content of an archived object can be rendered and interpreted, despite future changes in storage and access technologies.* "

The National Library of New Zealand (NLNZ) has developed a preservation metadata schema with detailed data elements needed to support the preservation of digital objects. This schema provided the basis for the design of a database repository and input systems for collecting and storing preservation metadata (NLNZ, 2003). Four entities were defined in the schema, including a file entity which provides technical metadata elements for recording the technical characteristics of digital data image, video, audio, text etc. for the purpose of preserving multimedia data (See appendix 3, 4).

In addition to keeping the value of data, data preservation management can also add value to data. However, data preservation management is a multi-facetted topic. It involves not only the choice of preservation metadata but also the standardization of policies and processes to implement the preservation actions. For example, a preservation action could be make sure that the data are transferred in to modern or current storage media formats when technology changes. This research will focus on the selection of preservation metadata elements which include information related to the long term management of data.

The goal of providing preservation metadata in the CANE project is to make data manageable today and in the future as well. Like any other digital data, multimedia data in the CANE project may vary widely in media types, storage formats and producing process. It is critical to use preservation metadata to record this information in order to satisfy the requirements of distributed implementation over long periods of time, during which participants' memories of the contexts of data creation will not suffice. It is necessary to include as much preservation metadata as possible in the profile. This research aims to explore two key types of preservation metadata:

1) Lineage Metadata

Lineage metadata includes source data information and process information. The purpose of source data metadata is to record the information of source data, and the purpose of process metadata is to record the complete history of actions performed on source data to get to the current multimedia object, including information such as who processed the source data to current data and how, what critical equipment or code were used and what were the outcomes of these actions etc.

2) Technical Metadata

Technical metadata becomes critical in order to survive migrations through successive generations of computer hardware and software, or move to entirely new delivery systems in the digital era. Technical metadata provide technical information, which is about the physical make-up of a multimedia object, e.g. frame rates, sampling frequency of a video or audio. These are key metadata for a multimedia object to provide the following information: preservation information, presentation information and fitness information.

- **Preservation Information**

Technical metadata has often been called the first line of defense against losing access to digital data. They are very important in achieving the long-term viability of digital files (or multimedia data). The reason is that technical metadata assures that the information content of a digital file can be rebuilt even if traditional viewing applications associated with the file have vanished (RLG, 2004). Therefore, from a data preservation perspective, technical metadata could provide technical information for data migrating into another format. For example, technical metadata could support the management and preservation of digital images throughout the different stages of their life cycles (RLG, 2004). However, technical metadata can be very detailed and complex, and it is not surprising that considerable efforts have been made to structure technical metadata for describing multimedia objects in many organizations. One technical metadata standard developed is NISO (The United States National Information Standards Organization) Standard (Z39.87), which is to satisfy the need of using a standardized data structure for describing text and still images. Further work is in the process to extend the standard for audio, video and web sites (NISO, 2004).

- **Presentation Information**

From the presentation requirement perspective, technical metadata could provide information for presenting multimedia data (or digital data). They provide information that allows machines to evaluate the accuracy of output from a multimedia object and the way to present the multimedia object. Typically, technical metadata information such as multimedia data type or dimensions of the digital file are used to identify the software, hardware, or other equipment needed to display or operate the multimedia object. This metadata also include format, coding and compression techniques that have been applied to a multimedia object. For example, technical metadata for an audio type multimedia object is described by the number of samples per second, number of channels, and the coding in which it has been recorded etc. However, a simple way of capturing the technical presentation metadata on the Internet is to use the Internet media type – MIME (Multipurpose Internet Mail Extensions type) to define computer media formats. As the Dublin Core metadata standard recommends that the best practice for its "format" (presentation) element is to select a value from a controlled vocabulary, a list of MIME types.

MIME type is also known as Content Type. It was first proposed in 1992 to specify more complex data than plain text. It is an Internet standard for describing message content types. Official MIME information is provided by the Internet Engineering Task Force (IETF) (W3schools: http://www.w3schools.com/media/media_mimeref.asp). In essence, MIME is used to specify the data type for HTTP and tell the browsers how to display the contents of the file. MIME type has grown over the years to support a variety of multimedia data types such as text, images, audio, video, and other application-specific data. Here are some of the example MIME types:

- text/plain;
- video/mpeg;
- audio/mpeg
- video/quicktime
- audio/x-pn-realaudio (RealAudio)
- audio/x-pn-realaudio-plugin (RealPlayer as a plug-in)
- application/vnd.rn-realplayer (RealPlayer File)

- **Fitness Information**

Technical metadata provides information for presenting multimedia data, which may be concerned by users for his/ her specific application such as:

- What is the compression technique?
- What is the version of the format?
- What is the resolution of an image?
- What is the physical size of the multimedia object?

5.2 REUSE OF MULTIMEDIA DATA

In a broad sense, the reuse of data means to structure data by modeling their metadata to enable data reusability for different applications. In the Internet environment, a typical way of facilitating data reuse through modeling their metadata is to structure metadata based on a specific classification, which will be discussed later in the data retrieval section 5.3 (2). This section will focus on the discussion of data usability from users' perspective, trying to answer the question of what fitness information needs to be captured in the form of metadata.

(1) Data Quality Information

Data quality is generally the key concern of users before they choose to use the data. Users can predict the fitness of data by checking their data quality metadata. For geospatial data, the most important data quality metadata is information related to lineage, positional accuracy, attribute/thematic accuracy, completeness, logical consistency, semantic accuracy, and temporal information (Guptill et al, 1995). For multimedia data, the key data quality information ranges from authenticity, legal liability, and other general data fitness information.

1) Authenticity

Multimedia is an efficient way of presenting and disseminating information. Some multimedia data are very easy to duplicate, modify and disseminate. For example, images can be duplicated or modified without much difficulty using particular software. The duplicated or modified data can be sent to other users by email or other methods in no time. This means that a user can easily become a user-provider or second provider of multimedia data. It is important for end users to have access to information that can be used to verify the authenticity about the data they receive.

The recent Indian Ocean Tsunami disaster in South Asia caught worldwide attention. Many multimedia objects related to the disaster, such as images, graphics and videos are available on the Internet. A dramatic photo about people emerging from huge waves was published on the front page of the Calgary Herald as part of a recent report of the Tsunami disaster. However, it was later found out that the picture was not about the Tsunami at all. Instead, it was taken during a tidal surge in China a few years back (See http://thunderbay.indymedia.org/news/2005/01/17492.php). Since no metadata was provided for the picture, the picture was mistakenly used by the Calgary Herald for reporting the tsunami disaster.

This story suggests that it is very important for users or second-providers to check the authenticity information about multimedia objects. A characteristic of cybercartographic projects is to use map products and multimedia to convey social science and earth science information to users. If erroneous information is provided, decision-makers may make wrong decisions; scientists may come to wrong conclusions for their research; students may acquire mistaken knowledge. It is of great importance to provide information to ensure the reliability of multimedia data in a cybercartographic project like CANE. Therefore, metadata in the profile should provide authenticity information about multimedia objects.

With countless web sites on the Internet, people sometimes question the reliability of web based documents. Authenticity of documents on the Internet is usually judged based on the credibility of the website or URL. Similarly, the authenticity of multimedia objects is usually judged based on the credibility of data providers. However, the tsunami example above indicates that it is not enough to provide only the providers' information to verify the reliability of a multimedia object. Two business rules need to be established in order to provide reliable multimedia objects in the CANE project: first of all, for multimedia objects that are adopted for the CANE project, all user-providers (second-providers, third-providers etc.) should be required to provide authenticity source data information and verify the reliability of source data. In this case, lineage metadata can be used to capture the data authenticity information. Secondly, for all multimedia objects created in the CANE project, the responsible parties (organizations or persons being involved in creating the multimedia object) should provide their own information and the source data information in order to ensure authentic information.

2) Legal Liability

Legal liability is always a cause for concern in publishing data on the Internet. There are two issues related to legal liability: one is about copyright of data, and the other is about being held liable for any potential damage that may result from the use of data, especially scientific data. As the CANE project will publish multimedia data on the Internet in a geospatial context, the project will also face these two issues.

The management of copyright for digital data on the Internet could be a big topic. This is usually called digital rights management, which holds the key to lock or unlock the access to an individual item or a collection of data on the Internet. The development such a digital rights management goes beyond the scope of this project. However, copyright relevant to the appropriate use and access of individual multimedia objects in the CANE project should be documented. In addition to the copyright of multimedia objects in the project, the other issue needs to concern is how to deal with source data's copyright. Some source data providers have clear copyright statement about the use of their data, while others are not. A content author from the project may be required to get permission of using specific source data from source data's author or provider. Both copyright information of multimedia objects and source data should be recorded in the form of metadata in the project.

Many organizations are deterred from releasing their data on the Internet because of the fear of litigation. This issue has been well recognized in the geography community; Metadata for describing data liability can be found in geospatial metadata standards. As multimedia data are being applied in a geospatial context, it is necessary for the CANE project to provide metadata to give a clear statement relevant to the use limitation about data provided by the project.

(2) Other Fitness Information

In addition to the above data quality information on multimedia data, there is other general data fitness information which may concern users when they look for data. These include:

- The content information of the multimedia data: to help users determine the fitness of the content represented by the multimedia object, such as what content it represents; what topics it is covering.
- Technical metadata: to help users judge if the multimedia object will satisfy to their specific application requirement
- Geographic information: this includes information such as whether the multimedia data are in the right geographic area of their interest, what feature entities are included in or associated with the multimedia data content, and where they are located.

Technical fitness metadata and location information metadata are discussed in other section, see technical fitness metadata in 5.1 and location metadata in 5.3.

5.3 DATA ACCESSIBILITY AND RETRIEVABILITY

There are two aspects of metadata required to ensure multimedia data accessibility and retrievability. The first is to provide metadata information to help users know the existence of the multimedia data and access the data. The second is to provide information about the fitness of data. The second aspect was discussed in section 5.2. For the first aspect, the focus is to provide more accurate metadata access criteria to enable data access.

In order to allow users to find multimedia objects in a usable and effective manner, specific choices of metadata for searching must be made. In the CANE project, multimedia objects are intended to be accessed from a metadata catalogue interface or map interfaces. Some search scenarios are as follow:

(1) Text-based Search

Users can search multimedia data based on text information they input. Text information may range from themes, place names, or time descriptions. For example, a search criterion can be based on title, general keywords and description information.

(2) Search from Keyword Dictionaries

Specifying the use of a particular vocabulary in the form of keywords will provide more coherent search to improve access to resources. This is also of critical importance to data reuse and access. The particular vocabulary of keywords could be a theme keyword dictionary or a series of controlled vocabularies based on a specific attribute. There are many existing defined theme keyword dictionaries from different domains. A potential theme keyword dictionary for the proposed Antarctic Atlas is "Antarctic Science Keywords" a well-defined hierarchical keyword dictionary with three levels (topic, term and variable) developed by NASA's Global Change Master Directory (GCMD) (See http://gcmd.nasa.gov/Resources/valids/gcmd_parameters.html). It has been widely used in the earth science domain, and adopted by many practical applications including the GDP portal (Geoconnections Discovery Portal). An alternative keyword dictionary with great potential for the Antarctic Atlas is ISO 19115's topic dictionary, which is developed by ISO and is intended to be applied to geospatial data and servers (See appendix 6). Despite extensive research, no existing classified keywords have been found to be a good candidate for the Trade Atlas. A specific classification may have to be developed for the Trade Atlas in the future.

The CANE project will involve various types of multimedia data. Some users may be interested in images only, while others may be more interested in videos or audio. A controlled vocabulary used to catalogue the representation types of the multimedia data will be helpful for users to narrow down to a particular data type when they search for a multimedia object. These vocabularies could be organized into a category based on the application requirements. For example, Hunter (1999) organized multimedia data into a hierarchical category based on the work done by Working Group on Resource Type and libraries (http://www.loc.gov/marc/dc/typequalif.html) and moving image archivists (http://www.loc.gov/rr/mopic/migform.html) (See table 5.2):

1. text
2. image
   - □ Moving
   - □ Advertising
   - □ Amateur
   - □ Animation
   - □ Film
     - ◦ Feature
     - ◦ Musical
     - ◦ Animation
     - ◦ Documentary
     - ◦ Silent
     - ◦ Short
     - ◦ Staged
     - ◦ Performance
     - ◦ etc.
   - □ Lecture
   - □ Performance
   - □ TV
     - ◦ Drama
     - ◦ Serial
     - ◦ Documentary
     - ◦ News
     - ◦ Current Affairs
     - ◦ Performance
     - ◦ Comedy
     - ◦ Children's
     - ◦ Review
     - ◦ Interview
     - ◦ Series
     - ◦ Special
   - □ Photograph
   - □ Slide
   - □ Graphic
   - □ Map
   - □ Painting
   - □ Musical Notation
3. Sound
   - □ Music
   - □ Speech
     - ◦ Lecture
     - ◦ Interview
     - ◦ Performance
     - ◦ Radio
       - Drama
       - Serial
       - Documentary
       - News
       - Current Affairs
       - Performance
       - Comedy
       - Children's
       - Review
       - Interview
       - Series
       - Special
   - □ SoundTrack
     - ◦ TV
     - ◦ Film
   - □ SoundEffects
     - ◦ Synthesized
     - ◦ Mechanical
     - ◦ Natural
4. Dataset
5. Software
6. Interactive
7. Event
8. Physical object

Table 5.2 A Hierarchical Classification of Multimedia Data, Hunter (1999)

As for the CANE project, a category of vocabularies about the type of multimedia data is also needed. Hunter's category could be used as a reference for the definition of the CANE project's category in the future.

(3) Search by Providers

Data provider and especially organization information can provide users with authentic information about the multimedia data. A user may prefer a multimedia object provided by a specific organization that they regard as more reliable. Giving users a search criterion of data provider can help users to efficiently find multimedia objects provided by particular providers, which they feel have higher credibility.

(4) Spatio-temporally Enabled Search

Spatio-temporal information is a distinguishing attribute for multimedia objects in the CANE project. This enables the connection among map products and multimedia objects.

- **Spatial Search**

Maps are used as the interface for users to access multimedia data in the CANE project. Some examples of this potential application include:

- Search by a bounding rectangle in which the content or an entity associated with a multimedia object is located;
- Search for images that were captured at a particular location;
- Point to a location and all multimedia objects relevant to the location can be shown;
- Give a buffer to a feature on the map and all the multimedia objects with features or capture location located in the buffer area will be presented.

There are many potential applications that use the geospatial information of multimedia objects. The first and most important thing to fulfil these applications is to provide geospatial metadata which characterizes spatial information of multimedia objects.

- **Temporal Search**

Temporal information is an important information type tightly integrated with geospatial information. It can be a very useful criterion for accessing geo-referenced multimedia information. Some of the scenarios for temporal search include:

- Search based on a specific time
- Search based on a time period

(5) Content Based Searching

All of the searching scenarios above treat multimedia objects as an identical object. For example, search a video, image or audio object based on some textual, spatial or temporal criteria. However, there are other searching functions that can apply to multimedia data. For example:

- Multimedia data especially video and audio can be accessed at a fine level, such as clips, key frames or segments;
- Video and images can be searched by attributes (shapes and colors etc.);
- A video clip can be portrayed as a storyboard of thumbnails while the sequences of thumbnail images represent the scenes and it can be used to quickly locate a specific scene within the clip.

These are search functions that belong to content-based applications, which use fine level or attribute level metadata for searching multimedia objects. Much research has been conducted to enable access to multimedia data through content-based metadata. For example, Lew's study (2000) shows that similar images can be found based on a chosen picture (or sketch). He also points out this could be the next generation of web search for visual content (See Appendix 5 for his example paradigms).

However, most content-based applications use complex methods that are beyond the CANE project at this stage. Given that cybercartography is highly interactive and aims to engage users in new ways, content-based search could be a potential searching function for future generations of the cybercartographic project.

5.4 SPECIFIC MEDIATYPE METADATA INFORMATION

The application of multimedia data is one of the distinguishing characteristics of cybercartography. The exploration of the application of multimedia data with combined use of map products is very important. Some applications may be media specific. Some potential media specific applications could be:

- Viewing video clips based on referenced locations
- Using thumbnail pictures to portray a video or image file
- Giving description about the events or persons in an images

All these applications are only applicable to particular multimedia data types. They need specific metadata for recording specific information for specific applications. Currently, these applications cannot yet be found in the Antarctic atlas prototype although these kinds of applications have been found in other research or applications. It is possible for the CANE project, or other project using the concept of cybercartography to adopt these kinds of application in the future. Therefore, the multimedia profile should be defined flexibly enough to allow the possibility of adding these specific metadata when needed in the future.

5.5 SUMMARY

This chapter reviewed and analyzed the needs and requirements of developing the profile based on four general purposes. First of all, metadata related to administrative information, relationship information and preservation information need to be included for long term management of multimedia data. Secondly, in order to ensure the reusability of multimedia data, data quality information such as authenticity and legal liability and other data fitness information need to be included. Thirdly, search information in text, time and geographic forms is needed to ensure the access and retrieval of multimedia data. Finally, the profile needs to be extendable to include media type specific metadata for multimedia applications, which may be needed in the future.

The needs and requirements analysis in this chapter provides the foundation for developing the metadata profile. However, one challenge faced in defining a profile for the CANE project is to determine the levels of granularity of defining metadata elements. Since the levels of granularity of defining metadata elements are determined by particular needs, it is important to find out what are the critical particular needs for defining the profile of the CANE project. But it is impossible for the CANE project to predict and list all the potential needs and requirements. In addition, the application of multimedia data in GIS (or Internet GIS) or cybercartographic projects is in its infancy. Researchers in the CANE project are now exploring the ways, particularly, the applications, to use multimedia objects with map products on the Internet in a geospatial context. It is difficult to define or collect detailed particular needs or requirements in this research; therefore it is extremely important to design the profile in such a way that new metadata elements can be added to the profile easily.

CHAPTER 6

DEVELOPING THE METADATA PROFILE

This chapter aims to develop the metadata profile based on the metadata standards reviewed in Chapter 4 and the needs analysis in Chapter 5. The limitations of using the ISO19115 geospatial metadata standard to describe multimedia objects in a geospatial context will also be discussed.

6.1 CONCEPTUAL METADATA STRUCTURE

The metadata profile should be designed to be both flexible and extensible. Metadata needed for describing multimedia data in the CANE project are classified, in conformity with their nature and purposes, into two different levels: collective metadata and MediaType metadata. Collective metadata include common metadata for all multimedia data types, mainly providing information about a multimedia object to ensure that the multimedia data are manageable, reusable, searchable, accessible and shareable as an identical object. The second level is called MediaType metadata, which includes unique information for individual media types. These two levels of metadata have a hierarchical relationship as shown on Figure 6.1. Collective metadata is the base class from which MediaType metadata can be derived. This hierarchy offers the flexibility to describe new multimedia types and add MediaType metadata in the future when new application of a specific multimedia type is defined.

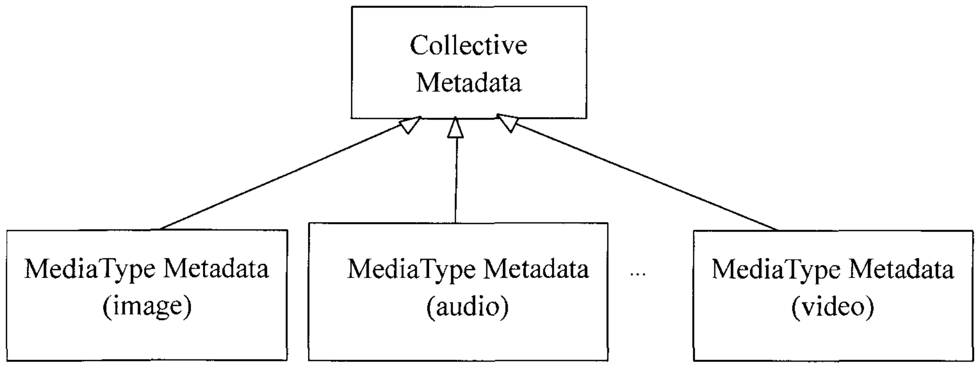


Figure 6.1: Levels of Metadata

Gilliland-Swetland (2000) pictured metadata as "the sum total of what one can say about any information object at any level of aggregation". An information object here means either a generic multimedia object or a combined multimedia object as defined in chapter 5. In order to get a clear sense of what kind of metadata are needed, it is important to define what questions need to be answered for multimedia data in each of the two level categories.

6.2 COLLECTIVE METADATA

Collective metadata are applicable to all multimedia objects in spite of their difference in types. Figure 6.2 shows collective metadata include three categories of metadata information as defined in chapter 5:

1) Data management information;
2) Data accessibility & retrievability information; and
3) Data reuse information.

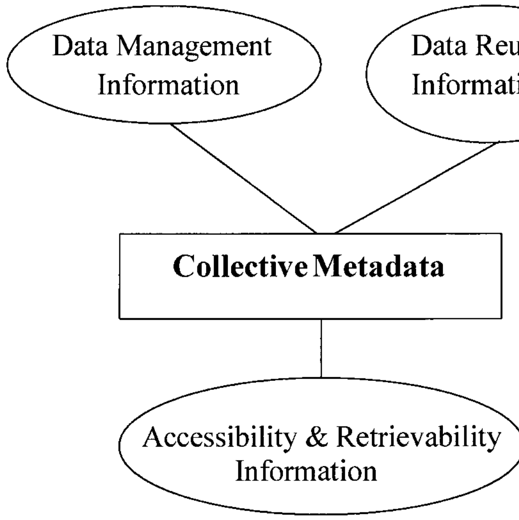


Figure 6.2: Collective Metadata Information

6.2.1 Data Management Information

Metadata in this category are used to manage and administer multimedia data and provide information on administration, relationship and preservation. A detailed description of this type of metadata information is as follows:

(1) ***Identification information:*** A Uniform Resource Identifier (URI) or standardized name for identifying multimedia objects;

(2) ***Title:*** A name given to a multimedia object, possibly including a version number;

(3) ***Description:*** A general summary about the content of a multimedia object;

(4) ***Date:*** Important dates for the multimedia object including creation date, download date, modification date etc.

(5) ***Purpose:*** Summarize the purpose for which the multimedia object was developed. For example, why was this multimedia object created or downloaded, or for what potential audiences?

(6) ***Meta metadata:*** Information about the metadata record, such as creating date, language, responsible person or organization for creating and maintaining metadata;

(7) ***Lineage information:*** They are information about source data and the actions used to

build the particular multimedia object. On one hand, this information about the source data will help users further verify the authorities of the source data and understand the copyright information on the source data. On the other hand, metadata for the source data will also provide potential information for recreating the multimedia object if needed in the future. Therefore, lineage information intends to answer the following questions:

- *Where did the source data come from?*
- *Who is responsible for the source data?*
- *What is the copyright information?*
- *Given that a combined multimedia object, such as an atlas content module, has many different source data, an important question for a combined multimedia object is: Which specific part of the multimedia object is the source data utilised in?*
- *Who contributed to (acted on) it?*
- *When and how the actions were done?*
- *What kinds of tools were used?*

(8) ***Relationship information:*** The purpose of this information is to record all the other multimedia objects which have relationships with this multimedia object. The metadata include information such as:

- *What is the other source's identifier or online location?*
- *What is the relationship of this multimedia object to other objects?*
- *What is the media type of the other source?*

6.2.2 Data Accessibility & Retrievability Information

Information for accessing and retrieving multimedia data needs to be provided in the profile as well. This information includes:

(1) ***Keywords:*** Usually these are descriptive information about the content of a multimedia object, expressed as text keywords or phrases that can be used for searching.

(2) ***Keywords dictionary:*** These are some particular vocabulary of keywords which could be theme keywords or a series of controlled vocabularies for the classification of multimedia data.

(3) ***Representation format:*** The representation form of a multimedia object, such as image, audio, video, text, etc. Ideally, this information should be categorized in a similar way as table 5.2 in Chapter 5.

(4) ***Spatio-temporal information:*** Spatial and temporal information is the key for supporting spatial and temporal searching, or integrating multimedia objects with map products. They are distinguishing characteristics of the multimedia objects in the CANE project.

- ***Spatial information:*** There are two different levels of spatial information: one is the coverage level spatial information that provides general coverage information for the multimedia data, represented as a bounding box or polygon, or described in text such as a place name. The other is the specific entity level spatial information that can be used to describe the location of individual entities associated to a multimedia object. The coverage level spatial information is applicable to most multimedia objects in the CANE project, while the entity level spatial information is only applicable to selected multimedia objects. A spatial query could be a search of multimedia data either at a coverage level or at an entity level. Therefore the metadata profile needs to capture both the coverage level and entity level of spatial information.

1) ***Spatial coverage information***

- ***Place name (Place name keywords):*** A text description of a place name, such as dry valleys, the King George Island in Antarctic etc.

– ***A bounding box:*** A bounding box uses geographic coordinates (longitude and latitude). It will help searching and locating multimedia objects within the box or allow overlay with a user specified bounding box.

– ***A polygon location:*** This could provide more accurate location coverage of the content of a multimedia object by providing projection coordinates of a series of points.

2) Spatial entity information

There are three types of feature information, or entities. An entity can be a physical feature that can be viewed in the content of a multimedia object. A flight route of a video clip, a mountain or a large lake in an image is a good example of a physical entity. An entity can also be an abstract feature which is invisible in the content of a multimedia object but is relevant to a tangible feature on earth. The relevance has to be defined by associating a feature with a multimedia object. For example, animation is associated with a feature (location) on earth to demonstrate phenomena while this feature (location) does not appear in the animation content. An entity can also be an exposure location where a multimedia object is captured. The first two types of entity information (physical and abstract features) can be captured or associated to a multimedia object at any time while the third type of entity (exposure location) is usually captured by devices or tools when the multimedia object is created.

An exposure location is where a multimedia object, especially an image, aerial photo, or satellite image is captured. An exposure location can be very close to the content location. For example, when a close-up picture of a plant on ground was taken, the exposure location is the location from which the picture was taken, while the content location is the location where the plant is. In this case, the exposure feature is very close to the location of the features in the multimedia object content. An exposure location can also be far away from the scene where an image is captured. Examples include aerial photos, satellite images, and other images that are captured from a remote distance, in which case the exposure location cannot be included in the same coverage (bounded box or polygon) as those features in multimedia object content. But they provide important information, which could used to deduce a future location in the content of a multimedia object.

Many camera devices have included GPS location information in their image metadata header files. The EXIF metadata standard which includes GPS properties is widely used by digital cameras (Adobe, 2004) to capture exposure location information. JPEG 2000 is an upcoming potential image coding standard with geographic location information. It is developed by the International Standardization Organization (ISO) with the intention of replacing the traditional JPEG format for many applications, providing better compression and a more flexible imaging model. Work on adopting GML in JPEG-2000 is currently under development (Galdos, 2004). The use of GML specific JPEG-2000 could have the prospect of using a uniform spatial metadata for describing exposure locations. However, as RLG (2004) pointed out, "the prospect may apply only to manufacturers' willingness to adopt JPEG2000 as optional file formats for the device". The form of metadata for exposure location in image files still depends on capture devices. According to the definition in GML, a feature collection includes features located in the same boundary. But the three different types of location feature cannot always be collected in the same boundary. The metadata profile should allow the existence of three different feature collections.

Through a discussion with researchers working on the Antarctic atlas, it is found that there is rarely any complex feature geometry, which consists of a mix of simple geometry types in the Antarctic continent. This metadata profile defines three simple feature geometry types including point, line string and polygon for individual entities.

Following are metadata elements for an entity:

- ***Name:*** The name of the feature (entity), such as, giving a name to a flight route or a mountain
- ***Description:*** The text description about the process of gain this feature
- ***Feature geometry (including projection):*** A feature's location geometry can be described in simple geometry, a point, line and polygon together with projection information.

- ***Temporal information***

The temporal information about the content of a multimedia object can be described in many different ways. It can be presented as time keywords with general descriptions, a specific time instance, or a period of time.

- ***Time description (Time keywords):*** A text description of a time or time period. For example, geologic times, or text time keywords etc.
- ***A time instance:*** A description of time using date and time formats as specified in standards such as ISO8601 (http://www.w3.org/TR/NOTE-datetime). For example:

  YYYY-MM-DD (e.g. 2005-04-15) for dates;

  HH:MM (e.g. 10:48M) for time;

  TZD (e.g. 0, +01:000, -01:00) for time zone designator;

  2005-04-15T08:15:30-05:00, a combined example standing for April 15, 2005, 8:15:30 am, US eastern standard time
- ***A time period:*** A period of time from the beginning time instance to the end time instance using formats as specified in the ISO8601 standard.

6.2.3 Data Reuse Information

This information helps users to evaluate and identify the fitness of data reuse. Some fitness information such as the content description information is included in data management information. Spatio-temporal relevant information is included in spatio temporal information. Here data reuse information refers to data quality information including "restrictions on use" and the data contributor's information (both individuals and organizations) which provides authority information, data presentation requirement information and data file size.

(1) ***Restrictions on use:*** Including legal limitation (copyrights or other rights information) and use limitation (a statement about not being held liable for any damage)

(2) ***Responsible parties:*** Information about individuals or organizations who contribute to the multimedia object, including their roles such as originator, provider

(3) ***Presentation requirement information:*** MIME (Multipurpose Internet Mail Extensions type) type of the multimedia object and other technical metadata concerned by users. More detailed technical metadata will be included in the technical metadata in section 6.3.

(4) ***File size:*** providing information about how big the multimedia object is

6.2.4 Mapping Collective Metadata Information to Metadata Standards

Once the information needed for documenting the multimedia data is clear, it is critically important to map the collective metadata information to metadata standards. The ISO 19115 metadata standard is a well defined standard for geospatial datasets or servers, aiming to satisfy all the potential applications for geospatial data sets or servers. It will be the dominant metadata standard in the geospatial domain. It is expected that many software tools developed in the geospatial domain application will be accessible to the ISO 19115 metadata standard. The CANE project will use the ISO 19115 metadata standard for geospatial data. The collective level metadata information is mapped to the ISO 19115 geospatial metadata standard in table 6.1. The result shows that the ISO 19115 geospatial metadata standard can meet the needs of most collective level metadata information.

Table 6.1 has four columns. The first column lists the metadata information for the metadata profile introduced in section 6.2.3. All the metadata information is listed under one of the three categories, including data management information, data accessibility & retrievability information and data reuse information. The second column shows the matched metadata element found in the ISO 19115. The lack of match is indicated as a sequence of "*". The third column shows whether the metadata element is mandatory. The mandatory metadata elements defined for the metadata profile are marked with "(m)" in this column. The last one is a "Note" column. Some metadata elements in the ISO 19115 geospatial metadata standard can be matched but are insufficient in the profile. They need to be extended or refined before being used in the profile. The "note" column has notes for extending or refining information of these metadata elements. Some metadata information does not have matched metadata from the ISO 19115. Adopting metadata from other standards, such as GML, XMP, is indicated in the "note" column too. Metadata information cannot be matched to any of the metadata standards are also noted in this column.

Metadata Information Required by the Metadata Profile	**ISO19115 Metadata Classes and Elements** (Note: 1) *No. Relevant to the ISO 19115' element No.;* 2) *"*" Represents no relevant element found in the ISO 19115)*	**Mandatory**	**Note**
Data management information			
1. Identification information	MD_Metadata.dataSetURI **(11.1)**	(m)	
2. Title	CI_Citation.title **(360)**	(m)	
3. Description	MD_DataIdentification.abstract **(25)**	(m)	
4. Date	MD_DataIdentification.citation CI_Citation.date **(362)**	(m)	Date role code see Appendix10, table 1
5. Purpose	IdentificationInfo.MD_Identification. purpose **(26)**		

6. Meta metadata 6.1 Metadata identifier 6.2 Metadata language 6.3 Metadata created date 6.4 Metadata contact information 6.4.1 Personal name 6.4.2 Email 6.4.3 Organization name 6.4.4 Online	 MD_Metadata.fileIdentifier **(2)** MD_Metadata.language **(3)** MD_Metadata.dateStamp **(9)** MD_Metadata.contact. CI_ResponsibleParty **(8)**	 (m) (m) (m) (m)	
7. Lineage information 7.1 Statements 7.2 What source used? 7.2.1 Source description 7.2.2 Provider contact information 7.2.3.1 Personal name 7.2.3.2 Organization name 7.2.3.3 Online 7.2.3.4 Role 7.2.3.5 Copyright description 7.2.3 SourceProcess	 LI_Lineage. Statement **(83)** LI_Lineage. Source **(92)** LI_Source.description **(93)** LI_Source.sourceCitation**(96)** CI_ResponsibleParty.individualName **(375)** CI_ResponsibleParty.organisationName **(376)** CI_Contact.onlineResource**(390)** CI_ResponsibleParty .role **(379)** ************************* LI_Lineage.processStep. description **(87)**		Need to define a new element
8. Has relation to (other objects) 8.1 What is the other source's identifier or online location? 8.1.1 Data identification information (or) 8.1.2 Online information 8.2 What is the relationship of this multimedia object to other objects? Relationship role 8.3 What is the type of the other source data? Representation form	 MD_Metadata.dataSetURI **(11.1)** CI_OnlineResource**(390)** ************************* CI_Citation.presentationForm **(368)**		For reference role code, see table 5.1 in Chapter 5 See appendix 10- table 2

Data accessible & retrievable information			
1. Keywords 1.1 Theme keywords 1.2 Place keywords 1.3 Temporal keywords	MD_Metadata.identificationInfo.MD_Identification.descriptiveKeywords **(33)**. MD_Keywords.type = theme (code 006) MD_Keywords.type = place (code 002) MD_Keywords.type = temporal (code 005)	(m)	 Keyword Type Code see Appendix 9
2. Keywords dictionary 2.1 ISO19115 topic keywords 2.2 Antarctic science keywords	 MD_Metadata.MD_DataIdentification.topicCategory **(41)** MD_Metadata.MD_DataIdentification.descriptiveKeywords **(52)**	 (m)	See Appendix 6 MD_TopicCate-goryCode See the web link[1]
3. Representation format	CI_Citation.presentationForm **(368)**	(m)	See appendix 10- table 2
4. Spatial-temporal information 4.1 Spatial 4.1.1 Geographic extent 4.1.2 Feature 4.2 Temporal 4.2.1. Instance time 4.2.2. Time period	 EX_Extent.EXGeographicExtent **(336)** ************************** Ex_Extent. EX_TemporalExtent **(337)** gml: TimeInstance gml: TimeDuration		 Defining a GCRCFeature class using gml (See figure 6.4c) (See figure 6.4d)
Data Reuse Information			
1. Restrictions on use 1.1 Use limitation 1.2 Legal limitation	MD_Metadata.MD_Constraints (**67**) UseLimitation**(68)** MD_LegalConstraints.useConstraints **(71)**	(m)	 See appendix 8 MD_Restrictio-nCode
2. Responsible party information *(Point of contact)* 2.1 Personal name 2.2 Organization name 2.3 Contact information 2.4 Role	CI_ResponsibleParty **(8)** CI_ResponsibleParty.individualName **(375)** CI_ResponsibleParty.organisationName **(376)** CI_Contact(387) CI_ResponsibleParty .role **(379)**		 See appendix 10- table 3 (Extended roles typed in bold)

[1] http://gcmd.nasa.gov/Resources/valids/gcmd_parameters.html

3. Format	MD_DataIdentification.resourceForm-at (32)		MIME Type as content (See section 5.2)
4. Size	**************************		Using the XMP element "Size"

Table 6.1: Mapping Collective Metadata Information to Relevant Classes and Elements from Metadata Standards

6.3 MEDIATYPE METADATA

Metadata at this level are unique for particular multimedia data types. They represent two information categories: metadata for media-dependant applications and technical metadata information (See figure 6.3).

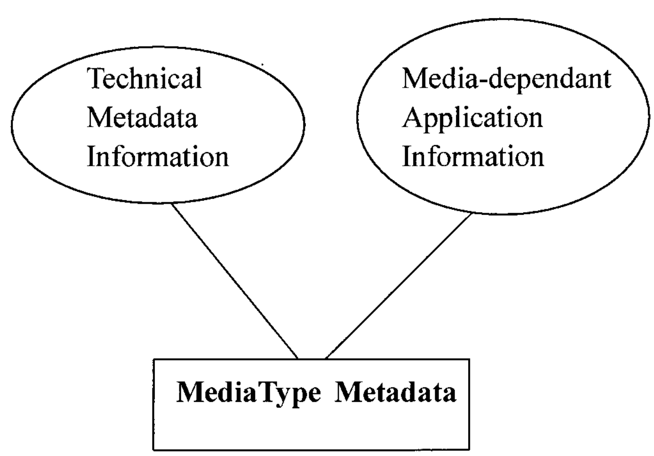


Figure 6.3: MediaType Metadata Information

6.3.1 Metadata for Media-dependant Applications

The current Antarctic atlas prototype has not defined the requirements for media-dependent applications yet. In order to demonstrate the possibility of this requirement, some scenario applications with relevant metadata are illustrated below.

Scenario 1: Suppose there is an audio object including lectures presented by different speakers. In order to facilitate searching or identifying the speakers in this audio object, it is necessary to produce two metadata elements, time (e.g., start and end time of an audio segment including the lecture of a specific speaker) and an additional metadata element in describing the speaker. In this case, two elements from Mpeg-7 can be applied.

(1) ***Mpeg-7 media time***

(2) ***Mpeg-7 text annotation***

Scenario 2: If there is a series of music renditions, some specific features of music files need to be defined. Some simple metadata information could be (Wilkie, 1997):

(1) ***Key signatures***

(2) ***Musical periods***

(3) ***Instrumentation***

Since the requirements for media-dependent applications are uncertain at this stage in the CANE project, it is hard to predefine what media-dependant metadata will be needed in the future. However, one requirement is certain, that is, the metadata profile should be designed to be extensible for adding media-dependent metadata when needed. The final definition of media-dependent application metadata should be determined and created when the applications are defined. Because this profile provide a flexible structure to describe metadata, all those particular metadata for specific application can be extended in the MediaType level metadata when they are known.

6.3.2 Technical Metadata Information

Technical metadata of a multimedia object is needed for the preservation of the object, the presentation of the object, as well as providing fitness information of the object. Technical metadata are usually generated when a digital file is created by a computer system and usually stored in the header file of a multimedia object. However, the availability of technical metadata of a multimedia object depends on whether the capture devices or tools have the capability of capturing technical metadata. If no such metadata information was captured in the digital file format, it is hard to add the technical metadata. Supporting software has been developed to expose, exploit, and transfer the metadata information found within image files, such as Kodak's Picture Metadata Toolkit, Canto's DIG35 Asset Store for the Canto Cumulus, and Adobe's XMP. But the usefulness of these programs has been limited by the generally inadequate amount of metadata that most cameras and scanners currently capture (RLG, 2003). Therefore, it is difficult to record all technical metadata for the purpose of data preservation. One potential solution is to use the popular media storage formats of multimedia data, which are less likely to become obsolete or related migration tools can be easily found in the future.

Technical metadata are usually specific for different media types. They may be represented in different metadata standards depending on the devices or tools which capture technical metadata. However, technical metadata elements defined by metadata standards as NLNZ and XMP can be treated as reference technical metadata elements for the image, audio, video and text in the CANE project. It is found that many technical metadata elements defined in XMP, which describes the characteristics of multimedia objects, overlap with the technical metadata elements defined in NLNZ, which is for preservation purposes. Technical metadata elements related to image, audio, video, text from NLNZ standard are listed separately in Appendix 4 (Table 1-4), where elements in bold can also be found in XMP's schemas.

6.4 OUTLINING THE METADATA PROFILE IN A UML FORM

Metadata information needed to describe multimedia data is discussed and developed through section 6.2 and 6.3 based on the conceptual structure in figure 6.1. This metadata information is also mapped to relevant metadata classes and elements from the ISO 19115, GML and XMP standards in table 6.1. This section will outline these mapped metadata classes or elements and unmapped metadata information into a UML diagram profile (See Figure 6.5 (a), (b), (c) and (d)) by leveraging the conceptual structure and metadata standards.

The UML (Unified Modeling Language) is a modeling language which uses some graphical notations to express designs. This profile uses class diagram notations to express the metadata information. Two notations applied in the profile are explained in figure 6.4.

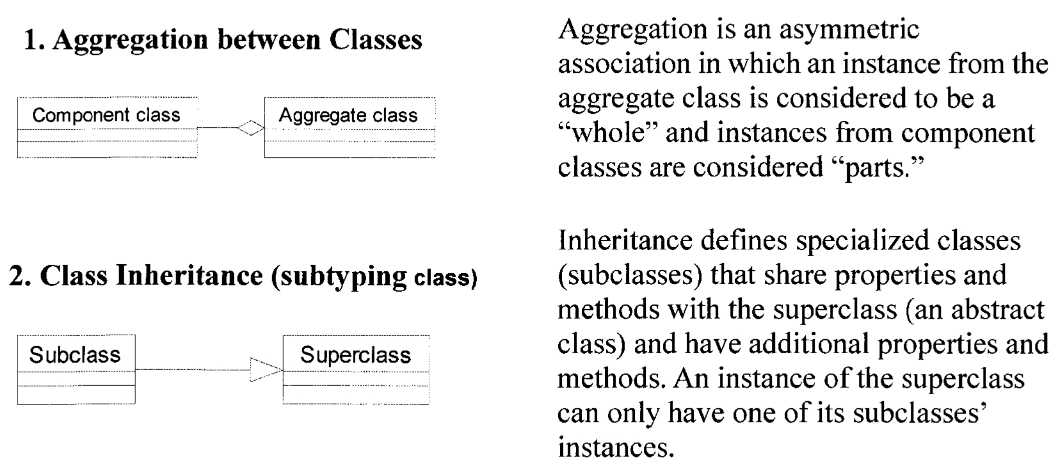


Figure 6.4: UML Notations

In this profile, namespaces are used to indicate the origin of metadata. The corresponding namespaces and standards are as follow:

smXML: ISO19115
gml: GML
xap (or xap...): XMP
mpeg-7: Mpeg-7

No name space in front of a metadata element indicates that this element cannot be found in any of the examined standards. Each element or class adopted from the ISO19115 is attached with an ISO 19115 serial number for the purpose of easily tracing back to the metadata information in table 6.1.

In figure 6.5 (a), the profile has a root class named GCRC_Metadata which includes five component classes. The four component classes “smXML:MD_Metadata”, “smXML:LI_Lineage”, “smXML:Extent” and “GCRCFeature” includes the collective level metadata information while the fifth component class “MediaType” is a superclass which includes MediaType metadata information. Since the specific requirements for MediaType metadata information are unknown, currently the profile demonstrates three subclasses of “MediaType” class separately for video, audio, image types to illustrate the potential needs of MediaType metadata in the metadata profile. Metadata elements in MediaType level have not defined yet.

Figure 6.5 (b) displays the layouts of six adopted ISO19115 classes including “smXML:LI_Source,” “smXML: CI_ResponsibleParty” , “smXML:CI_Contact”, “smXML:CI_Citation”, “smXML:CI_OnlineResource” and “smXML:MD_Keywords_Type”. These classes are usually used as data types in other classes from figure 6.5 (a) or (b). They belong to collective level metadata information.

Figure 6.5 (c) displays the class “GCRCFeature”, which include feature (entity) metadata information of a multimedia object. The “GCRCFeature” is a component class of the root class “GCRC_Metadata” in figure 6.5 (a) and it also has a component class named “ReferencedFeatureCollection”. The symbol “1-* ” shows that a “GCRCFeature” instance can have more than one “ReferencedFeatureCollection” instances. Figure 6.5(c) shows that each “ReferencedFeatureCollection” instance may contain more than one “featureMembers” instance, which can be represented by a point, a polygon or a line.

Figure 6.5 (d) displays metadata information of spatio-temporal coverage in a multimedia object. The class “smXML:Extent” is a component class of the root class “GCRC_Metadata” in figure 6.5 (a) and also has two component classes "smXML:EX_GeographicExtent" and "smXML:EX_TemporalExtent" from the ISO 19115 to separately represent spatial and temporal coverage information . Figure 6.5 (d) shows:

- A "smXML:EX_GeographicExtent" instance can have either a "smXML:EX_BoundingPolygon" or "smXML:Ex_GeographicBoundingBox" instance;
- A "smXML:EX_TemporalExtent" instance may have a "gml:TimeDuration" or a "gml:TimeInstance" instance.

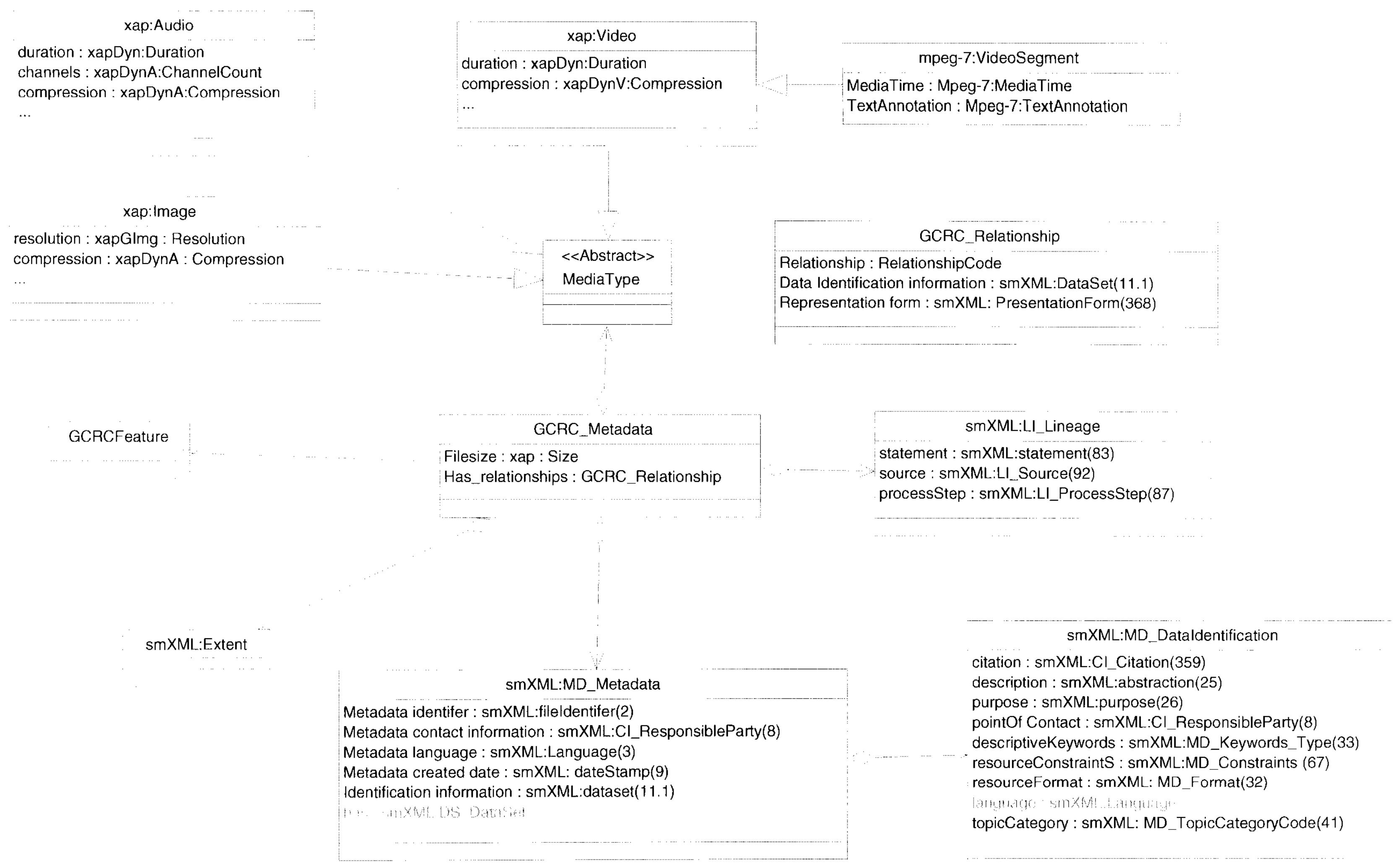


Figure 6.5 (a) The Metadata Profile in a UML Form

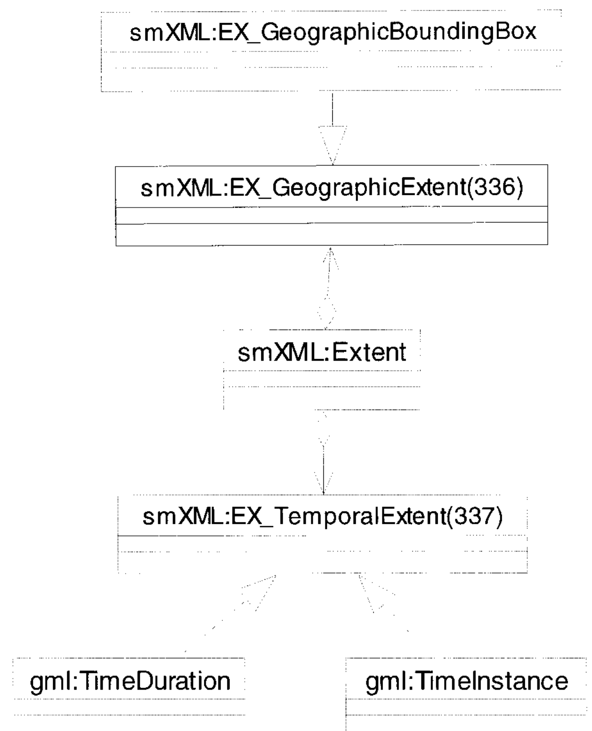


Figure 6.5 (d) The Spatio-temporal Coverage Information Class

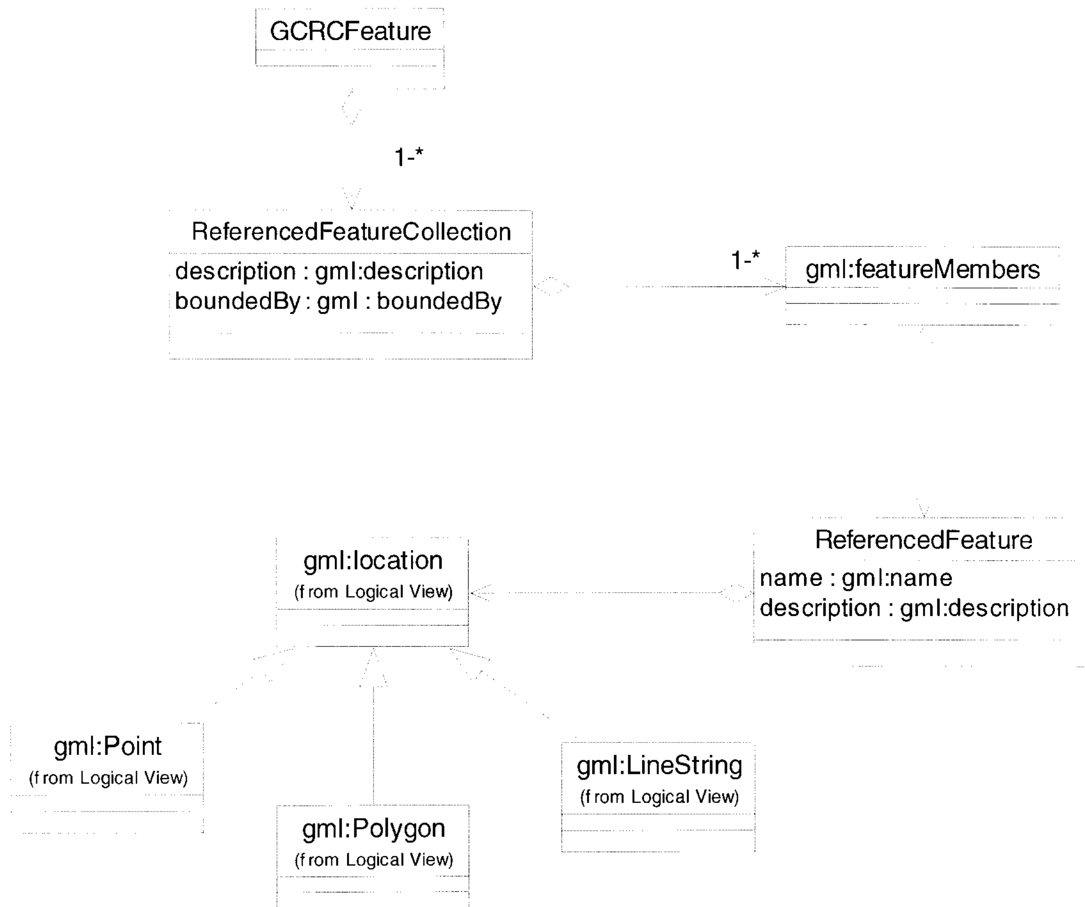


Figure 6.5 (c) The GML Compatible GCRCFeature Class for Describing Features (Entities)

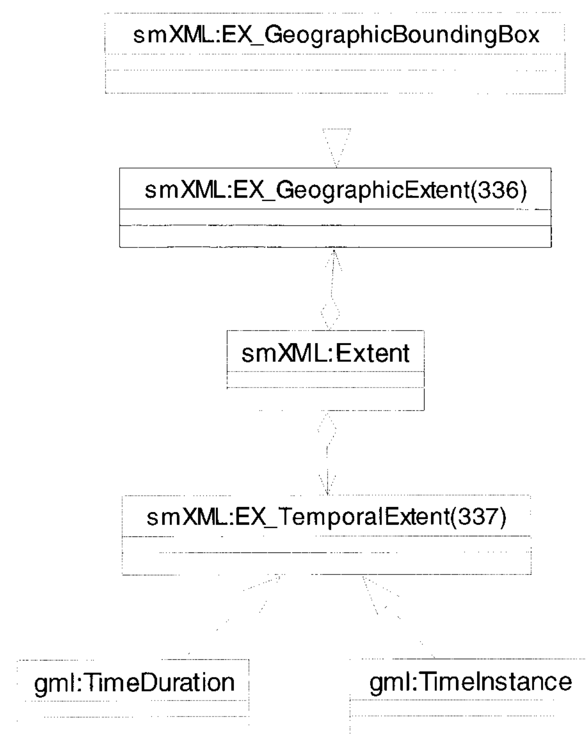


Figure 6.5 (d) The Spatio-temporal Coverage Information Class

6.5 THE LIMITATIONS OF THE ISO 19115 GEOSPATIAL METADATA STANDARD IN DESCRIBING MULTIMEDIA DATA IN A GEOSPATIAL CONTEXT

The ISO 19115 metadata standard was used as the basis for developing the profile, but in the process several limitations of the standard emerged. This is a very detailed and complex standard because it aims to satisfy all the application requirements related to management or distribution of the geospatial data and servers. It includes the discovery level metadata which could be applied not only to geospatial data but also other digital data. This is why collective metadata in this profile comes mostly from ISO19115. The elements and classes (schemas) from this standard have the potential to be used for describing multimedia objects at a collective level but here are some limitations:

(1) Online information about a source data set is not expressed appropriately

The online location information of a source data set should be very important in citing a source data set when it (e.g. an image) is downloaded from an online site. The problem is that a source data set's online location information cannot be found from "LI_Source" or it's "CI_Citation" which are used directly to describe source data information. Though there is a source online location attribute in "CI_Contact, it is supposed to describe the contact information about an individual or an organization, it may not be the actual online location information of the source data set. An expert on the ISO 19115 geospatial metadata standard recommended the use online information "CI_onlineResource" by including all its parent and grand parent classes from "LI_Source", "CI_Citation", "CI_Contact", to "CI_onlineResource", but this is not a flexible solution (See the classes in figure 6(b)).

(2) A "size" element is needed to describe the physical size of a digital file

A multimedia object is usually large in size. It is very important to inform users through metadata how big the file is in order to help users make a decision. Furthermore, the size information of multimedia objects could be used as a search criterion or sorting criterion. The ISO 19115 metadata standard includes an element "EnvironmentDescription" in the "Identification information" class which is for general description of a data set in the producer's processing environment. The content can be included in this element including items such as the software and computer operating system used, file name and the data set size of the data set. But it is not specific enough for describing the size of a multimedia object.

(3) A mandatory "has" element does not meet the needs

The ISO19115 implementation standard defines a mandatory "has" element in class "smXML:MD_Metadata" and a mandatory "language" element in class "smXML:MD_DataIdentification". They are not applicable for describing multimedia objects because a multimedia object may have no relationship with any other data sets or no specific language information (See the grey colour metadata elements in figure 6.1(a) "smXML:MD_Metadata" class).

(4) Some rules defined in the standard are not flexible enough

For example, data providers' information including both persons and organisations is critically important in helping users verify the authenticity of multimedia data. As authenticity information of a multimedia object, providers' information is more important than the information about "title" and "date". However, if the profile provides the source data's provider information according to ISO19115 metadata standard, it has to include the "title" and "date" metadata elements of the source data because they are mandatory elements in "CI_Citation" class. (See the highlighted metadata elements in figure 6.1(b) "CI_Citation" class)

(5) The lack of feature level spatial information

ISO 19115 metadata standard has defined "Extent information" for spatio-temporal coverage information of a data set. It is not sufficient to describe the spatial information of those features (or entities) which are required in multimedia objects.

(6) Some roles of codes need to be extended

Because the ISO19115 metadata standard is defined for geospatial datasets and servers, some code roles such as "CI_DateTypeCode", "CI_PresentatioinFormCode" need to be extended.

- **"CI_DateTypeCode":** ISO19115 provides three types of date role codes: creation, publication, revision. As a multimedia metadata standard, XMP metadata standard has defined more date role codes, such as converted, copied, cropped, edited, filtered, version updated, resized. As for the CANE project, many multimedia objects will be downloaded online, so a date code role such as "downloaded" is also very important to indicate when the source was downloaded (See Appendix 10, table 1).
- **"CI_PresentationFormCode":** This role code defined in ISO 19115 is specific for geospatial data presentation form although it includes some multimedia presentation forms such as imageDigital, videoDigital. But this is not sufficient. Extending is needed to include and classify all those multimedia types defined in chapter 3: Text, hypertext, hypermedia, still image, video, audio, animations, graphics, atlas content model and virtual reality etc.

(7) The deficiency of the ISO topic keywords

There are many arguments related to the use of ISO topic keywords in different domains in the geography community. It's not surprising to find the ISO topic keywords are insufficient for multimedia data considering a multimedia object usually represents information from different domains. For example, there is no ISO topic keyword that can be used to describe an atlas content module in the Antarctic atlas called "the exploration of the Antarctic". Further research is needed to evaluate or extend ISO topic keywords to satisfy the needs of the CANE project.

6.6 SUMMARY

This chapter has developed a metadata profile for geo-referenced multimedia objects of the Antarctic atlas in the CANE project based on the need and requirement analysis conducted in this research. This profile organizes metadata into two levels: collective level and MediaType level. This research finds that the 19115 geospatial metadata standard and GML can be used jointly to describe most of the collective level metadata information with some refining and extending efforts. Multimedia applications, such as using a segment of video, have not yet been defined in the project. Further work is needed to define and finalize MediaType level metadata for the metadata profile when media specific application requirements are defined in the future. Mpeg-7 and XMP metadata standards have demonstrated the potential to be used for MediaType level metadata information.

A common way of using external metadata is to use a database structure or other formats such as XML files to identify and associate metadata and relevant multimedia objects. This is very useful in a distributed system where multimedia objects are located in potentially multiple servers while their associated metadata can be stored locally or within a remote catalogue system. But the problem is how to ensure the dynamic attachment of a multimedia object with its metadata in a workflow.

The collective level metadata in this metadata profile is being used to capture metadata information and embedded to each multimedia object along with technical metadata which is already stored in the header file of an individual multimedia object. All of these metadata will be migrated into a metadata catalogue (or repository) in the future for the development of a geospatial web portal system. As for the new type multimedia data such as smell and tactile data, no data type has yet been defined. No metadata information can be defined until the data format and applications are defined. Once the metadata profile is outlined, the next step is to explore an initiative way of making multimedia data more accessible in a geospatial portal.

CHAPTER 7

INFORMATION VISUALIZATION

For many GIS applications, the most time-consuming work is to search and integrate geospatial data. One contributing factor to this is that metadata search results from a catalogue or other search engines are usually presented as a list of text information. Users need to click on metadata records one by one and read the text format metadata of each data item to find out the fitness of the data. This is a process that requires much human cognitive effort. Its lack of efficiency is especially obvious when the search results are several pages long, which is not an unusual circumstance. This will also happen to those users if they need to look for geo-referenced multimedia data through a geospatial portal. A study of efficient data access through a geospatial portal is necessary for geo-referenced multimedia data.

An important challenge faced by data providers is how to improve data accessibility once data are available online. If an efficient means of accessibility is provided, it will be easier for users to find data, which will allow them to spend more time on other aspects of data analysis, such as data integration. An important aspect of improving accessibility is to define an efficient metadata profile. A basic text, temporal and spatial search is very useful in accessing data. But a long list of query results could be very confusing to users. It is sometimes difficult if not impossible for users to read all query results one by one because each query result could be one or more pages of metadata information in text form. The daunting task of going through a long list of query results may actually turn users away. Therefore it is of great importance to display metadata query results in an efficient way so that users can easily understand and navigate to the data they need among the large amount of data being retrieved according to the query criteria.

In order to do this, comprehensible interfaces can be developed to specify what users want to know, and provide effective displays of search results. The most effective presentation is probably not a long rigid list of text format items, but some other type of graphical display.

Visual interfaces could be the solution. A visual interface "exploits powerful human vision and spatial cognition to help human beings mentally organize and electronically access and manage large, complex information spaces, and aims to shift users' mental load from slow reading to faster perceptual processes such as a visual pattern recognition" (Borner et al, 2002: 2). Information visualization is a technique that can be used to develop visual interfaces. Visual interface drawing on information visualization techniques has considerable potential to improve information access, retrieval, processing and management. This chapter aims to explore the possibility of using information visualization to facilitate the interoperation and access to metadata search results in geospatial portals.

7.1 INFORMATION VISUALIZATIOIN

Information visualization is an emerging interdisciplinary research field which involves researchers from many different domains such as computer science, library science, information science, geography, and various engineering fields. The main objective of information visualization is to enable information discovery, provide insights and explanations, and facilitate decision making.

According to Card et al. (1999), information visualization is defined as "the use of computer-supported, interactive, visual representations of abstract data to amplify cognition" (Card et al, 1999: 7). The purpose of visualization is to perceive information, provide insights, or rapid information assimilation or monitoring large amount of data rather than pictures (Card et al., 1999). There is a difference between information visualization and scientific visualization. Scientific visualization is to visually represent a **real physical thing**, while information visualization is applied to visualize **abstract data** and is concerned with abstract concepts such as text format data etc. (Card et al, 1999).

As a new discipline, information visualization has several different definitions other than suggested by Card et al (1999). For example, Schaffer et al (1996) defined information visualization in such a way that as much information as possible should be assimilated by the human perceptual system instead of relying on the human cognitive system. They suggest a method of presenting information by presenting a complete overview of all information available while further presenting detailed information about a focused specific topic. According to Robertson (1991), information visualization uses computer graphics and interactive animation to stimulate recognition of patterns and structure by shifting some of the user's of cognitive load to the human perceptual system in ways similar to scientific visualization, which allows scientists to perceive patterns in large data collections. A group of researchers at University of Illinois at Urbana Champain (UIUC, 1998) defined information visualization as "a method of presenting data or information in non-traditional, interactive graphical forms. By using 2-D or 3-D color graphics and animation, these visualizations can show the structure of information, allow users to navigate through it, and modify it with graphical interactions". (UIUC, 1998:1)

Despite the variety of definitions, one common characteristics of information visualization is to convert abstract information into a visual format to help users' perceptual process of acquiring knowledge. Information visualization is growing as a multidisciplinary field of study and has begun to reach a mature stage (Chen, 2002). It involves researchers from many different countries. With more and more information visualization systems and tools becoming available, a large amount of visualization and interaction techniques is being used in diverse application domains. The latest IEEE Information Visualization Symposium (October 10-12, 2004, Austin, Texas) started a series of discussions on infrastructure for information visualization, with the purpose of sharing views, understanding the issues involved and finding ways to avoid fragmentation and improve collaborations (See: http://vw.indiana.edu/ivsi2004/).

Well-designed visual interfaces could improve users' perceptual process in navigating and finding source data. Card et al (1999) summarized the key benefits of information visualization interfaces when compared with other non-visual interfaces (Card et al, 1999:16):

"*1) To reduce the time of searching for data by grouping or visually relating the data. Users can intuitively identify information related to maximum and minimum, such as the largest, smallest, most recent, most related, etc;*

2) To compact enormous amount of information into a small space by using 2D or 3D graphic representations, for example, providing a new ways to identify clusters or patterns through the graphic representation;

3) To allow hierarchical search by using overviews to locate areas for more detailed search, such as by using function of zooming in or popping up details on demand; and;

4) To index data spatially by location or landmarks to visually navigate users to find a particular item of interest in the context of an enormous amount of data. "

7.2 REVIEW OF INFORMATION VISUALIZATION APPLICATIONS

As a new discipline, information visualization has been researched in many different domains. Below is list of applications that use information visualization technology as a way of delivering searching results:

1. Graphical Interface for Digital Libraries **(GRIDL)** which use 2D display categorical and hierarchical axes by using 2D visual format (See http://www.cs.umd.edu/hcil/west-legal/gridl/);

2. Usernet Social Accounting Search Engine **(MSR Netscan)**, a prototype which shows the hierarchical relationships of Newsgroups in the Usenet (See http://netscan.research.microsoft.com/treemap/);
3. **Kartoo Search Engine**, a visual meta search engine with visual interfaces that present search results in a series of interactive maps (See http://www.kartoo.com) ;
4. **Musicplasma** , a visual music search engine which can display an overview of the queried musician information in a "map" (See http://www.musicplasma.com) ; and
5. **Visual Thesaurus**, an online visual thesaurus which translates language into a visible architecture by using spatial maps to display the interrelationships between words and meanings (See http://www.visualthesaurus.com/online/index.html).

The objective of information visualization is to help users efficiently access data and facilitate knowledge acquisition. Some search engines have taken advantage of information visualization to render the search results in innovative ways. In the above applications, some have been developed for commercial use, such as the Kartoo search engine, Musicplasma search engine and the online Visual Thesaurus. Others are only proof-of concept prototypes using information visualization techniques.

According to Harvey (2002), there have been substantial efforts in the geographical information community to develop and implement metadata content standards to make geospatial data accessible and reusable. However, “visualization techniques for metadata remain a shadow of these standardization efforts.” (Harvey, 2002: 333).

Skupin (2003) also pointed out that the mainstream of information visualization research is happening outside of the GIS community; Skupin & Fabrikant (2003) are working on information visualization technology, which they called "spatialization". They define spatialization as the systematic transformation of high-dimensional (non-geographic) data into lower-dimensional spatial representations to facilitate knowledge discovery from very large database. These low dimensional data are then visualized using spatial metaphors. Fabrikant et al. (2001) have demonstrated how spatial metaphors can be constructed for abstract information spaces in order to facilitate users' access to large complex data archives.

Some researchers such as Comenetz (2004) suggest an approach of visually displaying metadata information on thematic maps. He argues that in order to help non-specialist users to clearly and concisely understand metadata of the source data, using a visual cartography approach rather than text notes etc. is the best way to transmit metadata to thematic map users.

Another research study visualized metadata of NASA's Global Change Master Directory (GCMD), a geospatial web portal for searching earth science data sets and servers. The Human-Computer Interaction Laboratory (HCIL) in Maryland University has collaborated with NASA's GCMD to develop visualization interfaces to improve the ease of access to NASA's GCMD web portal. Their research focused on overview and preview, dynamic query user interfaces, and visualization designs. The main concept used in their work is "query preview" which allows users to perform rapid and dynamic elimination of undesired data. An operational prototype using visual query previews was implemented (See figure 7.1). It provides a visual interface to allow users to rapidly gain information of the content and scope of the whole data collection. The histograms represent data sets distribution over several attributes (metadata information). Users are enabled to search data sets by choosing those attribute values. Once they get a search result, a result bar will shows the cardinality of the result numbers. This visual interface provides an efficient way to help users get overall information about the data sets in a data collection; this can prevent users from submitting queries that would result in zero hits. But this research does not provide information to help users to refine and navigate their search results. And important information, such as the relationships among those records in the search result, which can help users further refine their search results, are not presented.

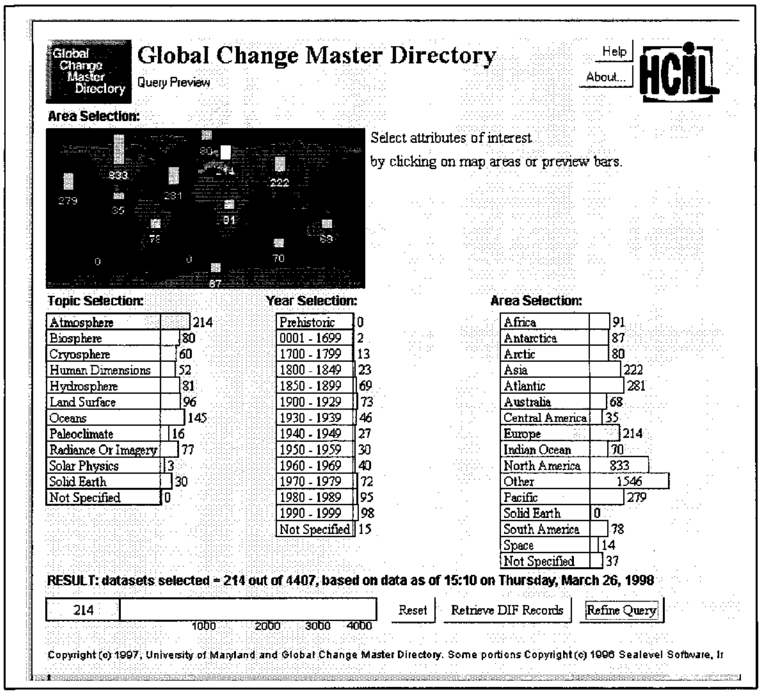


Figure 7.1 A Visual Query Preview Interface

Source: From a Prototype Figure of the Human-Computer Interaction Laboratory (HCIL), Maryland University: http://www.cs.umd.edu/hcil/eosdis/

An ISO19115 compliant metadata application profile which adopts metadata elements from the ISO19115 geospatial metadata standard has a hierarchical structure. Recently Demšar (2004) demonstrated a concept of visualizing the hierarchical structure of a geospatial metadata repository, which uses an ISO19115 metadata standards profile. He uses the combination of automatic and visual data mining exploration techniques to help users exploring geospatial metadata in the metadata repository. The hierarchical structure is visualized as a radial tree (See figure 7.2). The hierarchy is expressed with the edges and the similarity among metadata elements is presented by the color of the vertices and edges. The similarity is defined based on the nature relationships in the hierarchical structure. For example, metadata elements that have the same ancestral vertices at a nearby level are more similar to the metadata elements, whose ancestral branches meet higher up in the tree, while the similarity of the colors of the edges and vertices corresponds to the extent of similarity of metadata elements.

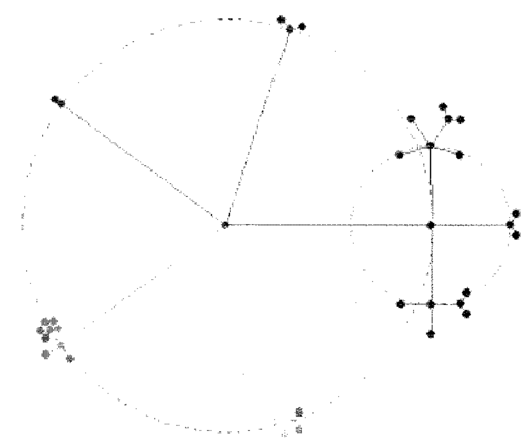


Figure 1: The recursive construction of a snowflake graph

Figure 7.2 A Radial Tree for Visualizing Hierarchical Structure of a Metadata Repository

Source: A Visualization Metadata of a Hierarchical Structure in Geographical; Demšar (2004)

Despite the substantial efforts on information visualization research work, the visualization of metadata, especially queries to facilitate data accessibility in geospatial context, are inadequate, and significant improvements are required.

A geospatial digital library is one kind of geospatial portal which enables users to search data by searching their metadata from its metadata catalogue. Borner et al (2002) have identified three common usage scenarios needed for visual interfaces of digital libraries (Borner et al, 2002: 2):

(1) "To support the identification of the composition of a retrieval result, understand the interrelation of retrieved documents to one another, and refine a search;

(2) To gain an overview of the coverage of a digital library and to facilitate browsing; and

(3) *To visualize user interaction data in relation to available documents in order to evaluate and improve digital library usage."*

These scenarios are consistent with findings from a research done by The Joint Information Systems Committee (JISC) of the United Kingdom who conducted a survey about the needs of information visualization for digital libraries (including spatial digital libraries). The majority of survey participants claimed that visual presentations are useful in assisting their search in digital libraries. Both data providers and end users were interested in exploring how the relationships between results could be displayed in a visual form. According to the survey, it has been widely accepted that information visualization can be helpful in contributing towards issues in a search procedure such as: (JISC, 2004)

(1) How are the results generated correlated with each other?

(2) How could users compare search results at a glance?

There is yet no existing research found which could be applied to guide the visualization work of a geospatial web portal. Borner et al (2002) offered some suggestion on effective design solutions towards information visualization and how visualization could assist digital libraries. Their suggestions can be used as potential guidelines for designing visual interfaces of a geospatial portal (Borner et al, 2002: 6):

"*1) Research on any visual interface to digital libraries should be based on a detailed analysis of users, their information needs, and their tasks;*

2) Provide new means to interact with data, for example, by providing an overview of what is covered by a digital library, enabling users to filter out relevant documents and to examine relationships among those documents;

3) To provide multiple perspectives to one data source;

4) Usability and usefulness studies are needed to improve interfaces and to specify what does and does not work; and

5) Strong collaboration among librarians and programmers will help to improve the design usability of interfaces considerably."

7.3 EXPLORING INFORMATION VISUALIZATION IDEAS FOR THE AMD (ANTARCTIC MASTER DIRECTORY)

The Antarctic Master Directory (AMD) is a large metadata catalogue maintained by the NASA's Global Change Master Directory (GCMD) portal. This catalogue uses the DIF metadata standard to describe their data sets and servers, while an element called "Parameter Keywords" in the DIF metadata standard is used to classify themes of data sets and servers. The metadata content of "Parameter keywords" is chosen from the hierarchical keywords dictionary – GCMD Antarctic science keywords. The multimedia metadata profile in the CANE project is also designed to adopt the GCMD Antarctic science keywords as theme classification keywords (See chapter 6), which is why this thesis includes information visualization ideas for visualizing metadata query results from AMD.

AMD has a text interface for searching data sets and servers through their metadata catalogue. Searching this metadata catalogue can result in a large amount of relevant metadata records. The AMD text search interface lacks the ability to support information exploration, making it very difficult for scientists, researchers and general users to gain a view of the search results, to locate relevant data, or to evaluate the fitness of data. New tools are needed in order to assist scientists, researchers and general users identify the data sets they need. This section will use the AMD text search interface as an example, to explore "information visualization" as a new tool in facilitating data accessibility and develop ideas for visual interfaces. Hopefully, a successful result could lead to an approach which would allow the search of the CANE project web portal in a visual format.

7.3.1 Thematic Spaces in Antarctic Science Keywords

There are many aspects that need to be considered when users look for a geospatial data set. These include the physical extent and temporal information, and the theme classification of the data set. Therefore, metadata information for geospatial data sets can have three general semantic spaces: (1) Geographical space, (2) Temporal space, and (3) Thematic space. Geographical space can be visually represented on maps. For example, maps are usually used as the interface for searching geospatial data sets (or geo-referenced data) through geographical space; usually, a geospatial portal provides text strings for searching geospatial data sets based on temporal or thematic information criteria. Likewise, information visualization interfaces can be used to search geospatial data through temporal or thematic space.

The GCMD science keywords are a series of hierarchical keywords that are highly structured and semantically rich. These characteristics enable the provision of an underlying metric for constructing information semantic spaces which can be visualized by information visualization technique in 2D or 3D representation forms.

7.3.2 Visual Interface Ideas for AMD Query Results

This section will introduce some ideas developed for visualizing metadata query results in the AMD. These ideas aims to find the best way of rendering query results to users in order to help them interpret the text format metadata information of any query results from AMD, and then help them to efficiently find the data they need. These ideas follow a search mantra:

"Overview first, zoom and filter, then details on demand"

This search mantra has been widely accepted in many applications. Card (1999) pointed out that this search mantra provides an excellent framework that can apply to different design environments and it might become a visual information-seeking mantra for designers. This mantra is also consistent with the scenarios proposed by Borner et.al (2002) for information visualization of metadata in digital library and the survey results conducted by JISC (See section 7.3). The proposed information visualization ideas of AMD will apply this mantra as follows:

Instead of displaying a text list, the query result of a query from the AMD will be displayed as a 3D graphic. After reviewing the 3D scene, users will be enabled to explore the relationships among different data sets and preview some key metadata information of each data set through visual interfaces. Ideally, this process will help users efficiently refine and reach the data sets that they need. See the following demonstration of these ideas for details.

Figure 7.3 is the text search interface of AMD. Users are able to input free text, location, and time information to search for data sets in the AMD catalogue.

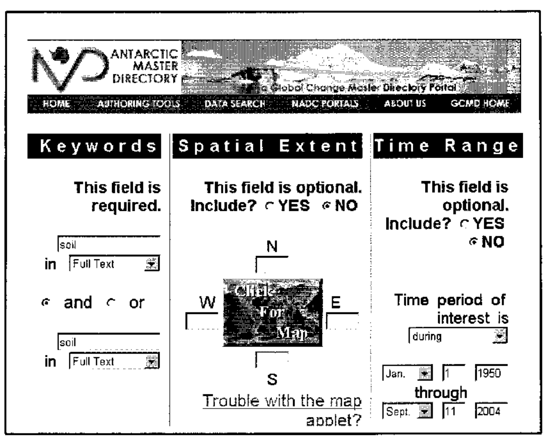


Figure 7.3 A Search from the AMD Text Search Interface
Source: From AMD Free Text Search Interface: http://gcmd.gsfc.nasa.gov/KeywordSearch/PageForward.do?ForwardPage=advancedSearch.jsp&KeywordPath=Parameters&Portal=amd&MetadataType=0

A free text "soil" search return a search results with 87 records listed (See figure 7.4). Each record only has the "title" metadata information about a data set. If users want to know what an individual data set is about, they need to read the detailed metadata information of the data set. Then they have to click on the record of the data set to load a web page which contains detailed metadata information of this data set. In order to interpret all these data sets or servers in this search result, a user needs to click 87 times to read all metadata information. Furthermore, it is impossible for them to gain information such as which data sets have relevance in the search result and enable them to choose to look at the relevant data.

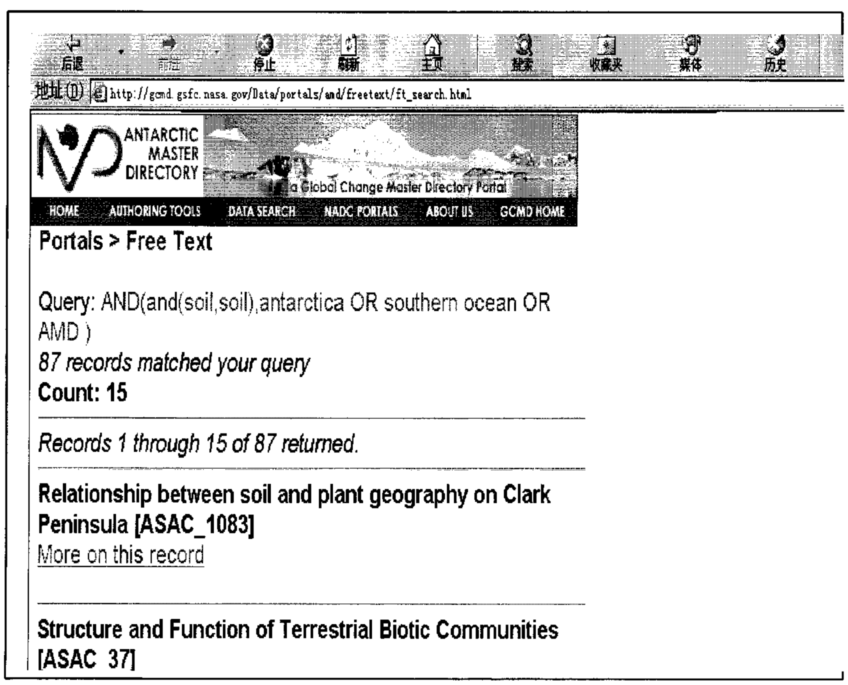


Figure 7.4 A Query Result Listed in a Text Form
Source: From AMD Free Text Search Interface

Instead of providing users a long list of a query result (87 records in the example above), a three dimensional visualization of the query result can give users the overall information about these data sets in the list. For example, which topic these data sets are more related to? Users can make a quick decision on choosing a topic of his/her interests by a glance of the visualization graphic. Figure 7.5 shows the 3D visualization of the query result (not including all 87 records)

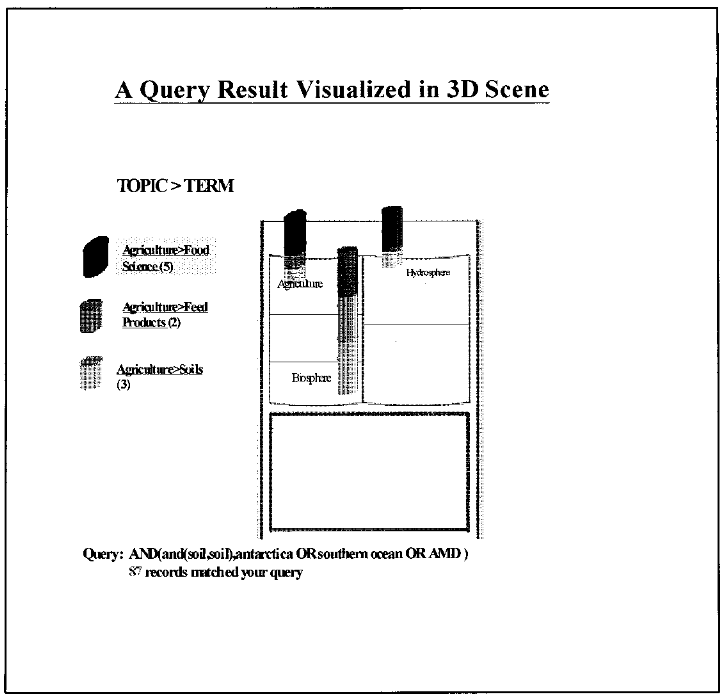


Figure 7.5 The Query Result in a Visualized Form

When a user chooses a topic to look at, all those data sets related to the topic will be displayed as points. If a user wants take a look a point's metadata information, he or she can move the mouse over the point at any time. Key metadata information such as the title of the data, will be displayed in the lower frame or two sides. By skimming the key metadata information, users can understand generally about the chosen data sets (See figure7.4). This will help them to avoid opening each web pages of each data set, and users can grasp information quickly.

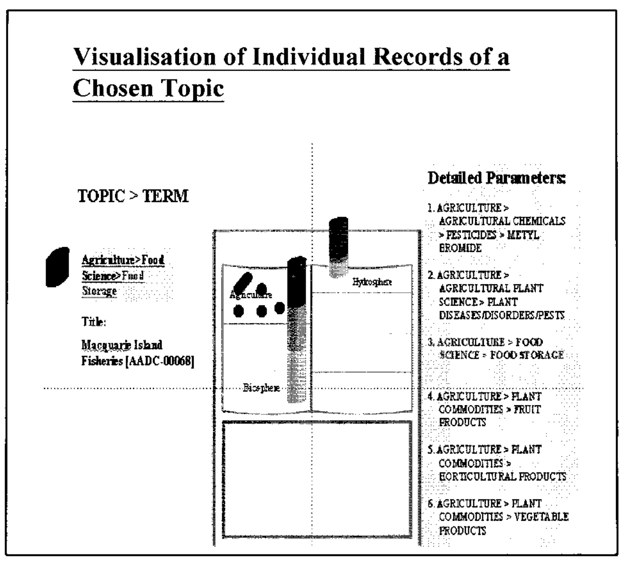


Figure 7.6 Visualization of Individual Records on a Specific Topic

Once a user has a general idea about those data sets, he or she may be interested in which data sets are similar to a current chosen data set. By simply clicking a data's represented point on the graphic, all those similar data sets are displayed as points on the graphic (See figure 7.6). The similarity can be represented by the thickness of the line connecting two points. The degree of similarity can be calculated based on the hierarchy of science keywords, which have been used to describe the data set.

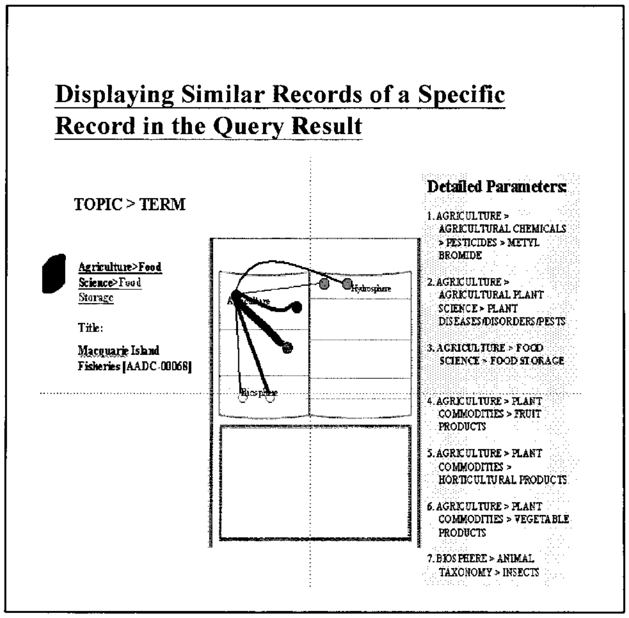


Figure 7.7 Displaying Similar Data Sets of a Specific Data Set

7.3.3 Current Limitations

Key ideas of visualizing metadata query results of AMD are introduced in the above section. These ideas are not readily applicable to the geospatial portal of the CANE project due to the lack of detailed user needs and requirements. For example, it is unknown what other appropriate information should be visualized along with the 3D representation in figure 7.5 to help users efficiently choose a specific topic to focus on. This calls for research on users' needs analysis for accessing geospatial portals. Researchers from the "Hot Lab" are conducting a user search behaviour research which has the potential to refine and improve these visualization ideas.

Overall, it is still rather challenging to apply information visualization of metadata to facilitate the accessibility of data. Like a new "thing" or "idea", such as a new type of music, it will take time for users to get used to it. Users need to understand and be familiar with the definition of each visual representation. A visual representation form of abstract information may be easily interpreted by some people but not all people. Furthermore, once people are familiar with one representation form, it will be difficult to accept another one. For example, Microsoft Windows users are very familiar with three buttons "close, minimize and maximize" located in the upper-right corner of a window, while the Apple Macintosh interface puts those buttons on the upper-left corner, which can make Microsoft Windows users uncomfortable using it. In addition, cultural difference may also be a potential factor leading to the misunderstanding of underlying information. Furthermore, it is necessary to avoid paying too much attention to fancy visual effects while ignoring the purpose of information visualization – to visually present information to perceive information rather than pictures. As Borner et al (2002) also point out, the development of an efficient information visualization application is not an easy task, designers, content providers and developers should work collaboratively.

7.4 SUMMARY

This chapter generally explores information visualization which allows users to interactively explore large amounts of data. Information visualization for metadata in a geospatial portal could be a potential solution to help users access data quickly and efficiently. But much further research is required. One challenge is how to design efficient interfaces to facilitate the insights of metadata information. Users' needs should be the centre of a design process. Analyzing users' needs, information seeking behaviours and choosing appropriate information visualization techniques are the main area for future work in designing metadata information visualization interfaces for efficiently accessing to a geospatial portal.

CHAPTER 8

CONCLUSIONS AND FUTURE RESEARCH

This study evaluated a variety of metadata standards and assessed the needs and requirements for developing metadata for multimedia data in a geospatial context. The main purpose of the research is to make data manageable, accessible and reusable. A high level metadata profile was developed by integrating metadata elements or classes (schemas) from different metadata standards. In order to enable interoperability with other geospatial data or potential geospatial software applications, the ISO19115 geospatial metadata standard was used as the base metadata standard in developing the profile. As part of the profile, GML was also used to represent spatial information of potential entities, which may be associated with multimedia data.

The ISO19115 geospatial metadata standard has developed an extension standard specific for imagery data. Considering the complexity of multimedia technical metadata which many organizations in other communities are studying and structuring according to different types of multimedia data, there is little chance that the geography community will develop an extension standard of ISO19115 specific for multimedia data. Therefore, a future direction to develop metadata for geospatial portal applications is to develop multimedia metadata application profiles by integrating metadata elements and schemas from different metadata standards. The study shows that the ISO19115 geospatial metadata standard is not flexible. Therefore, limitations are discussed about using the ISO19115 metadata standard in describing multimedia data used in a geospatial context. However, with some refining and extension efforts, the ISO19115 geospatial metadata standard and GML can be used jointly to describe collective level metadata information of multimedia data in a geospatial context.

ISO/TC211 is in the process of developing the ISO19139 standard, which is an XSD/XML based standard for the implementation of the ISO19115 geospatial metadata standard. Separating data from presentation, XML makes data easily exchangeable and processable, especially in heterogeneous systems. However, XML is machine readable, but not machine understandable. It is impossible for machines to interpret the relationship between different XML tags in an XML file. If a metadata profile schema is defined totally based on the ISO19139 standard and by extending metadata elements according to the rules defined in the ISO19115 metadata standard, machines will not have any problem reading and interpreting the semantic meanings defined in the profile. However, if a profile is built by integrating metadata elements from different metadata standards, machines will have to compare each element in an XML document with different schemas from different standards. Considering the complexity of ISO19139 schemas and the limitations of using the ISO19115 metadata standard in describing multimedia data, it will be inefficient or even impossible for machines to do the comparison. To solve this problem, a future research direction is to make use of new technologies such as RDF (Resource Description Framework) to implement this metadata profile. A RDF document is usually implemented in XML. RDF can provide a means for publishing not only human-readable and machine-readable but also machine-understandable vocabularies to help machines interpreting the semantic of information.

In addition to the implementation issue, one challenge which needs to be addressed for future study is to find an efficient way to balance the conflict between the simplicity required by metadata providers and the functionality needed by the applications. As metadata are provided mostly by researchers from the CANE project who are very busy with developing their atlas content modules, it takes extra work for them to input the metadata information for each multimedia object. Therefore, most metadata providers in the CANE project prefer to fill metadata from a dropdown list in order to avoid summarizing and writing the metadata content by themselves. Some of them also stated that they would not fill the metadata elements unless they were defined as mandatory in the metadata profile. To solve this problem, efficient tools should be developed to help metadata providers input metadata information in a convenient way. As much metadata information as possible should be extracted automatically by these tools; education should also be provided to help metadata providers recognize the importance and advantages of using metadata. Training should be provided to help them understand the meanings of each metadata element in the metadata profile. These are two critical steps to ensure that metadata providers attach metadata information for each individual object correctly and to fulfill the advantages and benefits of using metadata.

Since metadata information is usually in text form, information visualization has a great potential to help users access data efficiently and facilitate data acquisition in geospatial portals. However, this recognition is currently not recognised by most of organizations or data providers. In fact, most people do not recognize the importance of visually displaying metadata information. This research reviewed several web sites, most of which present metadata search results as rigid text lists like those in the AMD site; little attention is paid to visually display metadata information. However, various metadata visualization technique, ranging from simply displaying metadata information in different colors or fonts to more advanced visual form such as information visualization, which focuses on the visual representation and analysis of non-numerical abstract information, can be used to distinguish or emphasis the metadata information to help users understand and grasp metadata information quickly. In order to change the rigid outlook of metadata and to improve data retrieval and sharing, information visualization should be further studied by the geography community.

References

Acab R. M. (1996), What is MULTIMEDIA?, downloaded on Dec.2, 2004 from http://www.cs.yorku.ca/Courses95-96/4361/q1.html

Andersen C.N. (2003), Geographic Information Standards: International, National, and Federal, In Urban and Regional Information Systems Association, Issue 197

ANZLIC Metadata Guidelines: Core Metadata Elements for Geographic Data in Australia and New Zealand (Version 2.0), downloaded on Jan. 04, 2004 from <http://www.anzlic.org.au/asdi/metagrp.htm>

Agnew G. et al (2001), ViDe User's Guide: Dublin Core Application Profile for Digital Video, downloaded on Sept 23, 2004 from http://www.vide.net/workgroups/videoaccess/resources/vide_dc_userguide_20010909.pdf

Austerberry, D. (2004). Digital Asset Management (pp.175), London: ELSEVIER

Arkive (2004), Images of Life on Earth, downloaded on Feb. 7, 2005 from http://www.arkive.org/faqs.html#qb3

Becker, H., et al (1997), Dublin Core Element: Coverage, constructed by Ad Hoc Working Group: Coverage Element, downloaded on Oct. 20, 2003 from http://alexandria.sdc.ucsb.edu/public-documents/metadata/dc_coverage.html

Bieber, M. (2000), "Hypertext," Encyclopedia of Computer Science (4th Edition), Ralston, A. et al (Eds.), Nature Publishing Group, down loaded on Dec. 12, 2004 from http://www.cis.njit.edu/~bieber/pub/cs-encyclopedia/hypertext.html

Bodum, L. (1999), Future Direction for Hypermedia in Urban Planning, In Camara, S. A. & Raper, J. (Eds.), Spatial multimedia and Virtual Reality (pp. 21-34), London: Taylor & Francis

Borner, K. & Chen, C. (2002), Visual Interfaces to Digital Libraries: Motivation, Utilization, and Socio-technical Challenges. In Borner, K. & Chen, C. (Eds.), Visual Interfaces to Digital Libraries (pp. 1-9), Berlin, Germany: Springer

Cai, G. (2002), GeoVIBE: A Visual Interface for Geographic Digital Libraries. In Borner, K. & Chen, C. (Eds.), Visual Interfaces to Digital Libraries (pp. 171-187). Berlin: Germany: Springer

Camara, A.et al (2000), Spatial Multimedia, In S. Openshaw & R. J. Abrahart (Eds.) GeoComputation (pp275-291), London & New York: Taylor & Francis.

Card, K. S. et al (1999), Information visualization – Using vision to Think, San Francisco: Morgan Kaufmann Publishers

Chen, C. (2002), Information Visualization Is Growing, In Chen, C.(Editor-in-Chief), Information Visualization, Vol. 1, No. 1, pp. 159-164

DIG 35 (2001), DIG Specification: Metadata Standard for Images Working Draft (Version 1.1), downloaded on Oct. 3, 2003 from: http://www.bgbm.fu-berlin.de /TDWG/acc/Documents/DIG35-v1.1WD-010416.pdf

Dion S., (2001), Profile of the Canadian multimedia industry, downloaded on Dec. 18, 2004 from http://strategis.ic.gc.ca/epic/internet/inict-tic.nsf/vwapj/0107133e.pdf/$FILE/0107133 e.pdf

Domesday (2005), The Domesday Project - November 1986, downloaded on Jun. 8, 2005 from http://www.domesday.org.uk/

Dublin Core Metadata Element Sets (Dublin Core) (2003), Downloaded on Apr. 20, 2003 from http://dublincore.org/documents/dces/

Duval et al (2002), Metadata Principles and Practicalities, In D-Lib Magazine, downloaded on Apr.5, 2004 from http://www.dlib.org/dlib/april02/weibel/04weibel.html

Duff M.W. (2001), Evaluating Metadata on a Metalevel, In Archival Science 1 (pp.285–294), Netherlands: Kluwer Academic Publishers

Fabrikant S.I., (2001), Spatialization, downloaded on Feb.16, 2004 from http://www.geog.ucsb.edu/~sara/html/research/diss/spatialization.html

Geoconnections (1997), Chapter 2: The GeoConnections Discovery Portal., downloaded Nov. 12, 2003 from www.geoconnections.org/publications/Technical_Manual/html_e/Chapter_2.html

Gilliland-Swetland J. A. (2000), Defining Metadata, downloaded on Nov. 21, 2004 from http://www.getty.edu/research/institute/standards/intrometadata/2_articles/index.html

GDP (Geoconnections Discovery Portal), (2004), Final Findings Report from the Online Survey, (an unpublished report)

Graef L. J., (2004), Why is Metadata a Hot Topic?, downloaded on Feb. 2, 2005 from http://www.montague.com/review/meta.html

Wilkie, C. (1997), Multimedia Metadata - our 70 year experience, downloaded on Jul, 5, 2003 from http://www.computer.org/proceedings/meta97/list_papers.html

Guptill C. S. et al (1995), Elements of Spatial Data Quality, Oxford, U.K.: Elsvier Science Ltd

Harvey, F. (2002), Visualization data quality through interactive metadata browsing, In Fisher, P. & Unwin, D. (Eds.), Virtual Reality in Geography (pp. 332-340), London, Taylor & Francis

Hill, L. L. (1995), Stocking the Digital Library with Georeference data, In Crossing the Bridge to the Future: Managing Geoscience Information in the Next Decade, v.26, (pp.11-1), New Orleans, LA.

Hunter, J., (1999), Metadata Searching in a Multimedia Database Environment: Part 4: Multimedia Metadata Schemas, downloaded on Jul. 7, 2003 from http://www2.lib.unb.ca/Imaging_docs/IC/Part4.html;

Hunter, J., (2002), An Application Profile which Combines Dublin Core and Mpeg-7 Metadata Terms for Simple Video Description, downloaded on Sept. 20, 2003 from http://metadata.net/harmony/video_appln_profile.html/

ISO/TC 211, (2003), ISO/FDIS 19115 Final draft (ISO19115:2003(E)), Geographic information: Metadata International standard. Downloaded on May 28, 2003 from http://www.ncits.org/ref-docs/fdis_19115.pdf

JISC (Joint Information Systems Committee) (2004), IV Executive Summary and Contents, downloaded on Dec 12, 2004 from http://www.jisc.ac.uk/index.cfm?name=project_visualization

Lillywhite, J. (1991), Identifying available spatial metadata: the problem, In Medychyj-Scott, D. et al (Eds.), Metadata in the Geosciences (pp.5-6), Loughborough, UK: Group D Publications Ltd.

Kraak et al (1997), Principles of Hypermaps, In Computer & Geosciences, Vol. 23, No.4, (pp.457-464)

Kresse et al (2004), ISO Standards for Geographic Information, Germany: Springer

Lake, R. et al (2004), Geography Mark-Up Language (GML), England: Jon Wiley & Sons Ltd

Lehfeldt R. et al (2002), Metadata in Coastal Information Systems, downloaded on Jul 21, 2003 from http://nokis.baw.de/papers/ICHE2002/LeHePi2002.pdf

Lew, S. M. (2000), Next-Generation Web Searches for Visual Content, downloaded on May 12, 2004 from http://www.vcl.uh.edu/~7373s01/readlist/next.pdf

Lu, G., (1999), Multimedia Database Management System, Boston: Artech House

Marshall, D. (1999), What is HyperText and HyperMedia?, downloaded on Dec 2, 2004 from http://www.cs.cf.ac.uk/Dave/ISE_Multimedia/node11.html

Mason, J. S. (2000), The Transforming Power of Electronic Hypertext (Doctoral Dissertation Abstraction), downloaded on Mar. 2, 2005 from http://www.masondissertation.elephanthost.com/multimedia.htm

NAP (The National Academies Press) (2002), Geoscience Data and Collections: National Resources in Peril, in chapter 4, pp1-61, Washington, D.C., The National Academies Press, downloaded on Jun. 2, 2005 from http://www.nap.edu/books/0309083419/html/

NLNZ (National Library of New Zealand) (2002), Metadata Standards Framework – Preservation Metadata, downloaded on May 4th, 2003 from http://www.natlib.govt.nz/files/4initiatives_metaschema.pdf

NISO (National Information Standards Organization) (2004), Understanding Metadata, downloaded on Jan 5, 5005 from http://www.niso.org/standards/resources/UnderstandingMetadata.pdf

OGC (Open GIS Consortium) (2004), Geospatial Portal Reference Architecture (04-039), Rose, C. L. (Editor), v0.2, downloaded on Nov.27, 2004 from: http://www.opengeospatial.org/specs/

OpenGIS® Catalog Services Specification, version1.1.1, Douglas Nebert (Ed), Downloaded on Dec.18, 2003 from http://www.opengis.org/docs/02-087r3.pdf

Peng, Z. et al, (2003), Internet GIS, Hoboken, New Jersey: John & Sons, Inc

Peinel, G. & Rose, T. (2001), Graphical Information Portals—The Application of Smart Maps in GeoNet 4D, GeoInformatic, Vol.5, Issue. 4, (pp. 327-344)

Robertson, G. et al(1991), Cone trees: animated 3D visualizations of hierarchical information, downloaded on Aug. 4, 2004 from http://sitedown.acm.org/sitedown.cfm

RLG (2004), RLG GigiNews, downloaded on Apr. 5, 2005 from http://www.rlg.org/en/page.php?Page_ID=20462&Printable=1&Article_ID=1676

SSHRC (2001), National Research Data Archive, Consultation National Archives of Canada (An Internal Report)

Taylor, D.R.F. (2002), The Cybercartography and the New Economy Project Proposal, downloaded on Nov. 12, 2003 from: http://www.carleton.ca/geography/geography/Taylor_research.html#Cyber

Taylor, D.R.F., (2005), The Theory and Practice of Cybercartography: An Introduction (chapter 1), in CYBERCARTOGRAPHY: THEORY AND PRACTICE

Schaffer, D et al. (1996), Comparing Fisheye and Full-Zoom Techniques for Navigation of Hierarchically Clustered Networks. Downloaded on July 8, 2004 from http://www.markroseman.com/pubs/fisheye.gi.pdf

Skupin A. & Fabrikant S.I., (2003), Spatialization Methods: A Cartographic Research Agenda for Non-geographic Information Visualization, In Cartography and Geographic Information Science, Vol.30. No. 2, (pp 99-119)

UIUC (University of Illinois at Urbana-Champaign Digital Libraries Initiative) glossary, downloaded on Jun. 9, 2004 from http://dli.grainger.uiuc.edu/glossary.htm

Zeiner, H., et al (2003), Video Assisted Geographical Information Systems, In Spinellis, D. (Ed.), Cross-Media Service Delivery (pp.205-216), Boston: Kluwer Academic Publishers

Appendixes

Appendix 1: An overview of the Dublin Core element sets

Element Name: Title
Label: Title
Definition: A name given to the resource.
Comment: Typically, Title will be a name by which the resource is formally known.

Element Name: Creator
Label: Creator
Definition: An entity primarily responsible for making the content of the resource.
Comment: Examples of Creator include a person, an organization, or a service. Typically, the name of a Creator should be used to indicate the entity.

Element Name: Subject
Label: Subject and Keywords
Definition: A topic of the content of the resource.
Comment: Typically, Subject will be expressed as keywords, key phrases or classification codes that describe a topic of the resource. Recommended best practice is to select a value from a controlled vocabulary or formal classification scheme.

Element Name: Description
Label: Description
Definition: An account of the content of the resource.
Comment: Examples of Description include but is not limited to: an abstract, table of contents, reference to a graphical representation of content or a free-text account of the content.

Element Name: Publisher
Label: Publisher
Definition: An entity responsible for making the resource available
Comment: Examples of Publisher include a person, an organization, or a service. Typically, the name of a Publisher should be used to indicate the entity.

Element Name: Contributor
Label: Contributor
Definition: An entity responsible for making contributions to the content of the resource.
Comment: Examples of Contributor include a person, an organization, or a service. Typically, the name of a Contributor should be used to indicate the entity.

Element Name: Date

Label: Date

Definition: A date of an event in the lifecycle of the resource.

Comment: Typically, Date will be associated with the creation or availability of the resource. Recommended best practice for encoding the date value is defined in a profile of ISO 8601 [W3CDTF] and includes (among others) dates of the form YYYY-MM-DD.

Element Name: Type

Label: Resource Type

Definition: The nature or genre of the content of the resource.

Comment: Type includes terms describing general categories, functions, genres, or aggregation levels for content. Recommended best practice is to select a value from a controlled vocabulary (for example, the DCMI Type Vocabulary [DCT1]). To describe the physical or digital manifestation of the resource, use the FORMAT element.

Element Name: Format

Label: Format

Definition: The physical or digital manifestation of the resource.

Comment: Typically, Format may include the media-type or dimensions of the resource. Format may be used to identify the software, hardware, or other equipment needed to display or operate the resource. Examples of dimensions include size and duration. Recommended best practice is to select a value from a controlled vocabulary (for example, the list of Internet Media Types [MIME] defining computer media formats).

Element Name: Identifier

Label: Resource Identifier

Definition: An unambiguous reference to the resource within a given context.

Comment: Recommended best practice is to identify the resource by means of a string or number conforming to a formal identification system. Formal identification systems include but are not limited to the Uniform Resource Identifier (URI) (including the Uniform Resource Locator (URL)), the Digital Object Identifier (DOI) and the International Standard Book Number (ISBN).

Element Name: Source

Label: Source

Definition: A Reference to a resource from which the present resource is derived.

Comment: The present resource may be derived from the Source resource in whole or in part. Recommended best practice is to identify the referenced resource by means of a string or number conforming to a formal identification system.

Element Name: Language

Label: Language

Definition: A language of the intellectual content of the resource.

Comment: Recommended best practice is to use RFC 3066 [RFC3066] which, in conjunction with ISO639 [ISO639]), defines two- and three primary language tags with optional subtags. Examples include "en" or "eng" for English, "en-GB" for English used in the United Kingdom.

Element Name: Relation

Label: Relation

Definition: A reference to a related resource.

Comment: Recommended best practice is to identify the referenced resource by means of a string or number conforming to a formal identification system.

Element Name: Coverage

Label: Coverage

Definition: The extent or scope of the content of the resource.

Comment: Typically, Coverage will include spatial location (a place name or geographic coordinates), temporal period (a period label, date, or date range) or jurisdiction (such as a named administrative entity). Recommended best practice is to select a value from a controlled vocabulary (for example, the Thesaurus of Geographic Names [TGN]) and to use, where appropriate, named places or time periods in preference to numeric identifiers such as sets of coordinates or date ranges.

Element Name: Rights

Label: Rights Management

Definition: Information about rights held in and over the resource.

Comment: Typically, Rights will contain a rights management statement for the resource, or reference a service providing such information. Rights information often encompasses Intellectual Property Rights (IPR), Copyright, and various Property Rights. If the Rights element is absent, no assumptions may be made about any rights held in or over the resource.

Source: Dublin Core (2003)

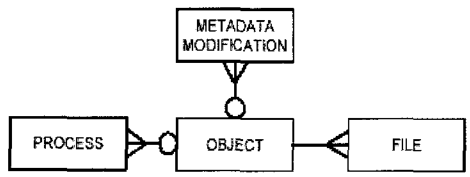
Appendix 2: Mapping between qualified Dublin Core (DCMI, 2000) and ISO 19115 (ISO, 2002)

Dublin Core Element	**ISO 19115 Element**
DC.Creator	Metadata.mdContact.RespParty(role = principal investor)
DC.Contributor	Metadata.mdContact.RespParty(role = resource provider)
DC.Publisher	Metadata.mdContact.RespParty (role = publisher)
DC.Date DC.Date.created	Metadata.Ident.Citation.resRefDate Metadata.mdDateSt
DC.Title DC.Title.alternative	Metadata.Ident.Citation.resTitle Metadata.Ident.idAbs
DC.Description.abstract DC.Description.tableOfContents	Metadata.Idnt.idAbs
DC.Subject	Metadata.Ident.descKeys
DC.Type	Metadata.Ident.Citation.citIDType
DC.Format DC.Format.extent DC.Format.medium	Metadata.Ident.Format.formatName Metadata.Ident.distTransOps.transSize Metadata.Ident.distTransOps.medName
DC.Identifier	Metadata.Ident.Citation.citRespParty
DC.Source	Metadata.Ident.Citation.citRespParty
DC.Relation	Metadata.Ident.mdParentId
DC.Language	Metadata.contInfo.catLang
DC.Coverage.spatial(DCMI Box) DC.Coverage.spatial(TGN) DC.Coverage.sptial(polygon) DC.Coverage.spatial (Veritical) DC.Coverage.temporal	Metadata.dataIdInfo.geoBox Metadata.dataIdInfo.geoDesc.geoId Metadata.dataIdInfo.datExt.geoEle.polygon Metadata.dataIdInfo.dataExt.vertExtent Metadata.dataIdInfo.datExt.exTemp
DC.Rights	Metadata.Ident.mdConst.useConsts

Source: Lehfeldt R. et al (2002)

Appendix3: NLNZ's preservation metadata model

Appendix 1 – Preservation Metadata Model



ENTITY 1 - OBJECT

1.1 Name of object
1.2 Reference number
1.3 Object identifier
1.4 Group Identifier
1.5 Persistent identifier
1.6 Preservation Master Creation Date
1.7 Logical composition
1.8 Is part of group
1.9 Structural type
1.10 Hardware environment
1.11 Software environment
1.12 Installation requirements
1.13 Access inhibitors
1.14 Access facilitators
1.15 Quirks
1.16 Metadata record creator
1.17 Date of metadata record creation
1.18 Structural composition
1.19 Comments

ENTITY 2 - PROCESS

2.1 Object identifier
2.2 Process type
2.3 Purpose
2.4 Person/agency performing process
2.5 Permission
2.6 Permission date
2.7 Hardware used
2.8 Software used
2.9 Steps
2.10 Result
2.11 Guidelines
2.12 Completion date and time
2.13 Comments

ENTITY 3 - FILE

3.1 Object identifier
3.2 File identifier
3.3 File path
3.4 *Filename and extension*
3.5 Former filename
3.6 File size
3.7 File date and time
3.8 MIME type
3.9 File format
3.10 File format version
3.11 Target indicator

3.12 IMAGE:
3.12.1 Resolution
3.12.2 Dimensions
3.12.3 Bits per sample
3.12.4 Colour space
3.12.5 Colour management
3.12.6 Colour map reference
3.12.7 *Orientation*
3.12.8 Compression

3.13 AUDIO:
3.13.1 Resolution
3.13.2 Duration
3.13.3 Bit rate
3.13.4 Compression
3.13.5 Encapsulation
3.13.6 Channels

ENTITY 3 – FILE (cont.)

3.14 VIDEO:
3.14.1 Frame dimensions
3.14.2 Duration
3.14.3 Number of frames
3.14.4 Frame rate
3.14.5 Codec method
3.14.6 Aspect ratio
3.14.7 Scan mode
3.14.8 Sound indicator

3.15 TEXT:
3.15.1 Character set
3.15.2 Mark up language

3.16 DATASETS:
Use common elements only

3.17 SYSTEM FILES:
Use common elements only

ENTITY 4 - METADATA MODIFICATION

4.1 Object identifier
4.2 Metadata record modifier
4.3 Date and time
4.4 Field modified
4.5 Data modified

Source: NLNZ (2002)

Appendix 4: Technical metadata from NLNZ (Table1-4)
Table 1: Technical matadata for images
[Elements in bold are also found in XMP standard]

Element 3.12: Images	Definition and Examples
3.12.1 Resolution	Definition: The spatial resolution of an image, expressed as pixels per inch or cm (ppi, p/cm) or dots per inch or cm (dpi, d/cm). Examples: 600 dpi; 320 dpi, 1500 d/cm
3.12.2 Dimensions	Definition: The dimensions of an image, expressed as the number of pixels along the vertical and horizontal directions. Examples: 4096 x 6144 pixels
3.12.3 Bits Per Sample	Definition: The number of bits per component for each pixel. Examples: 1 = 1 bit (bitonal) 4 = 4 bit grayscale 8 = 8 bit grayscale or palletised colour 8,8,8 = RGB 16,16,16 = TIFF, HDR (high dynamic range) 8,8,8,8 = CMYK
3.12.4 Colour Space	Definition: Designates the colour space of the decompressed image data. Examples:0, 1, 2, 3, 4, 5, 6, 7, 8
3.12.5 ICC Profile Name	Definition: The name of the International Color Consortium (ICC) profile being used. Examples: PhotoCD; OptiCal; Profile/80; Softproof (Photoshop plug-in)
3.12.6 Colour Map Reference	Definition: The location of the file containing the colour map. Examples: [URL]
3.12.7 Orientation	Definition: Orientation of an image saved on a disk, such as Normal or normal rotated 180°. Examples: 1 = normal*, 3 = normal rotated 180°, 6 = normal rotated cw 90°, 8 = normal rotated ccw 90°, 9 = unknown
3.12.8 Compression	Definition: The type and level of compression. Examples: 4 = ITU Group 4

Table 2: Technical matadata for audios (From NLNZ)

Element 3.13: Audios	Definition and Examples
3.13.1 Resolution	Definition: The rate of sampling, in samples per second, used to create an audio file. Also known as sample rate or sample frequency. Examples: 32100, 44100, 192000
3.13.2 Duration	Definition: The length of an audio recording in hours, minutes and seconds and three digits for representing decimal fractions of a second. Examples: 01:27:38:247
3.13.3 Bit Rate	Definition: The word length used to encode the audio. Consequently an indication of dynamic range. It is the maximum number of significant bits for the value without compression. Examples: 16, 20, 24
3.13.4 Compression	Definition: The name of the compression scheme, noise reduction scheme, or other non-linear processing applied to an audio signal. Note that audio compression, or bit rate reduction is a non-reversible, “lossy” process. Examples: MPEG 3, Dolby A
3.13.5 Encapsulation	Definition: The name and version level of the delivery format of the file. Examples: Real Audio II
3.13.6 Channels	Definition: A classification of the sound format type identifying the number of channels and how they are related to each other. **Examples:** Mono 2 channel stereo 5 channel surround other

Table 3: Technical matadata for video (From NLNZ)

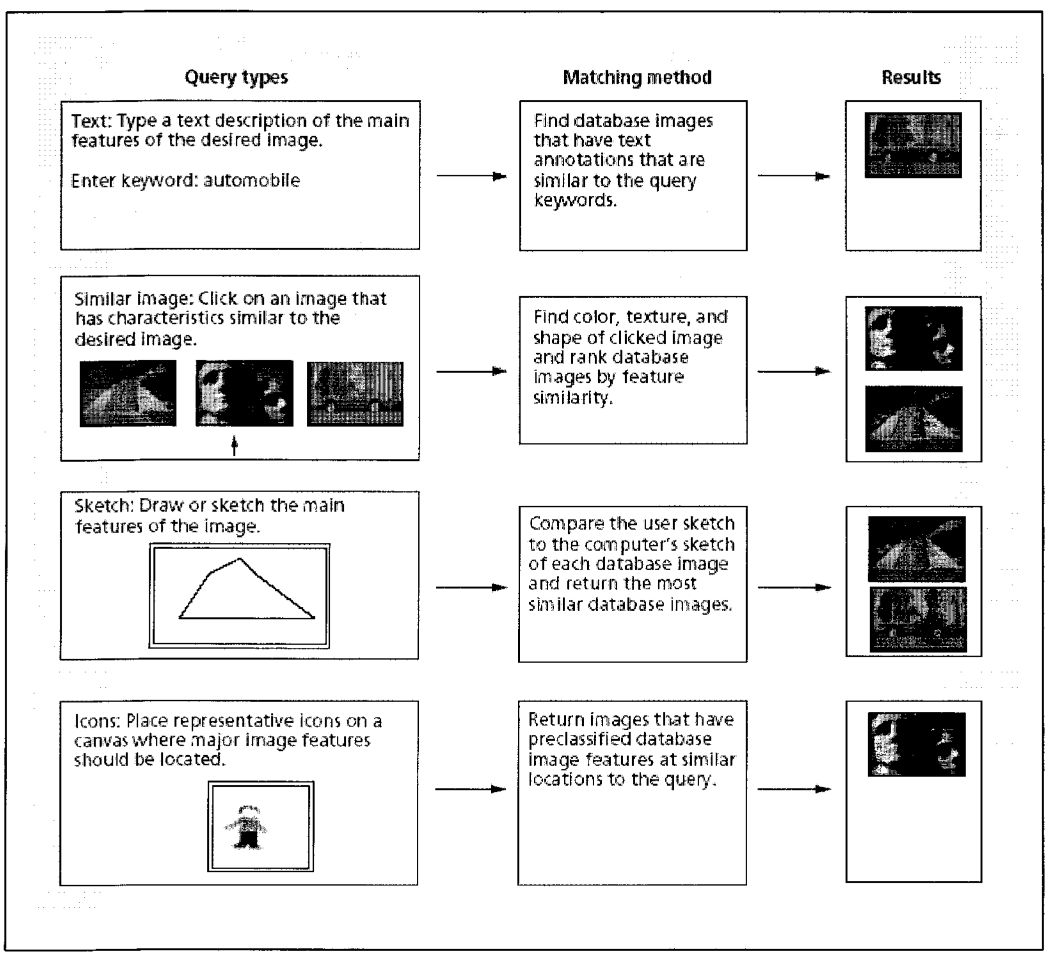
Elements 3.14: Videos	Definition and Examples
3.14.1 Frame Dimensions	Definition: The resolution in pixels of a single still frame. Examples: 640 pixels x 480 pixels
3.14.2 Duration	Definition: The length of the video recording in minutes and seconds, or minutes, seconds, 100ths of seconds. Examples: 01:27:38:247
3.14.3 Number of Frames	Definition: The number of frames present in the video recording. Examples: 10000
3.14.4 Frame Rate	Definition: The rate at which the video should be shown to achieve the intended effect – expressed in frames per second (fps). Examples: 25
3.14.5 Codec Method	Definition: The name, including version level, of the codec method applied to the video. Note that video compression, or bit rate reduction is a non-reversible "lossy" process. Examples: DivX 5.0.5
3.14.6 Aspect Ratio	Definition: The desired aspect ratio of the image on screen. Examples: 4:3
3.14.7 Scan Mode	Definition: An indicator showing whether the digital item is scanned in a progressive or interlaced mode. Examples: Progressive, Interlaced
3.14.8 Sound Indicator	Definition: An indicator of the presence of sound in the video file. Examples: Yes, No Note: If the value is 'yes', then the video file will also be associated with an instance of the Audio metadata (3.13) in addition to the Video metadata (3.14)

Table 4: Technical matadata for text (From NLNZ)

Element 3.15: Text	Definition and Examples
3.15.1 Character Set	Definition: The character set used when creating the file. Examples: ASCII; Unicode; EBCDIC, UTF-8
3.15.2 Markup Language	Definition: The type of mark up language used to mark up the document. Examples: SGML, XML, HTML

Source: NLNZ (2002)

Appendix 5: Content-based image search: text and image search paradigms



Source: Lew (2000)

Appendix 6: MD_TopicCategoryCode<<Enumeration>>

	Name	Domai-ncode	Definition
	MD_TopicCategory	**TopicC-atCd**	**High-level geographic data thematic classification to assist in the grouping and search of available geographic data sets.Can be used to group keywords as well. List examples are not exhausive.**
	farming	001	rearing of animals and/or cultivation of plants Examples: agriculture, irrigation, aquaculture, plantations, herding, pests and diseases affecting crops and livestock
	biota	002	flora and/or fauna in natural environment Examples: wildlife, vegetation, biological sciences, ecology, wilderness, sealife, wetlands, habitat
	boundaries	003	legal land descriptions Examples: political and administrative boundaries
	climatologyMeteorologyAtmosphere	004	processes and phenomena of the atmosphere Examples: cloud cover, weather, climate, atmospheric conditions, climate change, precipitation
	economy	005	economic activities, conditions and employment Examples: production, labour, revenue, commerce, industry, tourism and ecotourism, forestry, fisheries, commercial or subsistence hunting, exploration and exploitation of resources such as minerals, oil and gas
	elevation	006	height above or below sea level Examples: altitude, bathymetry, digital elevation models, slope, derived products
	environment	007	environmental resources, protection and conservation Examples: environmental pollution, waste storage and treatment, environmental impact assessment, monitoring environmental risk, nature reserves, landscape
	geoscientificInformation	008	information pertaining to earth sciences Examples: geophysical features and processes, geology, minerals, sciences dealing with the composition, structure and origin of the earth's rocks, risks of earthquakes, volcanic activity, landslides, gravity information, soils, permafrost, hydrogeology, erosion
	health	009	health, health services, human ecology, and safety Examples: disease and illness, factors affecting health, hygiene, substance abuse, mental and physical health, health services
	imageryBaseMapsEarthCover	010	base maps Examples: land cover, topographic maps, imagery, unclassified images, annotations
	intelligenceMilitary	011	military bases, structures, activities Examples: barracks, training grounds, military transportation, information collection
	inlandWaters	012	inland water features, drainage systems and their characteristics Examples: rivers and glaciers, salt lakes, water utilization plans, dams, currents, floods, water quality, hydrographic charts
	location	013	positional information and services Examples: addresses, geodetic networks, control points, postal zones and services, place names

	Name	Domai -ncode	Definition
	oceans	014	features and characteristics of salt water bodies (excluding inland waters) Examples: tides, tidal waves, coastal information, reefs
	planningCadastre	015	information used for appropriate actions for future use of the land Examples: land use maps, zoning maps, cadastral surveys, land ownership
	society	016	characteristics of society and cultures Examples: settlements, anthropology, archaeology, education, traditional beliefs, manners and customs, demographic data, recreational areas and activities, social impact assessments, crime and justice, census information
	structure	017	man-made construction Examples: buildings, museums, churches, factories, housing, monuments, shops, towers
	transportation	018	means and aids for conveying persons and/or goods Examples: roads, airports/airstrips, shipping routes, tunnels, nautical charts, vehicle or vessel location, aeronautical charts, railways
	utilitiesCommunicatio n	019	energy, water and waste systems and communications infrastructure and services Examples: hydroelectricity, geothermal, solar and nuclear sources of energy, water purification and distribution, sewage collection and disposal, electricity and gas distribution, data communication, telecommunication, radio, communication networks

Source: From the ISO19115 geospatial metadata standard, B.5.27

Appendix 7: CI_OnlineFunctionCode <<CodeList>>

	Name	Domain code	Definition
1	**CI_OnLineFunctionCode**	**OnFunctCd**	**Function performed by the resource**
2	download	001	Online instructions for transferring data from one storage device or system to another
3	information	002	Online information about the resource
4.	offlineAccess	003	Online instructions for requesting the resource from the provider
5	order	004	Online order process for obtaining the resource
6	search	005	Online search interface for seeking out information about the resource

Source: From the ISO19115 geospatial metadata standard, B.5.3

Appendix 8: MD_RestrictionCode <<CodeList>>

	Name	**Domain code**	**Definition**
1	**MD_RestrictionCode**	**RestrictCd**	**Limitation(s) placed upon the access or use of the data**
2	copyright	001	Exclusive right to the publication, production, or sale of the rights to a literary, dramatic, musical, or artistic work, or to the use of a commercial print or label, granted by law for a specified period of time to an author, composer, artist, distributor
3	patent	002	Government has granted exclusive right to make, sell, use or license and invention or discovery
4.	PatentPending	003	Produced or sold information awaiting a patent
5	trademark	004	A name, symbol, or other device identifying a product, officially registered and legally restricted to the use of the owner or manufacturer
6	license	005	Formal permission to do something
7	intellectualPropertyRights	006	Rights to financial benefit from an control of distribution of non-tangible property that is a result of creativity
8	restircted	007	Withheld from general circulation or disclosure
9	otherRestrictions	008	Limitation not listed

Source: From the ISO19115 geospatial metadata standard, B.24

Appendix 9: MD_KeywordTypeCode <<CodeList>>

	Name	**Domain code**	**Definition**
1	**MD_KeywordTypeCode**	**KeyTypCd**	**Methods used to group similar keywords**
2	discipline	001	Keyword identifies a branch of instruction or specialized learning
3	place	002	Keyword identifies a location
4.	Stratum	003	Keyword identifies the layer(s) of any deposited substance
5	temporal	004	Keyword identifiers a time period related to the dataset
6	theme	005	Keyword identifies a particular subject or topic

Source: From the ISO19115 geospatial metadata standard, B.5.17

Appendix 10: Extended Role Code Tables (Extended role code presented in bold)
Table 1: CI_DateTypeCode<<Codelist>> (B.5.2, ISO19115)

	Name	Domain code	definition
1	**CI_RoleCode**	**RoleCd**	**Function performed by the responsible party**
2	creation	001	Date identifies when the resource was brough into existence
3	publication	002	Date identifies when the resource was issued
4	revision	003	Date identifies when the resource was examined or re-examined and improved or amended
5	**downloaded**	**004**	**Date when the resource was downloaded**

Table 2: CI_PresentaionFormCode<<CodeList>> (B.5.4, ISO19115)

	Name	Domain code	Definition
	CI_PresentationFormCo-de	**PresFor-mCd**	Mode in which the data is represented
	documentDigital	001	digital representation of a primarily textual item (can contain illustrations also)
	documentHardcopy	002	representation of a primarily textual item (can contain illustrations also) on paper, photographic material, or other media
	imageDigital	003	likeness of natural or man-made features, objects, and activities acquired through the sensing of visual or any other segment of the electromagnetic spectrum by sensors, such as thermal infrared, and high resolution radar and stored in digital format
	imageHardcopy	004	likeness of natural or man-made features, objects, and activities acquired through the sensing of visual or any other segment of the electromagnetic spectrum by sensors, such as thermal infrared, and high resolution radar and reproduced on paper, photographic material, or other media for use directly by the human user
	mapDigital	005	map represented in raster or vector form
	mapHardcopy	006	map printed on paper, photographic material, or other media for use directly by the human user
	modelDigital	007	multi-dimensional digital representation of a feature, process, etc.
	modelHardcopy	008	3-dimensional, physical model
	profileDigital	009	vertical cross-section in digital form
	profileHardcopy	010	vertical cross-section printed on paper, etc.
	tableDigital	011	digital representation of facts or figures systematically displayed, especially in columns
	tableHardcopy	012	representation of facts or figures systematically displayed, especially in columns, printed on paper, photographic material, or other media
	videoDigital	013	digital video recording
	videoHardcopy	014	video recording on film
	…		

Table 3: CI_RoleCode<<Codelist>> (B.5.5, ISO19115 metadata standard)

	Name	**Domain code**	**definition**
1	**CI_RoleCode**	**RoleCd**	**Function performed by the responsible party**
2	resourceProvider	001	Party that supplies the resource
3	custodian	002	Party that accepts accountability and responsibility for the data and ensures appropriated care and maintenance of the resource
4	Owner	003	Party that owns the resource
5	User	004	Party who uses the resource
6	Distributor	005	Party who distributes the resource
7	Originator	006	Party who created the resource
8	PointOfContact	007	Party who can be contacted for acquiring knowledge about or acquisiti9on of the resource
9	PrincipalInvestigator	008	Key party responsible of gathering information and conducting research
10	Processor	009	Party who has processed the data in a manner such that the resource has been modified
11	Publisher	010	Party who published the resource
12	author	011	Party who authored the resource
13	**designer**	**012**	**Party who designed the multimedia object**
14	**developer**	**013**	**Party who developed the multimedia object**

Source: From the ISO19115 geospatial metadata standard