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thesis entitled

ESTABLISHING AN OPEN, DISTRIBUTED GIS DATA
ARCHIVE SYSTEM

presented by

VICTORINO AMORANTO BATO

has been accepted towards fulfillment
of the requirements for the

M.A. degree in Geography

David Skole

Dr. David L. Skole

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ESTABLISHING AN OPEN, DISTRIBUTED GIS DATA ARCHIVE SYSTEM

By

Victorino Amoranto Bato

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

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2006

ABSTRACT

Establishing an Open, Distributed GIS Data Archive System

by

Victorino Amoranto Bato

Earth Observing System Data and Information System is an information system for earth science being operated by NASA. An NRC evaluation of this information system concluded the system as not flexible, too-rigid, and does not meet the recommendations of the NRC for an information system that could effectively serve scientific research. The Philippines NGII is also an information system planned for development and is being headed by NAMRIA. The NGII was scheduled to have been completed by 2005, but several problems have stalled its implementation. Because there exists an absence of a truly functional information system for geospatial data that could serve scientific research, a need exists to create an ODGISDAS. Such a system will not only serve data users in the Philippines, but will also answer the need for a more flexible and adaptive system being envisioned by the NRC.

The ODGISDAS Landsat.org Philippines (http://202.90.128.189) was established at the NAMRIA, Philippines. This information system is capable of searching for Landsat data from the local database and from remote databases at Michigan State University, East Lansing, Michigan 48824, United States of America. The system is a "one-stop-shopping" portal for Landsat data and can be accessed from the World Wide Web using any web browser. Landsat.org Philippines and was created using hardware and software technologies commonly found in government offices and universities.

DEDICATION

1
In the beginning God created the heavens and the earth.

2
Now the earth was formless and empty, darkness was over the surface of the deep, and the Spirit of God was hovering over the waters.

3
And God said, "Let there be light," and there was light.

4
God saw that the light was good, and He separated the light from the darkness.

5
God called the light "day," and the darkness he called "night." And there was evening, and there was morning—the first day.

ACKNOWLEGEMENTS

I would like to give thanks and show my appreciation to my major professor Dr. David Lewis Skole for giving guidance and direction to my research and for providing me with an assistantship during the entire course of my master's program at Michigan State University, United States of America. I would also like to thank Dr. Jiaguo Qi and Dr. Stuart Gage for the help and the advice they provided for the improvement of this manuscript.

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Most of all, I would like to thank the Lord Jesus Christ, who makes all things possible.

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CHAPTER I

TOWARDS AN OPEN, DISTRIBUTED GIS DATA ARCHIVE SYSTEM

1.1 Introduction

Since the launch of ERTS 1 (Earth Resources Technology Satellites 1), the first land observing satellite, many images of the earth's surface have been acquired. These data are of varying spatial, temporal frequency, and radiometric characteristics, reflecting more than 61 different sensors and platforms deployed since ERTS 1.

The scientific community recognizes the value and benefits derived from inter-disciplinary research as a new approach to knowledge discovery. Making satellite data and processed products from different science disciplines readily and easily available to the scientific community will promote such type of research.

At the local community level, geographic information in the form of satellite data will aid environmentalists, planners, and government officials in making sound decisions for community development and environmental protection. Satellite images also provide an outreach mechanism for people who are not directly engaged in the process of research or planning. Thus, lay citizens can also gain knowledge and develop a deeper appreciation of the environment, as well as the planet earth, and the problems that affect them.

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1.2 The Need for an Open, Distributed GIS Data Archive System

Much geographic information has been gathered and archived. The most important challenge is to get the right information to the right people. For instance, Landsat data is acquired through 22 ground receiving stations, each with a unique collection of Ladsat data, but has not been coalesced into a single comprehensive archive because they are dispersed throughout many individual archives. In the US, 7 DAACs (Distributed Active Archive Centers) and numerous ESIPs (Federation of Earth Science Information Partners), are hosting a collection of satellite data (processed, unprocessed and byproducts) specific to their discipline, but are not inter-connected into a larger single archive. Though the science community has a massive collection of satellite data, searching for a specific data becomes a problem because the data centers do not function as a coherent system. This problem was brought to NASA's (National Aeronautics and Space Administration) attention by the NRC (National Research Council). NASA adopted the recommendations of the NRC, with the EOS Data Gateway as one result of such efforts. This gateway serves as a seamless "one-stop-shopping" portal for EOSDIS products. Despite such efforts, NASA still has failed to meet the user communities' and the NRC's expectations because of several problems encountered during the implementation of EOSDIS.

Similar to EOSDIS, the NAMRIA (National Mapping and Resource Information Authority) has developed plans to implement an information system that would serve the entire Philippine Archipelago. This information system is called the NGII (Philippines' National Geographic Information Infrastructure

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Framework Plan) and its objective is to make geographic data more accessible and available to local users by using World Wide Web technologies and protocols. Part of the goals of the NGII is to develop a "one-stop-shopping" for geographic data through a distributed data system and a data clearing house. However, there have been many institutional, technical, and standards issues, which have hindered NGII's implementation.

Though the size of data their archives differs, NASA and NAMRIA have a common goal of making data available to people by developing an open, distributed GIS data archive system (ODGISDAS). **Because a truly and functional ODGISDAS is currently unavailable and is needed by data users in the Philippines, a need exists to develop such a system.** An ODGISDAS for the Philippines would allow users to search and locate geographic data from distributed databases managed by data centers at different geographic locations. Customizing the ODGISDAS to suit local user's needs would give added value to geographic data, which will aid in knowledge discovery.

1.3 Objectives

The general objective of this study is to develop an open, distributed GIS data archive system (ODGISDAS) for the National Mapping and Resource Information Authority in the Philippines. This ODGISDAS would be capable of searching archives of Landsat data from a local database and from a distributed database at Michigan State University (MSU). The specific objectives of this study were:

1. Demonstrate the possibility of searching for Landsat data from multiple databases located at different geographic locations from a single web portal.
2. Develop an open, distributed GIS data archive system (ODGISDAS) using common computer technologies and software already available in most government offices and universities, but integrated through standards and protocols.
3. Develop a seamless "one-stop-shopping" interface for this ODGISDAS.
4. Conduct training of NAMRIA technical staff on the operation and maintenance of the ODGISDAS to provide technology transfer.
5. Provide a technical approach to data access that could support spatial decision support, planning, and policymaking.

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CHAPTER II

REVIEW OF LITERATURE

2.1 Overview

Landsat.org Philippines is an open, distributed GIS (Geographic Information Systems) data archive system. Landsat.org Philippines converges technological advances from different avenues of Computer Science and the Geographic Information Science. I will discuss the different characteristics and components, which comprise this system in the following order: distributed data archive system, geographic information systems, web GIS, and open standards.

2.2 Distributed Data Archive System

A distributed system is a collection of multiple information systems connected via a digital communication network that can synchronously cooperate to complete a computing task (Worboys & Duckham, 2004). In the case of a distributed data archive system or a distributed database, the definition of a distributed system still holds, except that the word "system" specifically refers to a database system. Worboys & Duckham (2004) mention four advantages of a distributed database system, namely: *decentralization, availability and reliability, performance, and modularity*. Distributed databases have been used by commercial industries because of the systems fail safe design and ability to handle multiple transactions. In the field of geographic information science, being able to access distributed databases would mean being able to seamlessly integ

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integrate and analyze geographic data from different sources. This seamless access is the vision of every scientist who utilizes geographic data in their research.

Seamless access to distributed databases is not without a problem. Laurini (1998) identified several problems with using multiple distributed databases. Some of these problems are: *boundary alignment, topological continuity, and geographic fragmentation* (Laurini, 1998). These problems are not directly a result of the distributed nature of the system and can be addressed by proper documentation through the metadata and by following certain data standards. Developing metadata and data standards for interoperability is currently one of the areas where the OGC (Open Geospatial Consortium) is exerting its effort.

2.3 Geographic Information Systems

Geographic Information System (GIS) is a *special type of computer-based information system tailored to store, process, and manipulate geospatial data* (Worboys & Duckham, 2004). GIS can be used as a tool to solve a wide variety of geospatial problems, from the most basic problem of determining one's global position to the more complex problem that requires spatial modeling scenarios. Coppock and Rhind (1990) mentioned six general categories of basic questions that can be investigated using GIS, these are: *location, condition, trend, routing, pattern, and modeling.*

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The first geographic information system was developed in Canada in 1963. This system was called the Canada Geographic Information Systems and was a product of the Canada Land Inventory, a nationwide effort to identify land resources, their current and potential uses. In 1964, the Harvard Laboratory for Computer Graphics and Spatial Analysis was established and released the first raster GIS called SYMAP in 1966. In the 1970's, the development of GIS was further fuelled by the declassification of military aerial photographs and the launch of the Landsat satellite system. This information served as input data for geographic information systems existing in those days. In the 1980's, GIS became popular among resource managers when the price of hardware declined. Further decrease in the price of hardware in the 1990's, together with the increased processing capacity and porting of GIS software to run on desktop systems, made GIS generally available. This event led to the opening of the many avenues of GIS that is currently in existence.

Much of the developments occurring in GIS are driven by advances in hardware and software technologies. These technologies are consumer and profit driven. Longley *et al.* (2001) estimates that the GIS software industry generates $ 1 billion in annual profit. Though some geographers like Pickles (1995) have argued the *negligible role [of geographers] in the development of proprietary systems* (lifted from Longley, 2000), nevertheless, *GIS provides a crucial means of dealing with the current proliferation of digital data, and has important implications for the future development of geography* (Longley, 2000).

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Much of the development efforts in GIS today are in the areas of distributed computing, Web-GIS, standards formulation, interoperability, advanced visualization, spatial data analysis, global positioning, and modeling. These different research avenues of GIS provides people new approaches of making "sense" and observing new patterns in data that were once less obvious.

2.4 Web GIS

Web GIS, Internet GIS, or online GIS is one of the areas of GIS that focuses on utilizing the Internet as a medium to perform analysis and disseminate geographic information. Utilizing the Internet as a medium has the following advantages: *world-wide access, standard interface, and faster, more cost-effective maintenance* (Green and Bossomaier, 2002). Because GIS is information driven, the integration of the Internet has revolutionized the discipline. Many of the expectations of GIS by scientists have started to become achievable and many new possible applications and research areas are emerging. According to Dragićević (2004) *GIS [is] now able to make its concepts more open, accessible, and mobile to everyone thereby facilitating notions such as democratization of spatial data, open accessibility, and effective dissemination.* The Internet has made GIS more accessible to people and has created the potential of applying GIS to solve practical everyday problems such as traffic routing.

According to Dragićević (2004), the web has enhanced the use of GIS in three main directions: *(1) spatial data access and dissemination, (2) spatial data* *exploration and geovisualization, and (3) spatial data processing, analysis, and modeling*. These three components are the main categories where most researchers focus their studies on. Any GIS application available today focus on just one of the directions/areas stated by Dragićević. One of the challenges for scientists doing research in the area of Web-GIS is to be able to create a system that harnesses the essentials of the three main directions/areas stated by Dragićević in an integrated and seamless manner. Research conducted by Tsou (2004) attempted to incorporate image processing capabilities to Web-GIS. Tsou's application utilizes Java applets to perform the image processing component. Java applets have a compatibility problem with most web browsers and Tsou's application suffered the same fate. In his conclusion, He recognized some of the problems/challenges that have to be solved: *metadata standards, data transmission formats, communication protocols, client/server balance, and ubiquitous access* (Tsou, 2004).

2.5 Open Standards

The OGC (Open GIS Consortium) is the organization responsible for maintaining standards of "openness" for geospatial products and services. OGC describes open standards as follows: *(1) is created in an open, international, participatory industry process, (2) has free rights of distribution, (3) has open specification access, (4) does not discriminate against persons or groups, and (5) ensures that the specification and the license must be technology neutral* (OCG, 2005). Based on these criteria, only those applications that adhere to OGC spe

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specifications may be considered open and not all applications that are free and published may be considered as such.

The OGC (2003) have specified three specific needs that can be addressed using open standards. These specific needs are as follows:

1. *The need for organizations to have access to each other's spatial information without copying and converting whole data sets.*
2. *The need to have the pieces of the solution work together.*
3. *The need to base geoprocessing on the World Wide Web open architecture.*

These specific needs boil down to the necessity to *maximize the value of past and future investments in geoprocessing systems and data* (OGC, 2003) and can only be solved using *geoprocessing systems and components that interoperate across open interfaces in the context of global (or in some cases local) distributed computing platform (usually the Web)* (OGC, 2003).

OpenGIS *is an adjective describing specifications and other products of OGC's consensus process that support transparent access to heterogeneous geodata and geoprocessing resources in a networked environment* (OGC, n.d.). OGC provides the OpenGIS specifications that developers can use as a guide in writing their programs. A program is ensured of openness and interoperability if it adheres to these standards.

One of the formats being prescribed, but is currently under development, by the OGC for the OpenGIS specification is GML (geography markup language). GML is a type of XML (extensible markup language) and is another u

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type of SDTS (spatial data transfer standards). There exists many advantages in using GML as a data transfer format. Some of these advantages are as follows: First, GML as a language can be used to create self-describing data. Second, because modern browsers are built with the capability to parse XML, these browsers can easily read GML, which is a type of XML. Using GML brings OGC closer to achieving its goals of an open and interoperable format.

Much of the geospatial standards being developed by OGC are a work in progress. These specifications may be called "standards" for the meantime because they change in response to the changing needs and technology. Therefore, products might be classified as compliant to certain OpenGIS specifications version.

CHAPTER III

BACKGROUND

(Note: Images in this thesis are shown in color.)

3.1 Server Architecture Models

The NSDI (National Spatial Data Infrastructure) has four reference server architectures for geospatial data centers: *centralized, distributed, combination, and centralized local* (OGC, 2005). Each type of architecture has its own advantages and disadvantages. In a centralized architecture, information is stored, managed, and served from a single server-database system. This architecture is suitable for mission critical applications wherein one is ensured of data access and availability and security is easily controlled. The downside of this architecture is the high cost of hardware necessary to handle the very big database and bandwidth necessary for simultaneous access to the server. In a distributed architecture, multiple autonomous server-database systems are connected via the Internet. In this configuration, data, security, and access is managed by each autonomous server. An advantage of this architecture is that if one of the servers fails or becomes compromised, the system will remain intact and will continue to function. Also, the entire system is scalable and the setup cost is much less than a centralized one. The combination architecture incorporates both centralized and distributed systems. At the lower (local level), computers store data on a central server-database system node. At the upper level, each node is inter-connected and functions as a distributed system. A centralized local architecture is similar to a centralized system, except that a replicate system is created to serve other purposes, including public access. Landsat.org Philippines follows an open, distributed architecture and is illustrated in **Figure 3.1**.

3.2 Earth Observing System Data and Information System (EOSDIS)

The Earth Observing System Data and Information System (EOSDIS) is a *distributed system with many interconnected nodes (Science Investigator-led Processing Systems and Distributed Active Archive Centers) with specific responsibilities for production, archival and distribution of Earth science data products* (NASA, 2004). EOSDIS was developed by NASA's Earth Science Data and Information (ESDIS) Project and is one of the major components of the Earth Science Enterprise as an access portal for data. The idea of a data and information system started in the 1980's when computational capabilities increased in tandem with the collection of satellite images of the Earth. Scientists realized the need for an information system to integrate and process different types of information acquired by different instruments at different times. A Data Panel comprised of scientists and program managers from NASA's EOS (Earth Observing Systems) developed the following recommendations for EOSDIS (NRC, 1999):

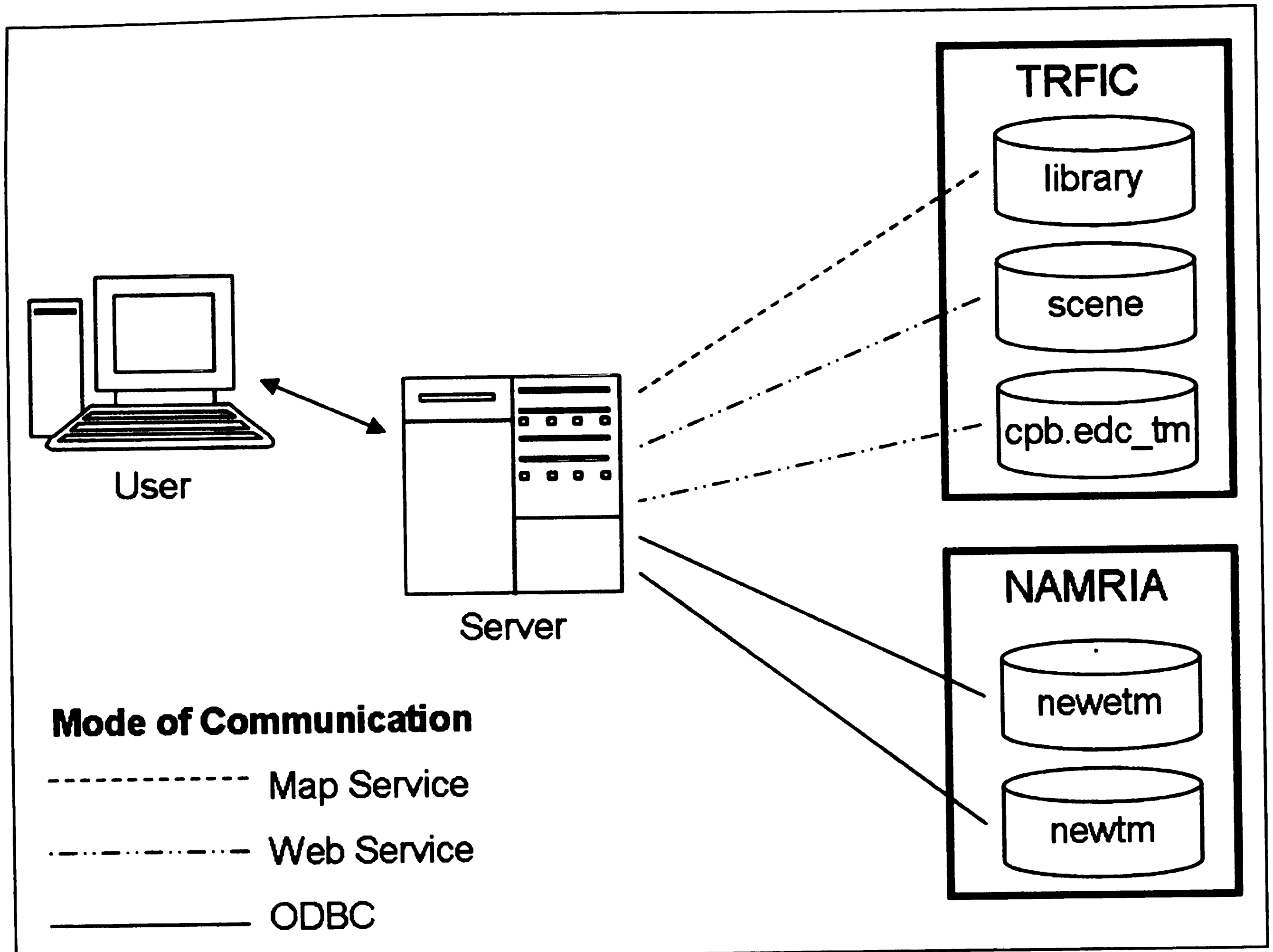

Figure 3.1. Computational architecture of Landsat.org Philippines.

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1. *Involve scientists directly and intimately in the planning and oversight of operations of EOSDIS.*
2. *Create a distributed system to stimulate creativity, enable prototypes, and facilitate evolution.*
3. *Enable scientists to interact with a wide range of datasets that are and will be widely dispersed.*
4. *Create the flexibility to adapt readily to rapid advances in electronic communications, networks, and computing capabilities.*
5. *Ensure that archiving approaches and facilities are both responsive and reliable.*

Scientists expected this system to be more than just a means to archive and retrieve data, including the capacity of data browsing, searching, online data processing, and archiving. Archiving processed data and making it available gives added value to raw data. EOSDIS has been envisioned as a flexible and adaptive system that serves the science community through engendering new modes of research. But NASA did not follow the recommendations of the Data Panel and the NRC and a *centralized* and *rigid* system emerged, instead of the envisioned distributed system (NRC, 1998).

EOSDIS is slowly evolving into a distributed system and has developed a "one-stop-shopping" portal called the EOS Data Gateway, which is being hosted at nine locations. These locations are shown in **Figure 3.2**. Every EOS Data Gateway node has the same "look and feel" and can be accessed from any part of the

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of the globe. **Table 3.1** shows the location and URL of each EOS Data Gateway node.

Although EOSDIS functions right now as a distributed system, it still does not meet some of the recommendations made by the Data Panel and the 1995 and 1998 recommendations of the NRC. EOSDIS is a distributed system within itself and fails to connect to other data repository areas including foreign ground receiving stations, ESIPs (Federation of Earth Science Information Partners), universities, government agencies, and data collections of project investigators. Another problem with utilizing the EOSDIS' EOS Data Gateway is that it requires a steep learning curve. Though functional, the interface has an intimidating appearance and is not intuitive for casual computer users to utilize. Also, because of the same "look and feel," of the data portal, the tools available for data search and query follows a "one size fits all" approach. Customization to account for different user needs and level of expertise is absent. Scientists, researchers, teachers, students, etc. will have to utilize the same set of tools for searching and querying data. In its implementation of the EOS Data Gateway, EOSDIS failed to take advantage of the concept of the search engine approach to search for information.

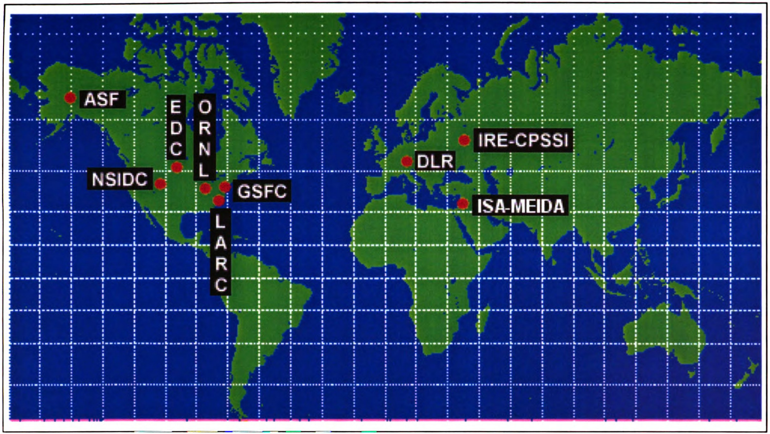

Figure 3.2. Geographic locations of EOS Data Gateway nodes.
Source: EOS Data Gateway Locations. URL:
http://redhook.gsfc.nasa.gov/~imswww/pub/imswelcome/imswwwsites.html

Table 3.1. Locations and URLs of EOS Data Gateway nodes.

Gateway Name	Location	URL
ASF	Alaska, USA	http://edg.asf.alaska.edu:8000/~imswww/pub/imswelcome/
DLR	Germany	http://ims.dfd.dlr.de/pub/imswelcome/plain.html
EDC	South Dakota, USA	http://edcimswww.cr.usgs.gov/pub/imswelcome/
GSFC/NASA	Maryland, USA	http://delenn.gsfc.nasa.gov/~imswww/pub/imswelcome/
IRE-CPSSI	Russia	http://www.ire.rssi.ru/~imswww/pub/imswelcome/index.html
ISA-MEIDA	Israel	http://www.nasa.proj.ac.il/~imswww/pub/imswelcome/plain.html
LaRC	Virginia, USA	http://edg.larc.nasa.gov/~imswww/imswelcome/index.html
NSIDC	Colorado, USA	http://nsidc.org/~imswww/pub/imswelcome/
ORNL	Tennessee, USA	http://daacl.esd.ornl.gov:8099/~imswww/pub/imswelcome/

3.3 Distributed Active Archive Centers (DAAC)

The Distributed Active Archive Centers (DAAC) are components of the EOSDIS and are *institutions that generate EOS standard data products and carry out NASA's responsibilities for data archival, distribution, and management* (NASA, 2004). There are 7 DAACs located in the United States of America. Each DAAC is unique and maintains an archive of data within the Earth Science discipline it serves. **Figure 3.3** shows the relative geographic locations of each DAAC and **Table 3.2** shows the functions of each. The DAAC are major components of EOSDIS and play an important role in the system's architecture. This role includes directly interacting with users and managing voluminous scientific data. **Figure 3.4** shows the function of the DAAC's in EOSDIS' architecture. Data acquired by a sensor are captured and processed by the ECS (EOSDIS Core System) contractor to level 0 and transmitted to the DAACs. The DAACs together with their science teams process level 0 data to level 1 using standard algorithms and/or data gathered from the field. These high-level, processed data are then distributed to users through the EOS Data Gateway.

DAACs. The DAACs together with their science teams process level 0 data to level 1 using standard algorithms and/or data gathered from the field. These high-level, processed data are then distributed to the users through the EOS Data Gateway.

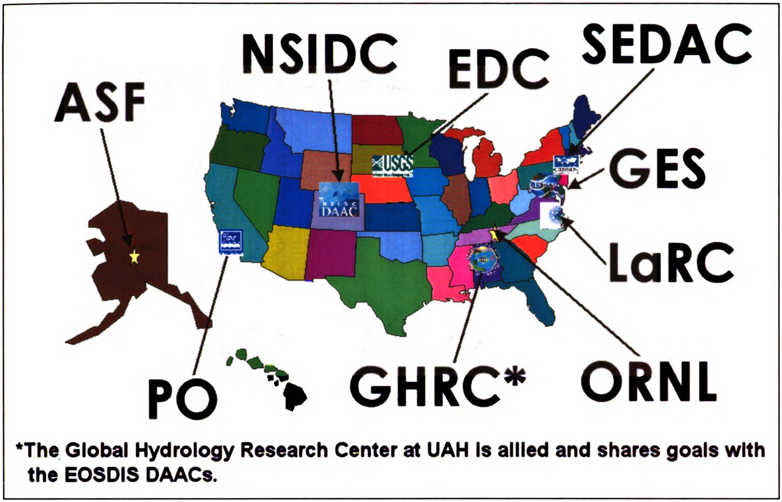

Figure 3.3. The relative geographic locations of DAACs.
Source: DAAC Alliance Data Centers. URL:
http://spsosun.gsfc.nasa.gov/eosinfo/Images/NewEOSDIS_Over_f2.gif

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Table 3.2. The DAACs and their functions.

DAAC	Full Name	Functions
ASF	Alaska Satellite Facility	synthetic aperture radar (SAR), sea ice, polar processes, Geophysics
NSIDC	National Snow and Ice Data Center	snow and ice, cryosphere, climate
LP	Land Processes	land processes
SEDAC	Socioeconomic Data and Applications Center	population, sustainability, geospatial data, multilateral environmental agreements
GES	GSFC Earth Science	upper atmosphere, atmospheric dynamics, global precipitation, global biosphere, ocean biology, ocean dynamics, solar irradiance
LaRC	NASA Langley Atmospheric Sciences Data Center	radiation budget, clouds, aerosols, tropospheric chemistry
ORNL	Oak Ridge National Laboratory	biogeochemical dynamics, ecological data, environmental processes
GHRC	Global Hydrology Resource Center	Hydrologic cycle, severe weather interactions, lightning, convection
PO	Physical Oceanography	ocean processes, air-sea interactions

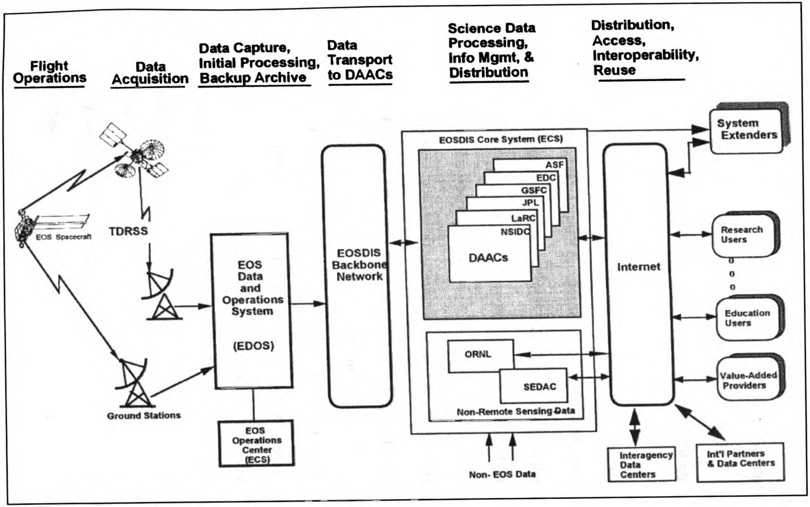

Figure 3.4. Function of the DAACs in the EOSDIS architecture.
Source: Review of NAS's Distributed Active Archive Centers (1999). Copyright © Natioanal Academy of Science. All rights reserved.

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In 1999, the NRC conducted a review of NASA's DAACs and their findings and recommendations have some similarities to the recommendations of the Data Panel and NRC's 1995 recommendations for EOSDIS. Some of the findings and recommendations are summarized as follows (NRC, 1998):

1. *To function optimally, the DAACs need to be intimately involved with the science community they serve.*
2. *The DAACs do not yet act as components of a coherent system.*
3. *To take advantage of the unprecedented flexibility afforded by the new Web-based technologies, ESDIS should allow the DAACs to incorporate only those components of the ECS that they require to satisfy the user community.*

Though EOSDIS interconnects the DAACs through the EOS Data Gateway and allows data searching from multiple DAACs, an individual DAAC has limited ability to access data from other DAACs and they do not comply with OGC Specifications. This limitation is one of the problems of the current information system design for EOSDIS because it prevents users of individual DAACs to take advantage of information archived at other DAACs. Each DAAC supports a unique science discipline. The available tools and the mode that data are served are customized to fit the unique needs of each DAACs' client. By providing access to data from other DAACs and customizing data for the use by local clients, a truly useful open, distributed GIS data archive system that would lead to knowledge discovery can be achieved.

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3.4 Earth Science Information Partners

The growth of the World Wide Web and emergence of powerful and affordable computers with increased storage capacity in the late 1980's made large-scale data processing and storage possible on ordinary desktop computers. Data management and processing tasks that were done by the DAACs, can now be performed more efficiently and cost effectively on ordinary desktop computers. These improvements in computing technology together with the growth of the Internet made the creation of a truly open, distributed information system feasible. Seeing this possibility, the NRC recommended the transfer, on an experimental basis, of some of the DAACs tasks, such as product generation, publication, and user services to a federation of partners from the academe, government, and the private sector. In 1998, NASA created the Earth Science Information Partners (ESIPs) as a prototype of such a federation. Three types of ESIPs exist, each with its set of characteristics and user communities. **Table 3.3** shows the responsibilities and compositions of each type of ESIP. The DAACs fall under the type 1 category of ESIPs. The list of type 2 and 3 ESIPs is attached as **Appendix A**.

ESIPs have in their archives a diverse collection of data products as a result of serving their clients. These products have added value because they have been processed, interpreted, and/or improved. Allowing other scientists to access and utilize these products will promote interdisciplinary research.

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Table 3.3. Responsibilities and compositions of ESIPs.

ESIP Type	Responsibilities	Composition
1	responsible for standard data and information products whose production, publishing or distribution, and associated user services require emphasis on reliability and adherence to schedules	DAACs and science teams for specific instruments
2	are responsible for producing innovative science information products and services, which primarily serve the global change and earth science communities	Science teams and global change scientists
3	responsible for providing innovative, practical applications of earth science data to a broad range of users beyond the global change research community	Science teachers, college earth science students, policy analysts, interested public, research scientist working outside their discipline, and for-profit businesses

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Like the DAACs, the ESIPs, though federated, are not directly interconnected information systems. Each ESIP maintains its own database for its exclusive access and use. Each ESIP has its own web portal through which users access data. If users need data from another ESIP, he or she will have to go to the other ESIP's website. The result is a fragmented information system and users do not get the benefit of having integrated data from different ESIPs.

3.5 Landsat Data Acquisition and Ground Receiving Stations

Twenty ground receiving stations, scattered around the globe, are capable of receiving Landsat data. These ground receiving stations are also capable of receiving data from other types sensors. Examples of these data are: radar, multi-spectral imageries from QuickBird® and IKONOS®, and hyper-spectral imageries. Each station maintains an archive of satellite data for its area of coverage. **Figure 3.5** and **3.6** shows the global coverage and distribution of ground receiving stations for Landsat TM and ETM+. The list of ground receiving stations is provided in **Appendix B**.

In 1992, the Land Remote Sensing Policy Act (Public Law 102-555) was enacted by the US Congress to support climate change research. This law ensures the availability of Landsat 7 data to the public, both local and foreign, without any restrictions on use and distribution, and at the most affordable price possible. The enactment of this law paved the way for the creation of the Landsat 7 Data Policy, which provides guidelines for the *acquisition, processing,*

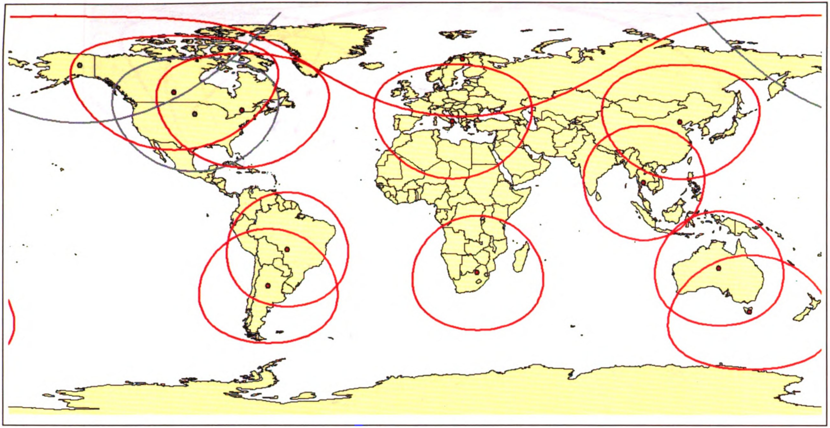

Figure 3.5. Landsat 5 ground receiving stations and their coverages.
Source: USGS Landsat Project. URL:
http://landsat.usgs.gov/project_facts/ground_assets/ias_network/images/landsat%205%20network%20for%20we

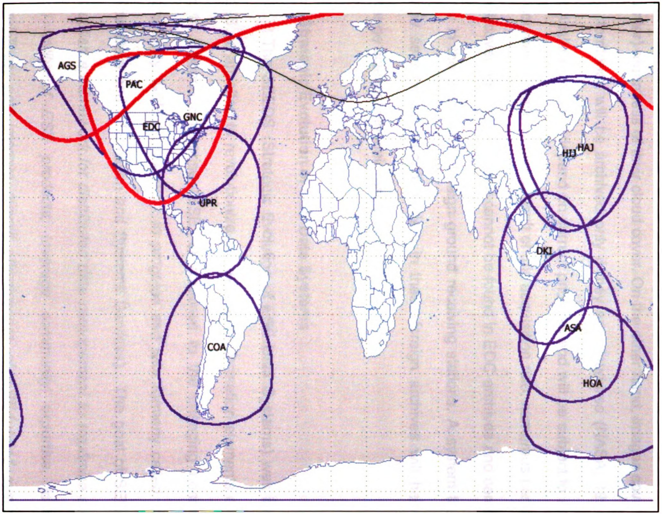

Figure 3.6. Landsat ETM+ ground receiving stations and their coverages, as of November 2004. Source: Landsat 7. URL: http://landsat.gsfc.nasa.gov/.

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archiv[ing], distribution, and pricing of Landsat 7 (NASA, 1994) data. This policy also stipulates that *Landsat 7 will acquire every daytime scene on every pass over the United States* (NASA, 1994) and will be archived by EDC (Eros Data Center) regardless of their cloud cover. On the other hand, images covering non-US territories will be archived only if they are *cloud-free* (NASA, 1994). Their acquisition will also depend on current priorities and will be subject to spacecraft resources limitations. As a result of this acquisition rule, numerous Landsat data that cover non-US territories cannot be found in EDC archives and can be found only in the archives of foreign ground receiving stations. A system that would allow searching for Landsat data in these foreign archives will help climate change scientists in their research.

3.6 Strategic Evolution of ESE Data Systems

The SEEDS (Strategic Evolution of ESE Data Systems) was initiated in 1998 as an effort to revolutionize the data and information elements of NASA's Earth Science Enterprise (ESE) in response to the changing needs of the community. SEEDS is a work in progress and was formerly called NewDISS (New Data and Information and Systems Services). The goal of SEEDS is to *establish a framework for distributed data management to maximize availability and utility of ESE products; leverage community expertise, ideas, and capabilities; and improve overall effectiveness of ESE-funded systems and services* (NASA, 2003b). SEEDS is the latest blueprint for the development of ESE and capitalizes on previous technologies developed for the enterprise, in

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including lessons learned from the implementation of past projects. SEEDS is an evolution and not a replacement of existing NASA information technologies. To achieve the goals of SEEDS, certain strategies should be followed when developing an information system. Some of these strategies includes using an *open, distributed set of data systems and service providers* (NASA, 2003b) and *leveraging information technologies from the commercial sector, such as web-based techniques, for data discovery and access, and involving the end user community in technology assessment and evolution* (NASA, 2003b).

Some of the objectives of this thesis are similar to the objectives of SEEDS. The results of this thesis will be useful to the science community and will be a direct contribution to NASA's SEEDS initiative.

3.7 The Philippines National Geographic Information Infrastructure

The Philippines National Geographic Information Infrastructure (NGII) is the Philippines' initiative to make geographic data available to people by using World Wide Web technologies and protocols. The NGII, an offshoot of the Philippines E-commerce Bill, signed into law on June 2000, was enacted through Executive Order 265. The NGII is the Philippines' version of the National Spatial Data Infrastructure (NSDI), modified and customized to suit needs of the Filipino people. The NAMRIA is mandated to head and manage the NGII working group. The different phases of NGII should have been implemented during 2001 to 2005. But because of standards issues, budget cuts, and some institutional problems, the implementation of the project was postponed. Many of the goals of

NGII are similar to the objectives of this research. Technologies used for this research can be used as baseline technologies to initiate the implementation of NGII.

The NGII is needed *to support the country's socio-economic development and maintenance of ecological balance* (NAMRIA, 2000). The NGII has several components: the institutional framework development plan, fundamental datasets, technical standards and protocols, and the clearing house network. With all its components and plans, the NGII is a very ambitious, but necessary, project that requires support and initiative from the national government because its implementation requires inter-agency involvement. Similar to the NRC's criticisms of NASA, NAMRIA's "top-down" approach in handling the development of its information systems failed to deliver the required results. Development of information systems is best done on a "bottom-up" approach because this model fosters early adoption and promotes creativity, which leads to further development of the technology.

A "bottom-up" approach is a type of developmental strategy wherein innovation is introduced first to the lower level end users. Adoption is expected to go up the organizational or industry chain. A "top-down" approach is a type of developmental strategy wherein innovation is introduced by administrators or departments to the rest of the organization. Adoption of the technology is expected to diffuse down the organizational or industry chain.

This research fulfills some of the goals of the NGII. Technologies and concepts used for this research may be used and/or improved to build the Philippines' NGII.

3.8 Landsat.org

The Tropical Rainforest Information Center (TRFIC) (http://www.bsrsi.msu.edu) is a type 2 ESIP with a mission to *provide NASA data, products and information services to the science, resource management, and policy and education communities* (TRFIC, n.d.). TRFIC provides Landsat data through an internet map server enabled web portal. TRFIC evolved into Landsat.org (http://www.landsat.org) and has the largest collection of Landsat data outside of the US government. In some ways, Landsat.org is a distributed information system. Though it maintains its own local database, the system is designed to interface with the USGS Landsat database at EROS.

Landsat.org is successful for several reasons: First, the graphical framework used for data selection is custom tailored to the Landsat tile system. Custom tailoring simplifies the selection interface and removes unnecessary details to accommodate other datasets. Second, very few steps are needed to perform a query and obtain results through rapid thumbnail browse products. Third, more comprehensive results are obtained from a search query due to Landsat.org's ability to obtain regular updates from the USGS Landsat database. Fourth, the presence of unique data visualization tools, such as GeoZoom and StripBuilder provide users the support needed to select the imagery. These tools

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allows the user to examine and interact with search results. Fifth, the ability of Landsat.org to financially sustain itself is a model information system that incorporates e-commerce. Though the majority of the cost of operating Landsat.org is being shouldered by NASA, the system generates income for system support and maintenance.

The same e-commerce concept should be imbedded in any information system. The purpose of putting a price on public domain data is not for profit, but to cover the cost of system maintenance and data delivery. This scheme ensures continuous availability of the system and encourages innovation and growth.

3.9 Democratizing Geospatial Information

Lack of access to information is one of the reasons why developing countries have not had significant improvements on their economies. While highly developed countries like the United States, Canada, or UK have made significant steps to utilize and develop their information infrastructures to improve their economies, deliver government services, and improve learning, developing countries have not done the same and the consequence is the widening of the information divide between these two disparate economies. Geospatial information, though may not be viewed as something that can directly contribute to the economy of a developing country, is needed in resource allocation decisions, which if made properly will contribute to economic growth. Bringing the right information to the right people through an information system will not only na

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narrow the information divide, but will also lead to a well informed community capable of making sound decisions regarding their environment.

Most developing countries, including the Philippines, do not allocate a large portion of their national budget to science and technology. The effect of this small budget allocation is the stunted state of these disciplines in these countries. It will take developing countries several years of concerted effort to catch up to the level of scientific advancement that highly advanced countries have achieved. The good news is that by improving the information infrastructure in developing countries, people in these countries can have access to information and technologies developed in more advanced countries. Developing countries can utilize these advancements to improve their economy and standards of living. Landsat.org Philippines is an information portal and would bring products and technologies to the hands of people. In essence, this system will democratize geospatial information.

3.10 The Open Geospatial Consortium

The Open Geospatial Consortium (OGC) is a non-profit organization who advocates the use of *interoperable solutions that "geo-enable" the Web, wireless and location-based services, and mainstream IT* (OGC, 2005). This organization is a consortium of 293 companies, government agencies, and universities from around the globe. Part of the work of OGC is to develop specifications for geospatial data publication, exchange, and GIS processing. These specifications are collectively called OGC Specifications. Technology developers adhering to

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OGC Specifications are ensured that their work is open and interoperable with other technologies that adhere to these specifications. Because the OGC is made-up of industry leaders and mainstream stakeholder, the specifications published by the organization automatically becomes an "industry standard" and is adopted worldwide. Any technology not adhering to these standards will find itself obsolete and isolated. As much of today's GIS data are searched, browsed, served, and transferred through the web, OCG provides an Internet map server standard that complies with W3C (World Wide Web Consortium) standards.

The OGC, formerly called Open GIS Consortium, also addresses the data exchange problems faced by GIS data users. When GIS technology was still young, researchers and students doing GIS often had to perform data translation before the data can be used. Data importation and exportation was a routine task when doing GIS and many times information is lost or corrupted during these processes. This problem was further exacerbated when new GIS software with closed proprietary data formats emerged from software manufacturers.

An optimal open, distributed GIS data archive system (ODGISDAS) is one that serves geospatial data in compliance with OGC and W3C standards. By using an internet map server such as ArcIMS®, which complies with OGC standards, and generic web technologies and formats such as Web Services, HTML, JavaScript, and JPEG, that are endorsed by the W3C, in the development of the ODGISDAS, one can ensure interoperability with other information systems available online and future usability. Ensuring interoperability among information systems eliminates the incoherency that plagued EOSDIS.

3.11 Web Services

Web services are self-contained and self-describing application components that utilize open protocols for communication. Web services utilize XML (extensible markup language) as language for communication and are platform-independent. Through web services, applications running on a Windows® operating system can communicate with another application running on a computer with a UNIX operating system. Web services utilize HTTP (hypertext transport protocol) for sending information. By default, HTTP utilizes port 80 for transactions. Utilization of HTTP for transactions is one of the greatest advantages of web services. HTTP is the protocol used for browsing the Web and all transactions using this protocol is processed through port 80. Web servers and firewalls are configured to allow transactions through port 80. Deploying and utilizing a web service is less complicated because no firewall and web server reconfiguration is required.

Web services have three basic platform elements: *SOAP, WSDL, and UDDI* (W3 Schools, 2005). The simple object access protocol (SOAP) is a protocol used by web services for exchanging information over the network. SOAP is XML based and utilizes HTTP. The universal description, discovery, and integration (UDDI) is a directory of web services and an open industry initiative to help businesses discover available services over the Internet and facilitate in the integration of their applications. UDDI is being sponsored by OASIS and can be accessed using the URL http://uddi.org. The web services description language (WSDL) is an XML-based language used for describing web services and their mode of access. WSDL provides information on the URL and methods required to utilize a web service.

3.12 Z39.50

Libraries around the world are using the Z39.50 protocol to communicate between each other's databases. The Z39.50 is a national and international (ISO 23950) standard defining *a client/server based service and protocol for [i]nformation [r]etrieval.* (Library of Congress, 2003). Though the Z39.50 has been around for quite sometime, the protocol has not been widely popular because of the absence of standards during its earlier phase and the difficulty in using its syntax. This protocol utilizes a special, text based, non-descriptive syntax in queries and results. Though the language used by the protocol is text based, it is non-descriptive and requires a look-up table to decipher the language. The Z39.50 utilizes the Internet and a special port for transferring information from one computer to another. The Z39.50 protocol is continuously evolving.

CHAPTER IV

CONCEPTUAL FRAMEWORK

4.1 Data Broker Model

Three classes of data holdings are in existence: class 1, central archives; class 2, large science facility/project holdings; and class 3, individual project investigators. Class 1 data holdings are big data repositories similar to NASA's DAACs. Class 2 data holdings are medium-size data repositories similar to the Tropical Rain Forest Information Center (TRFIC) at Michigan State University. Class 3 data holdings have a small collection of data usually being held by the project investigator or a small group of individuals. Developing a system that can connect to these different classes of data holdings requires following a new data broker model different from traditional ones.

A facility that follows the traditional data broker model acts as long term data repositories and data ordering centers for the user community. These facilities handle different types of data from different sensors designed for different science disciplines (land, atmosphere, snow, etc.) and are all available to the user. These facilities have a web portal so that users can browse and access their data collection. Because the portal handles different types of data, it bears the characteristic of a "wholesale super store" rather than a data center. The web interfaces of these facilities are built around data management and inventory needs and are not based on user's needs. Thus, users with different levels of expertise, including scientists, teachers, students, resource managers, etc. will have to utilize the same interface.

A new data broker model proposed by Skole (2005) is the "supply chain management approach" (**Figure 4.1**). This model has been successfully used by popular fast food chains around the globe. The clear advantage of this model over the traditional one is that data brokers do not just provide data to users, but also provide their services with domain expertise. Data brokers can serve their clients more effectively because they know their client's needs and are the right people to fulfill these needs.

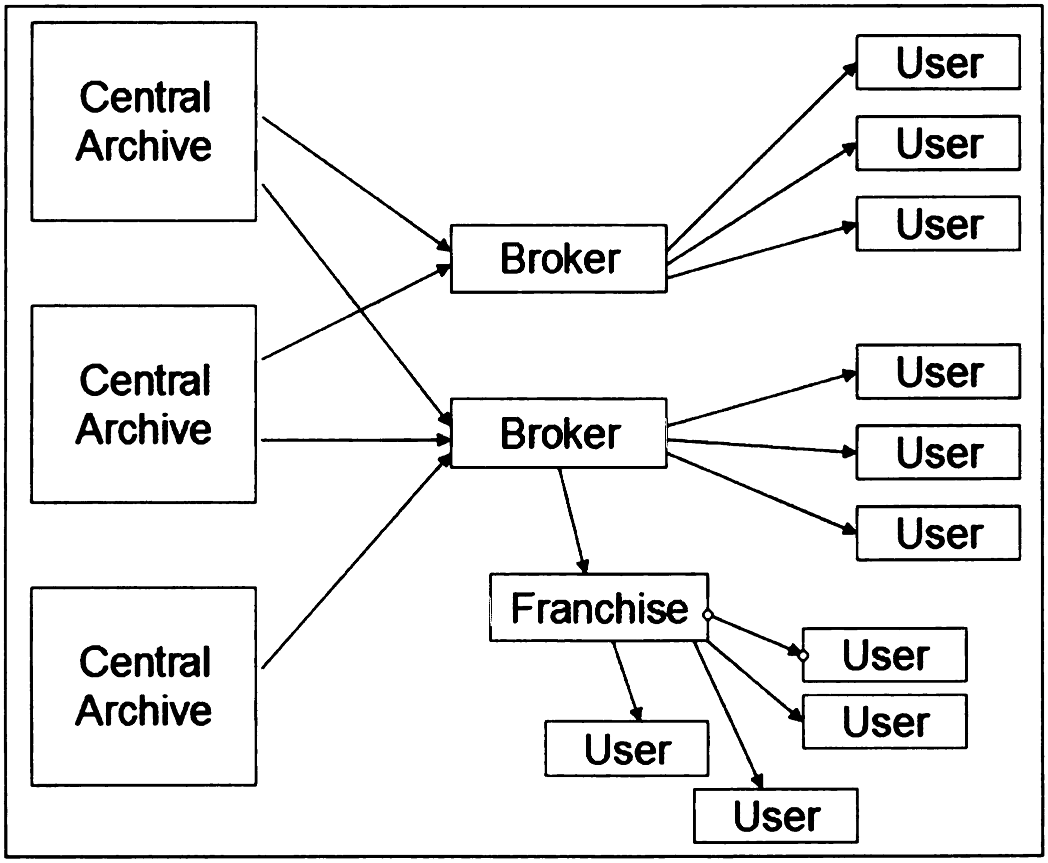

Figure 4.1. Supply chain management data broker model. Adapted from Skole (2005).

A good illustration of special client needs is the EasySearch™ interface of Landsat.org Philippines. EasySearch™ utilizes the names of places in the Philippines to select for Landsat data. EasySearch™ was developed to cater to numerous clients who may want a satellite data but are not familiar or would not bother learning the WRS2 tile system. Landsat.org Philippines satellite data search is also linked to an online topographic map. Many traditional resource managers in the country are used to using the topographic map as reference. This link will help these people in their search for Landsat data. Data brokers may also form alliances and franchises to better serve the needs of the community.

One of the advantages of the "supply chain management approach" is its flexibility to expand its network through the franchising scheme. Several franchises can be created depending on the demand for data and services. Franchisees have freedom to innovate and can develop tools to encourage the local community to utilize GIS data in their decision making. Franchisees are in a better position to lend their technical expertise to local users because they are much closer to them and understand their needs. In other words, franchisees have domain expertise.

The franchising scheme has been proven effective in distributing satellite data to users. TRFIC is the pioneer of the "supply chain management approach" and the franchising scheme to Landsat data distribution. The first franchise of TRFIC is Landsat.org Indonesia (URL: http://btic.biotrop.org/landsat7/), which has been serving users in Indonesia for five years. Landsat.org Philippines is another franchise that will serve the Philippines.

Data in the custody of individual project investigators may easily be shared using peer-to-peer technology. Peer-to-peer software has become popular among college and university students for sharing copyrighted music and movies. The same technology used by these students can be used for sharing satellite data. Some examples of peer-to-peer software are BitTorrent®, Jaxta®, Kazaa®, etc. The only downside of this method is the bad publicity it has been getting from the RIAA (Recording Industry Association of America) and MPAA (Motion Picture Association of America) who have been filing cases against individuals for downloading and sharing copyrighted material over the Internet. Nevertheless, peer-to-peer technology is here to stay and may be used by scientists to share their data.

4.2 Landsat.org Philippines Transaction Model

Landsat.org Philippines is a franchise of TRFIC and follows the "supply chain management approach" model for data distribution. Landsat.org Philippines serves as Landsat.org's information node in Southeast Asia and offers customized features that cater to the needs of local users. Examples of these features are: translated language for the web site, Southeast Asian country navigation, local place name search, etc. **Figure 4.2** shows the data broker diagram for Landsat.org Philippines.

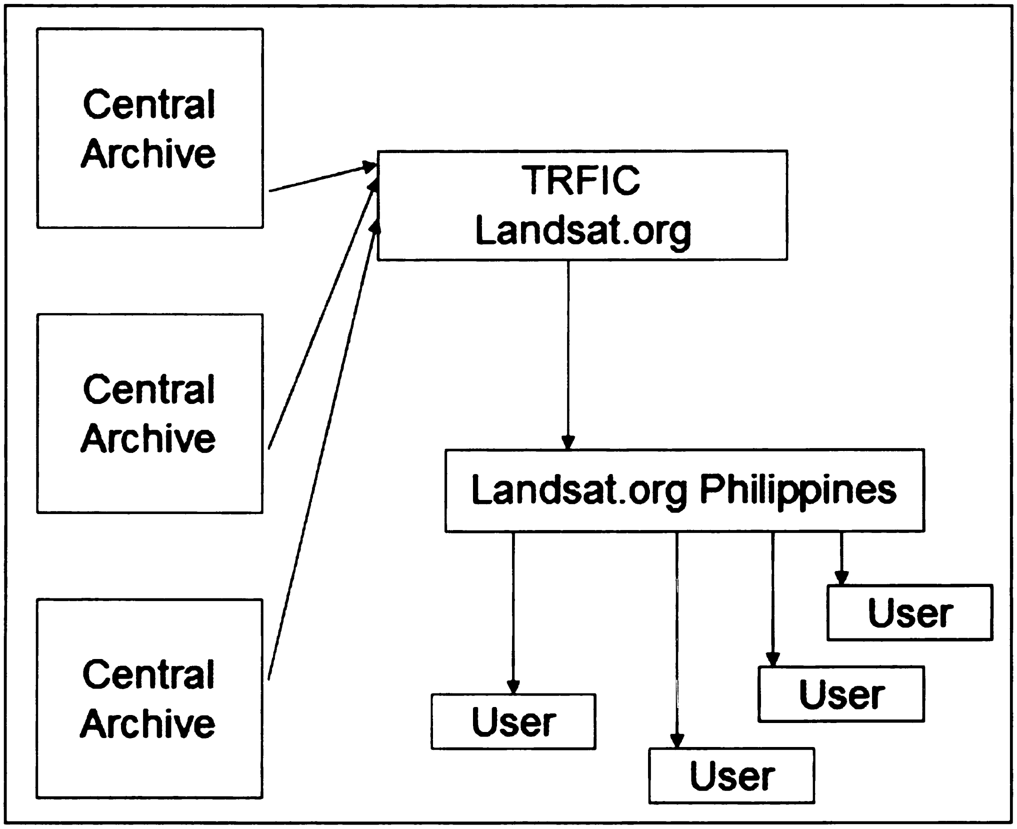

Figure 4.2. Data broker diagram for Landsat.org Philippines.

4.3 Landsat.org Philippines' Relevance to REASoN

REASoN (Research, Education and Applications Solutions Network) is NASA's distributed network of data and information providers for earth science enterprise science, application and education. Simply put, REASoN is a network of NASA information partners. The purpose of this network is to *support science findings and applications directed toward understanding and predicting the future of the Earth and developing policy and resource management decision support systems, and education tools to inspire and* *tra*

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train current and future generations of scientists (NASA, 2003).

A CAN (Cooperative Agreement Notice) was issued by NASA soliciting proposals for *"solutions" that exploit the capabilities of the Internet for data delivery, access to information, dynamic updating of databases and educational use of data and information* (NASA, 2002). The group whose proposal was accepted by NASA for funding will automatically become a part of REASoN. TRFIC, being an existing information partner of NASA, is already a part of REASoN. Landsat.org Philippines, being a franchise of TRFIC's Landsat.org, extends the functions of TRFIC to Southeast Asia and contributes to the thrust of REASoN. Like Landsat.org, Landsat.org Philippines, utilizes the Internet as a means for users to access satellite data.

4.4 History of Landsat data Usage and Distribution

Up to the mid 1990's most researchers utilized single scene Landsat. Analysis was limited to such a small extent because of hard disk space and computational limitations. The way Landsat data was ordered then was also on a per scene basis. An IMS (information management system) was developed by NASA and was built around the per scene ordering scheme. The IMS is used for browsing and querying data, doing inventory of scene orders, and performing "hyper-GIS" for information retrieval and analysis.

The new approach to environmental research has evolved from specific (deductive) to a wholistic approach. Scientists have recognized the complexity of the environment and the interaction among different factors and events. To account for these complexities, scientists required the use of a much larger extent satellite data, going beyond the traditional per scene ana

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analysis. Advances in computer technology have made possible processing and storage of massive amounts of satellite data with high-spatial resolutions. Now, it is common for researchers to order numerous high-spatial resolution satellite data for their research. A need exists to develop technologies for searching, querying, and ordering numerous Landsat data that transcends beyond the per scene ordering model.

Because researchers now use massive amounts of satellite data in their projects, their individual laboratories and institutions have become large repositories of satellite data. These *data sets are not fully exploited, and much new information remains to be uncovered* (NRC, 2002). A need exists to develop a technology that could access these dispersed data repositories so that scientists can have access to the satellite data that they require for their research.

Recent advances in Internet technology have made possible the performance of complex, interactive operations and movement of large amounts of data from one computer to another. Distributed access is common among banks and retail stores that operate using multiple servers and databases distributed geographically. Publishing maps on the web is already done by government agencies involved in resource management. With existing computer and Internet technologies, a new mode of distributing and utilizing Landsat data can be developed. By using popular scripting languages, applications can be developed to perform discovery, query, and access to Landsat data stored at different repositories distributed around the world. Seamless, multiple queries can be performed on distributed Landsat databases, going beyond traditional scene boundaries into larger geographic extents. Web GIS can be utilized to perform complex geographic queries and operations on distributed geospatial data. One of the ultimate goals in GIS and remote sensing is to perform analysis on data residing on distributed databases without the need to physically store or download a copy of the original data onto the user's hard drive. Only the results of the analysis are required on the local hard drive.

4.5 Area of Application

Forests are a natural resource and are an integral part of the earth's ecosystem. Forests are a source of raw materials for shelter and manufacturing and a source of food and livelihood for many people. Forests are essential components of the hydrologic and carbon cycle. Because of the versatility and value of forest resources, the majority of the world's forests are continuously under the threat of deforestation.

Forests serves as carbon sinks and their degradation and regeneration affects the amount of carbon present in the atmosphere. To understand the contribution of forests to the global carbon budget, massive, multi-temporal, high-resolution images covering the world's major forests are needed. Landsat data is suitable for use in studying forest dynamics because it provides a synoptic view of the landscape and massive multi-temporal data have been acquired and are stored in data archives. Matricardi (2003) has demonstrated using such data in studying forest degradation in the Amazon. Utilizing Landsat data to study forest contribution to global carbon flux will involve using several tiles of adjacent Landsat images taken at different times. Though the science community has a massive collection of Landsat data, these data are not readily accessible because they are stored in highly dispersed data archives. The scattered nature of the archives has limited and/or prevented the optimum usage of these data by researchers. The current challenge is to be able to implement a system that allows discovery, query, and access to distributed archives using open standards and protocols.

CHAPTER V

METHODS

5.1 Overview

The architectural diagram of Landsat.org Philippines is shown as **Figure 5.1**. As a data archive system, Landsat.org Philippines does not merely archive data but organizes and manages them for easy search and access by internal and external users. Being an open system, Landsat.org Philippines uses standard protocols and technologies. Using these standards means the system can be accessed from and can interface with any application developed for any operating system. As a distributed system, Landsat.org Philippines relies on distributed databases scattered at different geographic locations. Being able to access multiple databases means a more comprehensive data search results and is one of the major strengths of Landsat.org Philippines. Landsat.org Philippines utilizes the Internet to connect to TRFIC and other remote databases. Landsat.org Philippines can be accessed using the URL: http://202.90.128.189.

The development of the ODGISDAS was guided by the following objectives, also stated in Chapter 1:

1. Demonstrate the possibility of searching for Landsat data from multiple databases located at different geographic locations from a single web portal.
2. Develop an open, distributed GIS data archive system (ODGISDAS) using common computer technologies and software already available

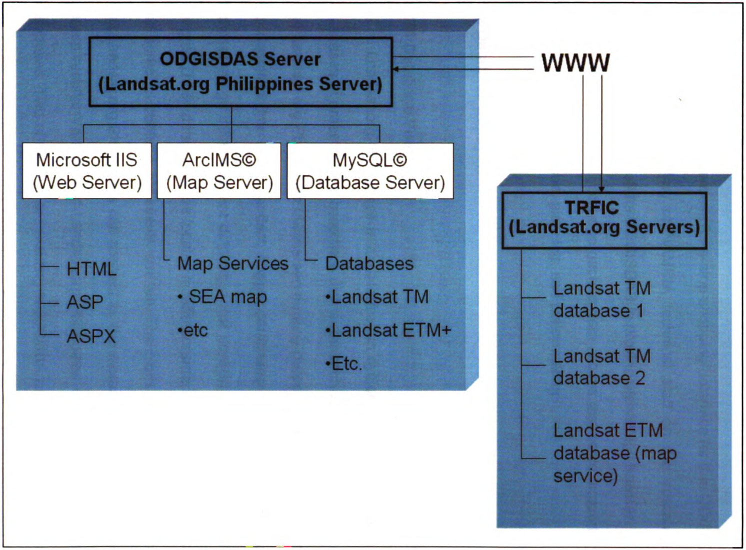

Figure 5.1. Archirectural diagram of Landsat.org Philippines.

in most government offices and universities, but integrated through standards and protocols.

3. Develop a seamless “one-stop-shopping” interface for this ODGISDAS.
4. Conduct training of NAMRIA technical staff on the operation and maintenance of the ODGISDAS to provide technology transfer.
5. Provide a technical approach to data access that could support spatial decision support, planning, and policymaking.

5.2 Database Subsystem

5.2.1 Database Function

Landsat.org Philippines is an information system and requires access to databases in order for it to become a distributed archive system. The databases that Landsat.org Philippines utilizes serve many purposes. These databases can be classified into two: Landsat image databases and systems databases. Landsat image databases are databases that contain information about Landsat images. These databases are located in different data centers distributed globally and serve as contents for search queries. The more Landsat image databases that Landsat.org Philippines can connect to, the more comprehensive will be the search results. Version 4 of Landsat.org Philippines utilizes five Landsat image databases. Two of the five are residing in NAMRIA and the three are located at the TRFIC, Michigan State University. **Figure 3.1** is a diagram showing these Landsat image databases.

Systems databases are databases that Landsat.org Philippines needs in order for it to run. These databases are used by the system to provide advanced capabilities and store user's order information. Version 4 of the system utilizes the databases ancillary, parowcorner2 and seanames to provide for the advanced capabilities. These three databases are static or do not grow in size because they are not written into. The databases userinfo and userorder are the user related databases and they store user information such as address, telephone number, order information, etc. These databases grow in size because they are written into. **Table 5.2** is the list of MySQL® database tables used by different versions of Landsat.org Philippines. The schemas of the databases used in the system are listed in detail on **Appendix C**.

5.2.2 Establishing the Local Database

Prior to the conduct of this research, NAMRIA did not have a database of its Landsat data collection. A local database had to be established to hold the list of Landsat data and to support features of Landsat.org Philippines. MySQL® database software was chosen to handle these tasks. MYSQL® was chosen over other database because the software is free, fully functional, can handle multiple online transactions, well supported, easy to install, and well documented. By using a free database, the objective of this research to establish the ODGISDAS at the least possible cost, using common off-the-shelf technologies is achieved.

MySQL® database and its ODBC driver were installed on the ODGISDAS server. The ODBC driver is needed by GateKeeper3 to access MySQL® databases even if both applications are hosted on the same server. MySQL® Administrator and Control Center were also installed on the ODGISDAS server. These two additional programs are used to manage MySQL® with a graphical user interface, an alternative to the command line mode of management. Blank database tables, including their schemas, can be created in the Control Center and later updated with values. Database table contents can also be edited and deleted using this program. **Figure 5.2** is a screen capture of MySQL® Control Center, showing the schema of landsatetm. User names, permissions, and passwords for databases are created and set in MySQL® Administrator. A user account for Landsat.org Philippines users was created in Administrator and the access permission for each database was set. **Figure 5.3** shows a screen capture of MySQL® Administrator. **Table 5.1** is the list of MySQL® database tables with Landsat.org Philippines user access permissions. The tables that were brought into MySQL® were originally in Microsoft Access® or Excel®, Dbase, or ASCII (American Standard Code for Information Interchange) formats. These data had to be exported into a comma delimited format and imported into MySQL®.

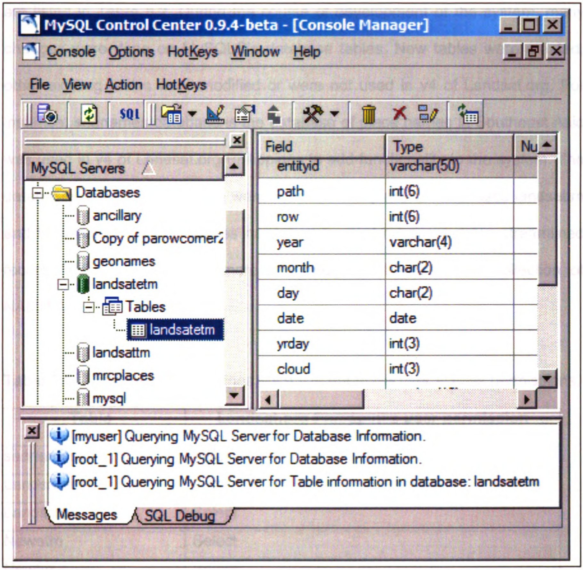

Figure 5.2. Screen capture of MySQL® Control Center with landsatetm table selected and schema shown.

Landsat.org Philippines uses several MySQL® database tables and they are listed in **Table 5.2**. During the course of development of the system, many changes were done on MySQL®'s database tables. New tables were created, other existing tables were modified or were not used in v4 of Landsat.org. For instance, seanames database is the database of place names in Southeast Asia was used in v4 of Landsat.org Philippines to add functionality to the system. The databases newtm and newetm were used in v4 in place of databases landsattm and landsatetm. The databases newtm and newetm have a more streamlined record fields and represent more accurately the Landsat data collection of NAMRIA.

Table 5.1. Landsat.org Philippines MySQL® database user access permissions.

Table	Landsat.org Philippines user permission
seanames	Select
Landsatetm	Select
Landsattm	Select
Newetm	Select
Newtm	Select
Parowcorner2	Select
Places	Select
Seaparow	Select
Userinfo	Select, update, delete
userorder	Select, update, delete
Ancillary	Select

Table 5.2. MySQL® database tables being used by different versions of Landsat.org Philippines.

Table Name	Description	V1	V2	V3	V4
Landsatetm	Initial Landsat ETM+ database	✓			
Landsattm	Initial Landsat TM database	✓			
Newetm	More comprehensive Landsat ETM+ database		✓	✓	✓
Newtm	More comprehensive Landsat TM database		✓	✓	✓
Parowcorner2	Path and row geographic coordinates of corners coordinates	✓	✓	✓	✓
Seanames	More comprehensive list of places with geographic coordinates				✓
Places	List of places with geographic coordinates			✓	
Userinfo	User's information database	✓	✓	✓	✓
Userorder	User's order database	✓	✓	✓	✓
Ancillary					✓

The database tables, landsatetm, landsattm, newetm, and newtm are Landsat image databases that holds image information. The schemas of these tables were patterned after the schemas of Landsat.org's Oracle® database tables.

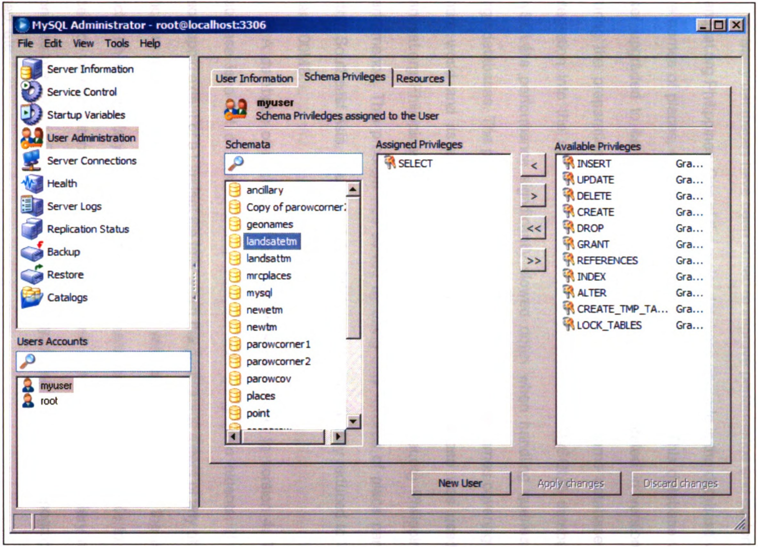

Figure 5.3. Screen capture of MySQL® Administrator with landsatetm table selected and privileges shown.

Many databases have been added to improve performance and customize Landsat.org Philippines. One of the major database upgrade is the database with the names of places, which is being used by EastSearch®. This database was later upgraded to be more comprehensive and is incorporated in version 4. During the preparation of this more comprehensive place name database for integration into the system, I discovered a problem with MySQL® database. MySQL®'s performance significantly slowed down when handling queries on large databases. The place name database contained place names covering the entire world and its size was about 2GB. If such a database was used in Landsat.org Philippines, the database will slow down Landsat.org Philippines' performance. This problem was solved by using only records of place names within Southeast Asia. The size of the database was significantly reduced to less than 100MB.

A database of ancillary spatial data was also added to version 4. This database is a list of available map services with geographic extents. If the geographic extent of a Landsat tile falls within the geographic extent of any of the ancillary map service, a list of these services will be generated when the user clicks on the ancillary data link. These map services become available to the user for viewing interactively or statically. Some of the available ancillary map services are: slope, DEM, forest cover density, forest cover map, topographic map, etc.

5.2.3 Connecting to Remote Distributed Landsat Databases

Under laboratory conditions, Landsat.org Philippines communicated with TRFIC databases using ODBC (Open Database Connectivity). This mode of communication worked because of the corporate security measures in place for the entire laboratory computer network. But when Landsat.org Philippines was installed on NAMRIA's server where the network conditions were different, Landsat.org Philippines failed to perform as designed. NAMRIA's server is behind a hardware firewall. A hardware firewall is another computer in between the web server and the World Wide Web. The function of the hardware firewall is to keep hackers away from the web server by serving as a physical barrier, closing unnecessary ports, and filtering traffic. NAMRIA's hardware firewall can be controlled and configured using a software manufactured by Symantec®. NAMRIA's hardware firewall has prevented Landsat.org Philippines from communicating with TRFIC databases using ODBC connection. Theoretically, the hardware firewall can be configured to allow internet traffic caused by ODBC to pass through. But several attempts to configure NAMRIA's firewall failed to yield the desired results.

A solution to the problem of making Landsat.org Philippines work with NAMRIA's network was to install Landsat.org Philippines on a separate server that would bypass NAMRIA's hardware firewall. This solution allowed ODBC connection to TRFIC databases. But because Landsat.org Philippines is not under the protection of NAMRIA's hardware firewall anymore, Landsat.org Philippines server is vulnerable to hacker attacks. Because of such vulnerability,

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TRFIC databases administrator prohibited the use of ODBC to transact with TRFIC databases because this mode of connection will require TRFIC databases username and password on Landsat.org Philippines' codes. If Landsat.org Philippines' server gets hacked, the hacker can get hold of the username and password to TRFIC databases. Because ODBC cannot be used to communicate with TRFIC databases, a new mode of connection is needed to fulfill the objective of a distributed system through Landsat.org Philippines. This new mode of communicating with TRFIC databases was done using web services. Web services are self-contained and self-describing application components that utilize open protocols for communication. Web services can utilize HTTP (port 80) to transfer information between computers and can therefore go through firewalls of web servers.

I created a web service in C# that connects to two TRFIC Oracle® databases, namely: cpb.edc_tm and scene. Cpb.edc_tm and scene are databases that hold Landsat TM image information. The C# web service I created still utilizes ODBC to communicate with these databases, but the difference is that the web service is running in one of TRFIC's servers and not in Landsat.org Philippines' server. Having the web service running in one of TRFIC's servers means that the application is being managed by a TRFIC administrator and is under the TRFIC system's corporate network security. Landsat.org Philippines will just send a request to the web service and the web service will return the results. To make the web service more secure, a password is required for every request sent to the service. Without the correct password, the web service will not return a result. **Figure 5.4** shows the mode of transaction taking place between the server, the web service, and database. **Figures 5.5** and **5.6** is a screen capture of the two web services being used of the system as accessed from the Internet.

5.3 Map Server Subsystem

5.3.1 Map Server Function

The map server generates maps to user and performs the majority of the GIS functionalities of the ODGISDAS Landsat.org Philippines. Having GIS functionalities is essential because Landsat.org Philippines is an information system that deals with geospatial data. The GIS tools allow users to interact and query geospatial data. In essence, the map server with its associated GIS tools would help fulfill the objective of this research to provide data access that could support spatial decision support, planning, and policymaking.

ArcIMS® is the map server used by Landsat.org Philippines (**Figure 5.12**). Users utilize the map served by ArcIMS® to select Landsat tiles using geographic query by mouse selection. ArcIMS® also handles the serving of tile and place locator maps and geospatial ancillary data. **Figures 5.7** and **5.8** shows the Interactive Map and Interactive Map Lite for Landsat tile selections, **Figure 5.9** shows the locator map, **Figure 5.10** shows the Extents Map, and **Figure 5.11** shows the generic data viewer map, all of which are generated and served by ArcIMS®. The maps that ArcIMS® serves comes from map services running

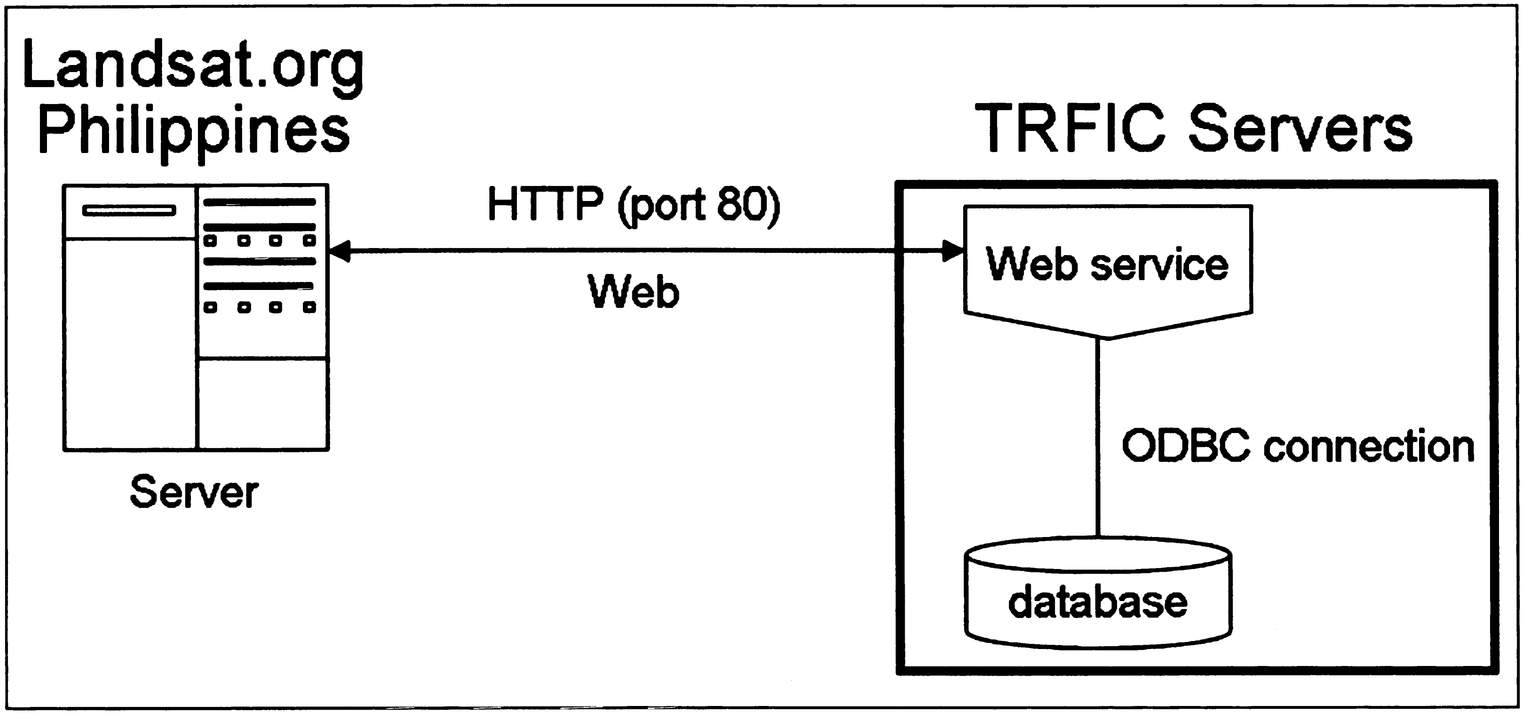

Figure 4.4. Transaction flow between the server, web service, and database.

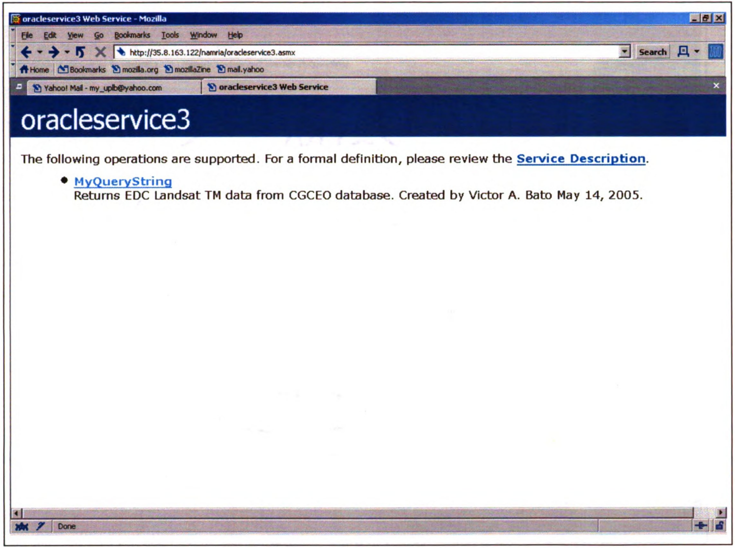

Figure 5.5. Web service oracleservice3 showing the available operation.

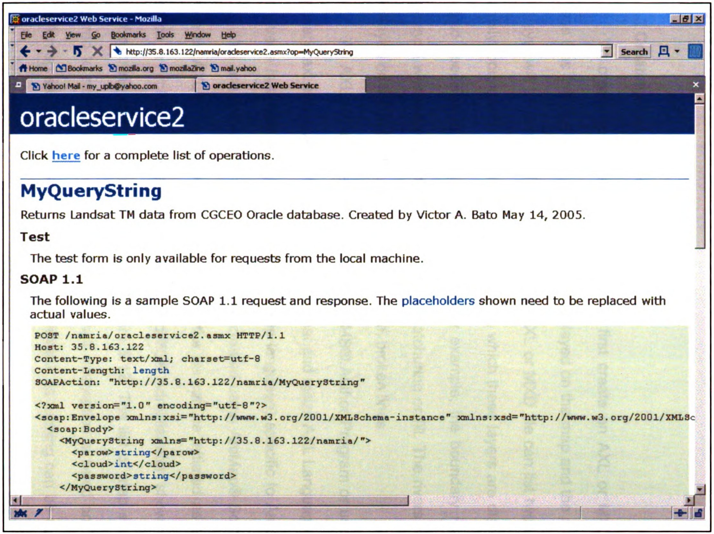

Figure 5.6. Web service oracleservice2 showing the different query syntaxes.

inside ArcIMS® and are managed using ArcIMS®'s Administrator Program (**Figure 5.12**).

5.3.2 Creating Map Services

To create a map service, one has to first create an AXL or MXD file. These files lists the layers that need to be displayed on the map and the manner the layer will be displayed. For instance, an AXL or MXD file can list two layers namely: boundaries and rivers. The manner in which these layers are displayed is also specified in the AXL or MXD file. For example, the boundary may be displayed with black, solid lines without any hatchuring or fill. The rivers will be displayed on top of the boundary layer with blue, broken lines.

An AXL file may be created in the ArcIMS® Author Program or using an ordinary text editor. AXL files are in ASCII format and utilize AXL Language. AXL Language is a type of XML (extensible markup language) specific to ArcIMS®. MXD files are ArcMAP® project files and are created using ArcMap® Software. Once an AXL or MXD file has been created, the file can be initiated as a map service in ArcIMS®. The screen capture of ArcIMS® Administrator, showing the list of running map services is shown in **Figure 5.12**. The list of map services required to run Landsat.org Philippines and their description is listed on **Table 5.3**. A map service shown by ArcIMS® Administrator as running can be queried and/or published in the web using ArcIMS® Designer or by creating a customized program using any scripting language.

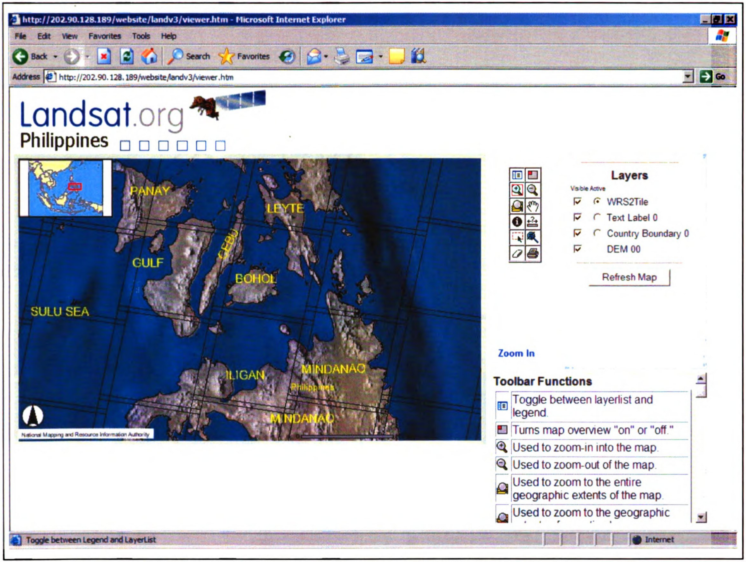

Figure 5.7. The Interactive Map is one of the means users can select data using GIS tools.

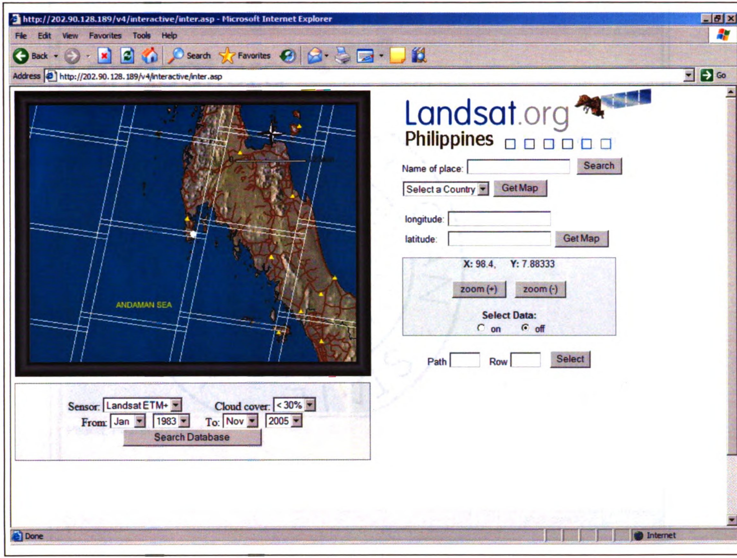

Figure 5.8. The Interactive Map Lite is a customized viewer and is used to select Landsat data.

Figure 5.9. The Locator Map is a utility that displays a place searched using EasySearch.

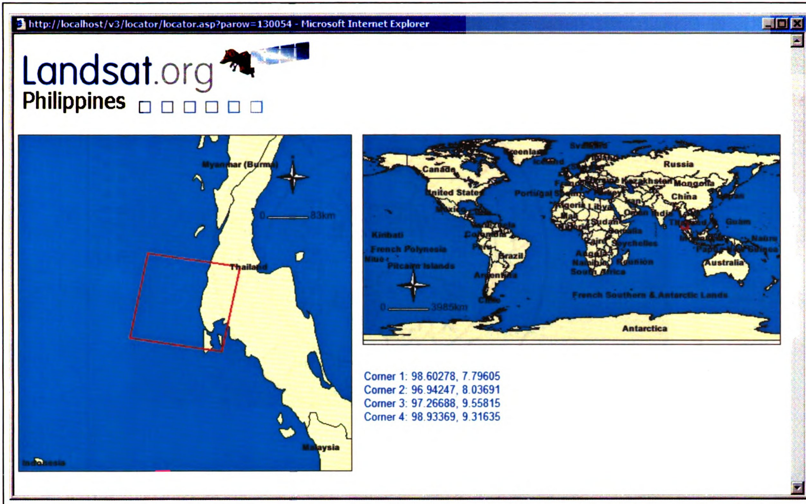

Figure 5.10. The Extents Map is a utility that shows the footprint and coordinates of a Landsat tile.

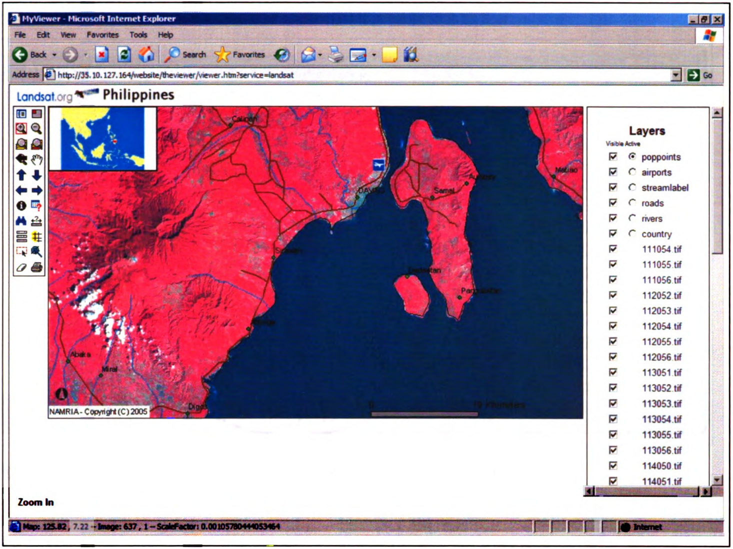

Figure 5.11. The Generic Map Viewer is a utility that displays ancillary data.

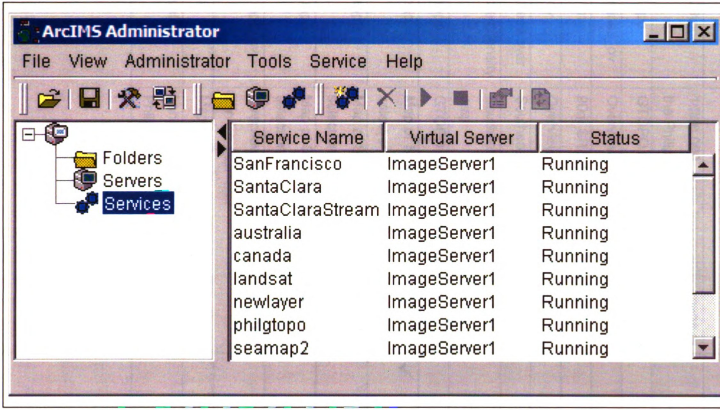

Figure 5.12. ArcIMS® Administrator is where map services are managed.

Table 5.3. Map services being used by different versions of Landsat.org Philippines.

Map Service	Description	V1	V2	V3	V4
250000topo	1:250,000 scale topographic maps of the Philippines				✓
Philgtopo	GTOPO data of the Philippines				✓
Philippines_ov	Overview map of the Philippines			✓	
Philsrtm	90m SRTM data of the Philippines				✓
Sea_ov	Overview map of Southeast Asia				✓
Seaforestcover	Southeast Asia 2000 forest cover map				✓
Seaforestdensity	Southeast Asia 2000 forest density map				✓
Seagtopo	GTOPO data of Southeast Asia				✓
Seamap	Map of Southeast Asia for Landsat tile selection	✓			
Seamap2	Map of Southeast Asia for Landsat tile selection		✓		
Seamap3	Map of Southeast Asia for Landsat tile selection			✓	✓
Seamap3_ov	Overview of Southeast Asia for map service seamap3			✓	✓
World	Map of the world			✓	✓
Landsat	Landsat data mosaic of the Philippines				✓

5.3.3 Upgrading the Map Server

ArcIMS® v. 4.0.1 was used in version 1 to 2 and in the earlier part of version 3 of Landsat.org Philippines. Problems were encountered in the administration of map services with this version of ArcIMS®. Often, and for unknown reasons, an existing map service could be refreshed or deleted or a perfectly working AXL file could not be converted to a map service. Upgrading to ArcIMS® v. 9.0 solved these problems. The ArcMap® image server license is also included in the installation package of version 9.0, which is a separate package that has to be purchased for version 4.0.1. This image server allows an ArcMap® MXD file to be used to create a map service, making map composition more efficient than doing it by hand in AXL programming. After upgrading ArcIMS® to version 9.0, ArcMap® was used to compose maps for ArcIMS®.

5.3.4 Setting up the Map Server Servlet Connector

ArcIMS® requires a servlet connector for execution. A servlet connector connects and communicates between the map server and the web server. **Figure 5.13** shows a diagram of Tomcat® connecting ArcIMS® with the web server. New Atlanta ServletExec® is the servlet connector that comes with the ArcIMS® installation CD by default. The installation package does not include a license for this servlet, thus, limits the available connection to only one. An alternative to the New Atlanta ServletExec® is Jakarta Tomcat®, which is free and can handle unlimited connections. Installing Tomcat® is not straightforward. Tomcat® needs to be customized with Microsoft® IIS (Internet Information

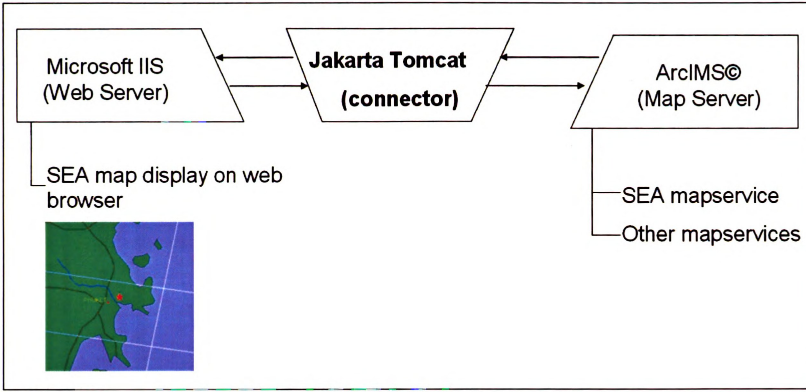

Figure 5.13. Diagram showing Tomcat® connecting ArcIMS® with the web server.

Services) and a redirector file (isapi_redirector.dll) is needed for the servlet to work. The procedure for making Tomcat work with ArcIMS® is available at the ESRI website.

5.4 The Web Server Subsystem

5.4.1 Web Server Function

The web server subsystem of Landsat.org Philippines is being handled by Microsoft® IIS (Internet Information Services). The web server integrates the other two components (database and map server subsystems) of Landsat.org Philippines. This subsystem runs the numerous scripts that access the distributed databases, displays maps, and provides the graphical user interface for the system. The different components of the Landsat.org Philippines like GateKeeper3, Shopping Cart, etc. are run and brought together by the web server subsystem into a seamless "one-stop-shopping" portal, thereby accomplishing this objective.

5.4.2 Creating the Scripts

Scripts that comprises Landsat.org Philippines were created using ASP (Active Server Pages), JavaScript, and HTML (Hypertext Markup Language). The programming process was done using a freeware editor called AceHTML®. **Figure 5.14** shows AceHTML® 5 Freeware highlighting code syntaxes of GateKeeper3. ASP scripts added interactive capabilities to the web interface of

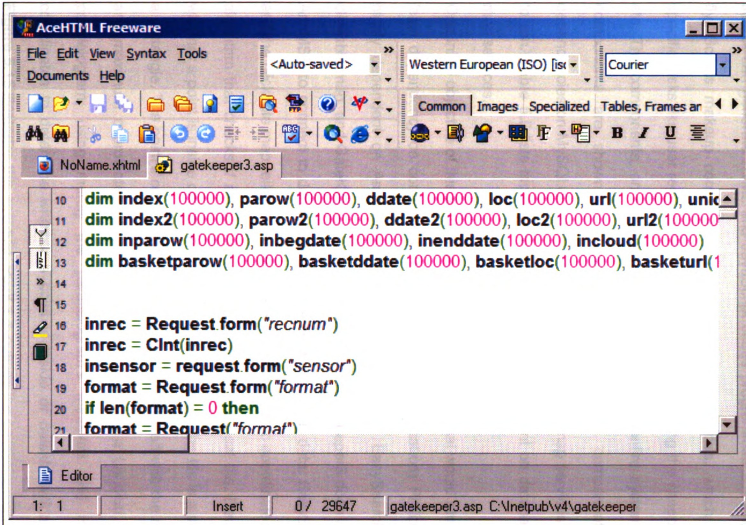

Figure 4.14. AceHTML® Freeware highlighting code syntaxes of GateKeeper3

the system. This interactivity cannot be achieved by merely using HTML. ASP scripts can generate HTML and JavaScript codes programmatically and on the fly. Scripts makeup components of Landsat.org Philippines, which handles specific tasks like user registration, database access, running the shopping cart, etc. The components, on the other hand, integrates the entire system. These components are shown in **Table 5.4**. Some of the components have dependencies on MySQL® database tables and ArcIMS® map services in order to run. **Table 5.5** lists the dependencies of each component on databases and map services.

One initial objective of this study was to develop a system that would run with the least dependency on commercial software. Though Landsat.org Philippines is highly dependent on ArcIMS® for its mapping function, EasySearch™, the clickable map, and GateKeeper3 can run without it. GateKeeper3 does not need ArcIMS® to connect to databases and search for Landsat data. EasySearch™ and the clickable map relies on a databases with geographic coordinates and an algorithm that checks if a point is within a particular Landsat tile. Determining whether a point is inside or outside a Landsat tile is easy if the tile is a square or a rectangle. The point's coordinates will have to be compared with the minimum and maximum coordinates of the polygon. But because a Landsat tile is a parallelogram, using merely the parallelogram's minimum and maximum coordinates to determine whether a point is inside or outside will not work. **Figure 5.15** illustrates this scenario. Point 1 is outside the parallelogram, points 2 and 3 are inside the parallelogram, and point 4 is outside

Table 5.4. Code components being used by different versions of Landsat.org Philippines

Code Component	Description	V1	V2	V3	V4
Index, help, documents, and about up pages	Front page, help documents, and others	✓	✓	✓	✓
Interactive Page	ArcIMS generated map page for Landsat tile selection	✓	✓		✓
Interactive Lite Page	Customized ArcIMS map page for Landsat tile selection			✓	✓
Advanced Search Page	Landsat data search by form	✓	✓	✓	✓
Graphical Page	Clickable graphics map for Landsat tile selection	✓	✓		
Easy Search Page	A place name search approach to Landsat tile selection			✓	✓
Shopping Cart	The shopping cart	✓	✓	✓	✓
User Registration Page	User registration page	✓	✓	✓	✓
Gatekeeper Page	Main program, which searches different databases for Landsat data	✓	✓	✓	✓
Zoomimage Page	Page for zooming in and out on Landsat quicklook images	✓	✓	✓	✓
Locator Page	Locates a place on a map			✓	✓
Data Coverage Page	Maps the extents of a Landsat tile			✓	✓
Ancillary Data Page	Shows a list of available ancillary data				✓

Table 5.5. Landsat.org Philippines code component dependencies on databases and map services.

Code Component	Map Service Dependency	Database Dependency
Index, help, documents, and about up pages	None	None
Interactive Page	Seamap3	
Interactive Lite Page	Seamap3	Places, prowcorner2, seaplaces
Advanced Search Page	none	none
Graphical Page	none	Parowcorner2
Easy Search Page	none	Places, seaplaces
Shopping Cart	none	Userinfo, userorder
User Registration Page	none	Userinfo
Gatekeeper Page	library	Newetm, newtm, cpb.edc_tm, scene
Zoomimage Page	none	none
Locator Page	World, seamap3	none
Data Coverage Page	world	Parowcorner2,
Ancillary Data Page	various	ancillary

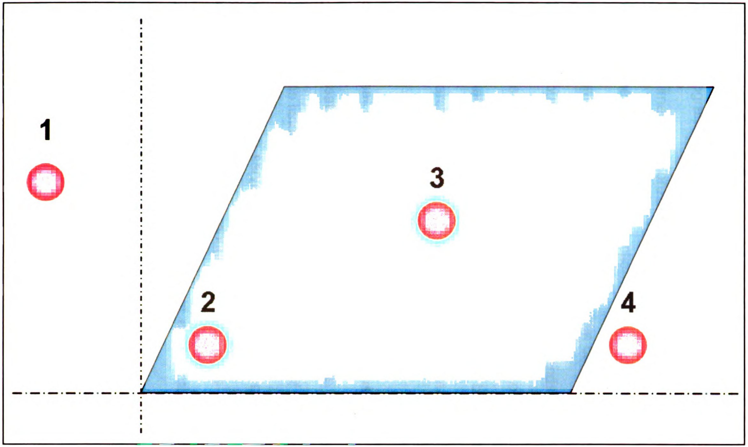

Figure 5.15. A hypothetical Landsat tile with points inside and outside.

the parallelogram. Based on merely the minimum and maximum coordinates of the parallelogram, point 4 would seem to be inside, but in reality it is outside. By drawing an imaginary horizontal and vertical line that passes through point 4 and counting the number of intersections the line made with the sides of the parallelogram on all four directions, the system can determine whether point 4 is inside or outside. The point is inside the Landsat tile if the number of intersections on each of the four directions is odd, otherwise it is outside. The algorithm that performs this work is shown in large, bold fonts and imbedded in the EasySearch™ parse.asp code attached as **Appendix D**.

5.4.3 Landsat.org Philippines Server Specifications

Landsat.org Philippines was installed on a server with the following specifications listed on **Table 5.6**. The specification of the server is far from ideal, especially for a map server, which reads Megabytes of raster data. By utilizing a computer with a modest computing power, I was able to demonstrate the possibility of deploying the ODGISDAS at a very minimal cost, using ordinary hardware and software.

Table 5.6. Landsat.org Philippines server specifications.

Item	Specification
Processor	2.26GHz Intel Celeron™
Memory	128MB
Hard Disk	40GB IDE
Operating System	Windows 2000 Server™
Map Server Software	ArcIMS™ v. 9.0
Anti Virus	Norton Anti-Virus™
Firewall	BlackIce Defender™
Remote Access Software	Windows Terminal Server and/or PCAnywhere™
Internet Connection	500KBps

5.4.4 Administration, Maintenance, and Implementation

Access using remote desktop connection was a problem because the ODGISDAS server's initially installed firewalls did not allow such connections. The problem with remote desktop connection was fixed by having someone with physical access to the server install PCAnywhere® and open the firewalls to specific IP addresses. PCAnywhere® is a software product of Symantec® that allows remote desktop access to computers. Once the remote desktop connection using PCAnywhere® was established, the server was configured for use with Windows® Remote Desktop Connection and was later used to manage the server remotely. The server's old firewalls were also replaced with the one specified on **Table 5.6**. The firewall was configured and tested to determine the optimum settings that would prevent hacking, but will still allow remote administration. Installation, management, and update of patches, anti-virus definition, software, and data are currently being done on the ODGISDAS server using Windows® Remote Desktop Connection. **Figure 5.16** shows the server's desktop accessed through Windows® Remote Desktop Connection.

Because Landsat.org Philippines will be a functioning website, it will have to be always accessible to the public, in running condition, and protected from viruses and hackers. A maintenance and implementation plan was created outlining the regular maintenance tasks needed to be done on the ODGISDAS server at least once a week and steps to be undertaken if the server's security gets compromised. The detailed maintenance and implementation plan is attached as **Appendix E**.

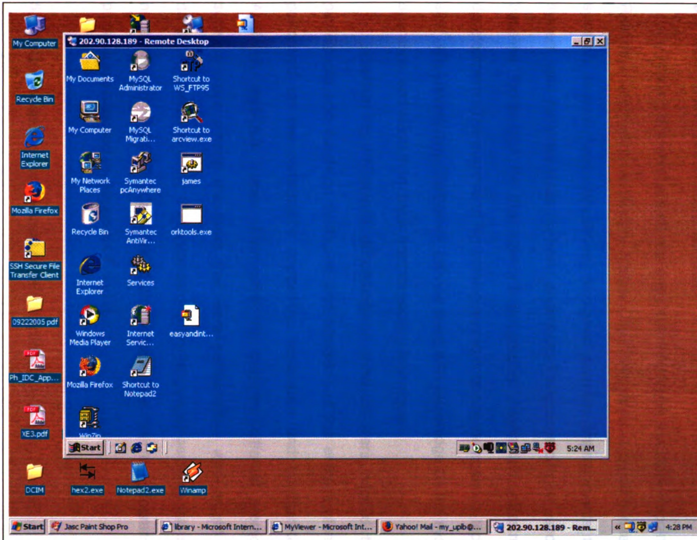

Figure 4.16. The server's desktop accessed through Windows® Remote Desktop Connection.

5.5 Training and Technology Transfer

Training of technical staff was done at the NAMRIA (National Mapping and Resource Information Authority), Makati City, Philippines. I demonstrated the system's features and capabilities, discussed possible improvements to the system, and explored ideas on how Landsat.org Philippines can be used as a baseline technology for the agency's geographic information infrastructure development. The purpose of the training was to acquaint the agency's technical staff with Landsat.org Philippines, provide them with knowledge on the system's operation, and teach them basic troubleshooting techniques.

Landsat.org Philippines documentation manuals were handed to the participants and hands-on setting-up and operation of the entire system was performed on the participant's computers. Installation and configuration of ArcIMS®, MySQL® Server, Microsoft® IIS, and the different prerequisite software were among the tasks that were performed. I also taught basic database operation using SQL (standard query language) because this skill is necessary in MySQL™ database management. The training program and pictures are attached as **Appendix F** and **G**.

5.6 Data Processing for Landsat.org Philippines

Although most of the work involved in developing Landsat.org Philippines was programming, data processing and preparation were some of the minor, but necessary task required to produce the necessary map layers and databases for the system. Higher resolution raster data and vector files that represents better actual ground features were secured and used instead of the more common and readily available coarse resolution datasets. Datasets in different projection systems were reprojected to Geographic Lat/Long Projection with a WGS84 datum. Raster and vector files were clipped to the extent of Southeast Asia to improve performance of the system. Spreadsheet files of place names were trimmed to remove unnecessary columns and were converted to MySQL® database format. Scanned topographic maps were rectified and cropped to their extents to create a mosaic map without any gaps.

CHAPTER VI

RESULTS AND DISCUSSIONS

6.1 Assessing Landsat.org Philippines Based on Objectives

One way to assess if I have successfully developed an ODGISDAS through Landsat.org Philippines is to examine the system based on the objectives that were set at the start of this research.

The first objective is to demonstrate the possibility of searching for Landsat data from multiple databases located at different geographic locations from a single web portal. This objective has been met by Landsat.org Philippines. In particular, GateKeeper3 can access two local databases and three remote Landsat databases located at Michigan State University, USA. Data searching for both TM and ETM+ sensors are done seamlessly from the system's web interface. The system can also access non-Landsat ancillary map services on different servers in the United States. Ancillary data are linked geographically and seamlessly to every data search results returned.

The second objective is to develop an open, distributed data archive system using common computer technologies and software already available in most government offices and universities, but integrated through standards and protocols. Objective two has been met by Landsat.org Philippines. Surprisingly, the system runs on a server with specifications below that of a descent desktop computer. The system also uses open source software such as MySQL® database and utilizes web standard technologies such as HTTP and JavaScript.

Though the system was written in ASP and designed to run on a Windows® Server operating system, a similar system that runs on a Linux® operating system can be made using PHP® or JSP®. Although some parts of the system utilizes ArcIMS®, a proprietary software, the system can be written in such a way that it does not depend on such technologies. ArcIMS® only adds neat functionalities to Landsat.org Philippines. If needed, ArcIMS® can be replaced with an open source map server.

The third objective is to develop a seamless "one-stop-shop" interface for the ODGISDAS. This objective has been met by Landsat.org Philippines. The system allows seamless searching for both TM and ETM+ satellite data. Users can also directly order data through the system's shopping cart.

The fourth objective is to conduct training of NAMRIA technical staff on the operation and maintenance of the ODGISDAS to provide technology transfer. This objective was met when I went back to NAMRIA, Philippines, to install the first version of Landsat.org Philippines. Training on the operation, maintenance, and troubleshooting was given to some of the technical staff of the Database Management Division, Information Management Department, NAMRIA. Handouts were also distributed to the participants. The pictures taken during the training are shown as **Appendix G**.

The fifth objective is to provide a technical approach to data access that could support spatial decision support, planning, and policy making. Landsat.org Philippines has fulfilled this objective. Landsat.org Philippines utilizes the Internet and the latest software and computing technologies to bring information to people. These information are vital in decision support for planning and policy making. Using technology, particularly the Internet, to disseminate geographic information is non-conventional as compared to the paper maps and data storage media that most users are accustomed with. This method for disseminating information is efficient and cost effective in the long run.

6.2 Evaluating Landsat.org Philippines Based on Similar Online Services

6.2.1 The Difference Between Landsat.org Philippines and Google® Map, Google® Earth, Terra Server® USA, and MapQuest®.

Many online mapping websites exists with very impressive contents, speeds, and functionalities. Examples of these types of websites are Google® Map, Google® Earth, TerraServer® USA, MapQuest®, etc. Each of these commercial websites have their own unique capability, which makes them sellable to consumers. MapQuest® is a favorite among travelers as it provides them with road maps, detailed directions, hotels, etc. Google Map is competing with MapQuest® in providing users with the same service, plus the added value of viewing high resolution satellite imagery. Google® Earth is another interactive online application with 3D viewing capabilities. The TerraServer® USA provides online viewing of topographic maps and high resolution imagery.

One of the main difference of Landsat.org Philippines with these online mapping website is that the former is a distributed system and the others are not. These websites function using a central database system, although may be distributed as database grids, with database control and management exclusive to the owner of the site.

Another difference between Landsat.org Philippines and the commercial websites that were mentioned are their functions. The function of Landsat.org Philippines is to provide seamless access and ordering of Landsat data. These commercial websites focus on providing services to users like road direction, hotel searching, 3D viewing, etc. These commercial websites function more as service providers than data distributors.

Google® Map, Google® Earth, and TerraServer® USA, though no doubt useful and impressive, do not provide multi-temporal data access and viewing. These services only provide users with a "pretty picture" of the Earth's surface as a one time shot. Users are unable to view and compare old data with newer ones, a function necessary for change analysis. On the other hand, Landsat.org Philippines allows users to search for and visually compare Landsat data taken from different dates.

Google® Earth requires the installation of an application to the user's computer in order to access and utilize the system. On the other hand, Landsat.org Philippines is web based and will only require the user to use a web browser. Requiring users to install a software on the computer is a bad practice and violates interoperability and downward compatibility.

Landsat.org Philippines has a special niche in the scientific community. Similar to Landsat.org and the USGS National Map. Landsat.org Philippines provides essential services to the people, scientific community, and the government. These services can never be provided by commercial companies because they are not profitable enough. Providing access to multi-temporal Landsat data is Landsat.org Philippines's niche. Not many people would be interested to acquire a Landsat data, but access to these data have to be provided to serve scientists, resource planners, environmentalists, and students conducting research on the environment.

6.2.2. Difference Between Landsat.org Philippines and Geodata.gov

Geodata.gov, which can be accessed using the URL http://www.geodata.gov, is an information portal *designed to facilitate communication of geographic data and resources to enhance government efficiency and improve citizen services* (Department of the Interior, n.d.). Geodata.gov brings together all the geospatial information compiled and maintained by different federal agencies and some private sectors into a single web portal. Geodata.gov does not maintain geospatial data, but only maintains a master list of data providers and repositories.

One major difference between Landsat.org Philippines and Geodata.gov is their data collections. Landsat.org Philippines focuses on Landsat data; Geodata.gov handles all geospatial information. Also, Geodata.gov does not maintain copies of geospatial data and serves only as a clearinghouse, Landsat.org Philippines maintains copies of Landsat data.

6.2.3. Difference Between Landsat.org Philippines and Landsat.org.

Landsat.org Philippines is the Southeast Asian node and a franchise of Landsat.org. Both systems have the same basic function of providing access to Landsat data. While Landsat.org serves the entire globe, Landsat.org Philippines caters to the Southeast Asian market. Landsat.org Philippines provides the user a feeling of closeness through its interface and maps. The maps the system uses only shows Southeast Asia, giving the system a more local touch. Landsat.org Philippines enjoys some degree of independence from Landsat.org and could develop innovative tools that cater to the needs of the local users.

The major difference between the two systems is on the way they utilize databases. Landsat.org Philippines connects to distributed database systems, while Landsat.org does not. Landsat.org Philippines searches distributed Landsat databases scattered throughout the globe on-demand. Landsat.org does not perform this task, but updates its database in a different way. Landsat.org Philippines also utilizes "open" standards and protocols to connect to distributed databases and map servers.

Other differences that exist between the two systems are the tools used by users to select and interact with data. Landsat.org Philippines have useful tools that were built from scratch that are not present in Landsat.org. A good example is the EasySearch™. This tool was designed for users who are comfortable with search engines. Another example is the linking with ancillary data, which provides the benefit of being able to compare different data side by side.

6.3 Usability of Landsat.org Philippines

6.3.1 Landsat.org Philippines in the Local Language

In order for Landsat.org Philippines to effectively fulfill its mission of bringing information closer to people, the system's wordings were translated into the local language - Tagalog. Not many websites in the Philippines have their wordings in Tagalog because many people in the country can understand English, as it serves as the country's secondary language and official language used for business transactions. By translating the wordings of the website to the local language, Landsat.org Philippines can reach people, who are not comfortable in using the English language, to have an interest in the science of GIS and remote sensing and what it can do for the environment. Landsat.org Philippines is bridging the information divide in science by removing the language barrier that exists between science and technology and the common people. Landsat.org Philippines being translated into the local language is a paradigm shift from the way websites in the country are made and will serve as a model for other websites. **Figure 6.1** shows the front page of Landsat.org Philippines translated into Tagalog, one of the local languages in the country.

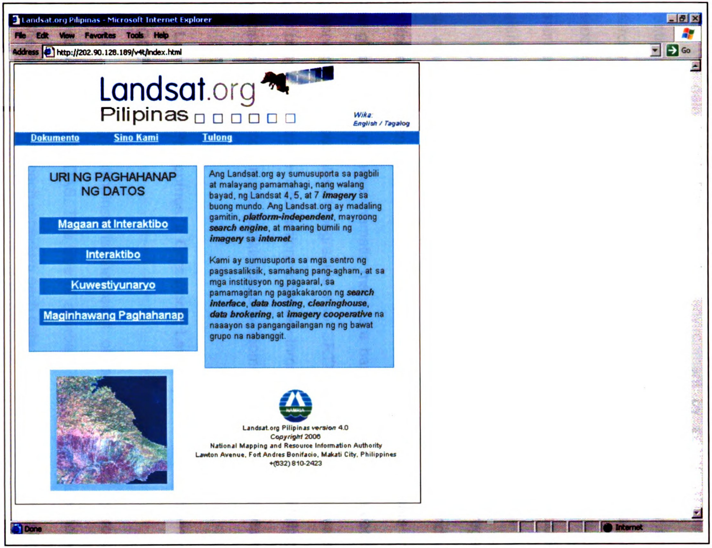

Figure 6.1. The front page of Landsat.org Philippines translated into Tagalog, one of the local languages in the Philippines.

6.3.2 Linking Ancillary Data with Landsat.org Philippines

Landsat.org Philippines search results are linked to a variety of ancillary data. We gain knowledge about the environment by seeing patterns and identifying linkages and associations. The purpose of linking ancillary data to search results is to reveal these patterns and make more visible the linkages and associations between the Landsat data and other biophysical data. This linking is essential because it will lead to the discovery of many new things hidden in nature.

One of the prerequisites for planners to make sound decisions regarding the environment are thematic maps of their area of interest. Landsat.org Philippines' ancillary data are thematic maps taken from different servers around the globe. Some of these thematic maps are baseline information needed for planning like the seamless topographic map, SRTM elevation, roads, rivers, etc. By bringing all these information together through Landsat.org Philippines, decision makers could make sustainable development plans for the community.

6.4 Landsat.org Philippines, a Grassroots Level Approach to Implementing an ODGISDAS.

Landsat.org Philippines is the result of grassroots level approach to developing an ODGISDAS. This type of approach was recommended to NASA by the NRC. This approach considers each data archive center as a key player in the system and provides them with some degree of autonomy to innovate and develop tools more appropriate for their areas of jurisdiction. This approach also eliminates bureaucracy and the rigidity it imposes to development. Experience had shown time and again that bureaucracy is in direct opposition to the democratization of information and the advancements in information technology. Because a grassroots level approach to development was utilized in Landsat.org Philippines, it did not fall prey to the implementation hurdles of a top to bottom approach that NASA experienced in implementing EOSDIS.

6.5 Landsat.org Philippines, a Springboard for the Development of the Philippines' National Geographic Information Infrastructure.

The implementation of the Philippines' National Geographic Information Infrastructure has experienced many problems like technological, institutional, standards, etc. These problems are valid and requires attention, but can be addressed little by little with each version release of the infrastructure's system components. Although Lansat.org Philippines is far from the ideal system envisaged by the planners of the NGII, this ODGISDAS can serve as baseline technology needed for the entire project to take-off. Teams working on the NGII can build upon Landsat.org Philippines' technology and can benefit from the experience and the lessons learned from building the system. With Landsat.org Philippines, the country already has a tangible output that could spark a renewed interest from people at the management level, inspire people at the development team to continue working on the NGII, and that the project can be accomplished one version at a time.

6.6 Using Landsat.org Philippines

6.6.1 Front Page

Version 4.0 is the final version of the open, distributed GIS data archive system Landsat.org Philippines and can be accessed using the URL http://202.90.128.189/v4/index.html. Landsat.org Philippines can be accessed from any computer with an internet connection using W3C compatible browsers. The front page of Landsat.org Philippines provides the user with links to the different data search methods and other supporting web pages such as documents, help, and about us. Four data search methods are available for use: interactive lite, interactive, form, and EasySearch™. Each search method has its own set of advantageous features and will be discussed in the following sections.

The web pages of Landsat.org Philippines were created devoid of fancy graphics that require external plug-ins and consume bandwidth and processing power. This ensures that the system can be used efficiently on older computers. The front page of Landsat.org Philippines is presented in a straight forward manner. The links to the different methods of searching for Landsat data can never be missed by the user because it occupies a significant portion of the page. **Figure 6.2** shows the front page of Landsat.org Philippines.

Figure 6.2. Front page of Landsat.org Philippines.

6.6.2 Documents, About Us, and Help Page

The documents page can be accessed by clicking on the "Documents" link on the banner menu of the front page. This page contains documents and links related to the use of Landsat data. Some of these documents are: journal articles, research papers, steps for radiometric correction, data user's handbook, etc. **Figure 6.3** shows the documents page. The about us page can be accessed by clicking on the "About Us" link on the banner menu of the front page. The about us page provides the user information about the host of Landsat.org Philippines, office address, telephone numbers, and emails. **Figure 6.4** shows the about us page. The help page can be accessed by clicking on the "Help" link on the banner menu of the front page. The help page provides the user with a detailed, step by step procedure on utilizing Landsat.org Philippines and its components. **Figure 6.5** shows the help page.

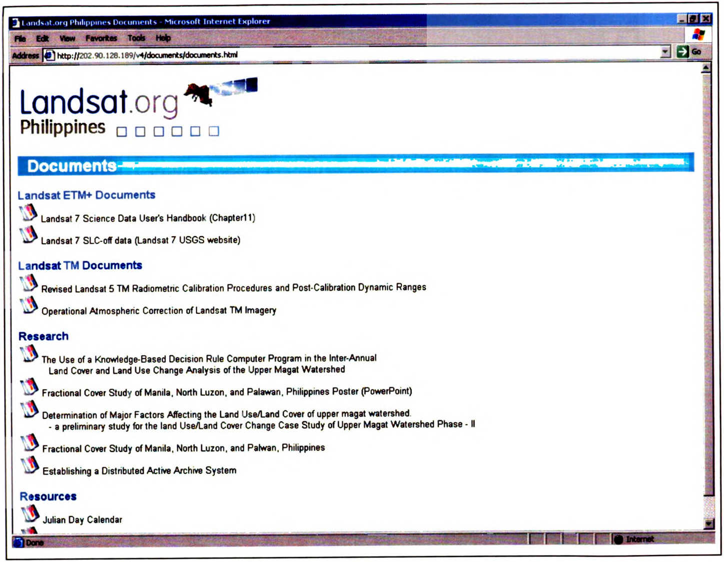

Figure 6.3. The documents page.

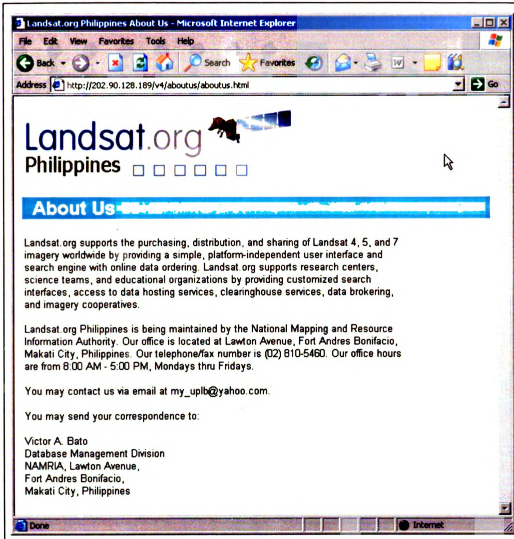

Figure 6.4. The about us page.

Figure 6.5. The help page.

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6.6.3 Interactive Lite Page

The interactive lite page can be launched by clicking on "Interactive Lite" link on the data search method menu on the front page. **Figure 6.6** shows the interactive lite page. This page loads much faster than the interactive page, does not utilize frames, and is recommended for users with slow internet connections. This interface allows users to visually select Landsat tiles from a map generated by ArcIMS® with WRS2 tiles overlain.

Zooming-in and zooming-out of the map is performed by pressing the zoom-in and zoom-out buttons. Panning can be done by clicking on a portion of the map that the user wants to go to. The point that the user clicked will become the new center of the map, identified by a white dot. The coordinates of the white dot is reported to the user as X and Y values and is located next to the zoom-in and zoom-out buttons. **Figure 6.7** shows the reported coordinates of the white dot, the zoom in and out buttons, and the select data radio buttons.

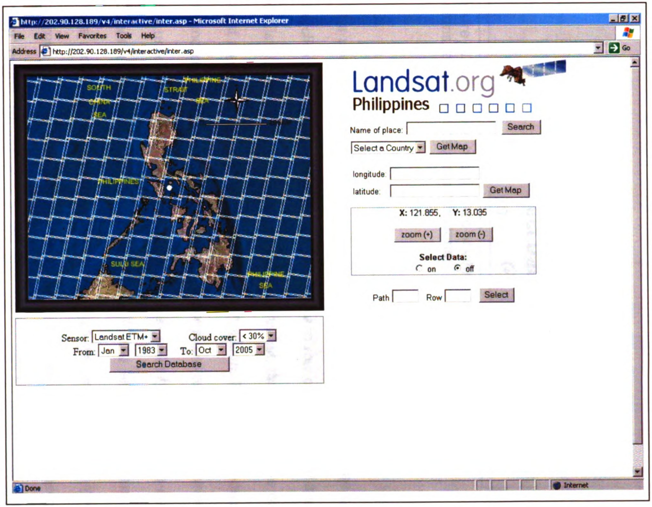

Figure 6.6. The interactive lite page.

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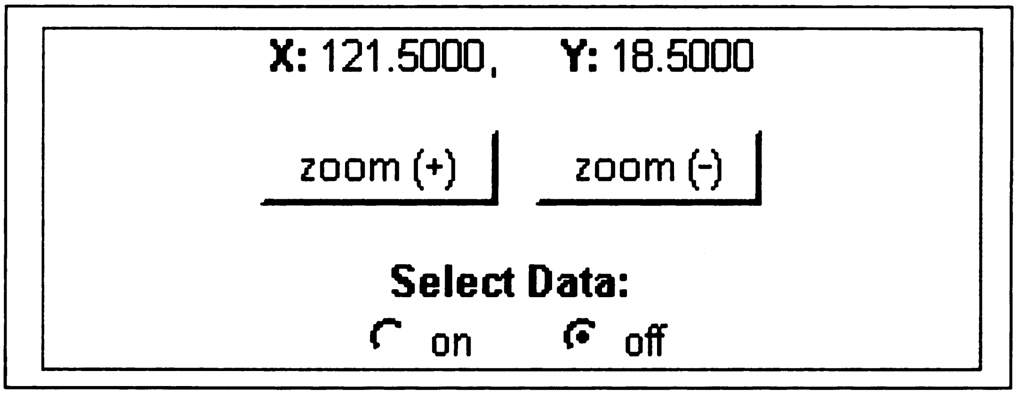

Figure 6.7. Reported coordinates of white dot, zoom in and out buttons, and select data radio buttons.

The user has two options for selecting Landsat tiles. The user can either point and click on a tile or directly specify the path and row of a tile to add it to the selection list. Once the tile has been added into this list, the user has the option to highlight the tile on the map using the "map it" function. **Figure 6.8** shows the "map it" function highlighting a tile. To utilize the point and click mode of selecting a tile, the user will have to turn "on" the select data radio button from its default "off" position and select a tile by clicking on it with the left mouse button. The select data radio button is shown in **Figure 6.7**. To select a tile by direct input of path and row, input the path and row on the path and row text boxes and press the "Select" button. Refinements to the data search can be done by specifying the sensor, cloud cover, and starting and ending dates before pressing the "Search Database" button.

One of the unique features of the interactive lite page is that the selection list is being handled by ASP's scripting object dictionary. This feature allows user

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users to select, for example, a tile located in Indonesia and move to Taiwan to select another tile while maintaining the previously selected tiles on the selection list. Another unique feature of this page is its capability to allow users to perform a place name search similar to that of EasySearch™. Coupled with this feature is the ability to navigate to the area of interest once a place is selected from the list of possible places returned by the place name search operation. Once the matching place is identified and selected for display, the user is presented with a map with the place of interest identified by a white dot on the center. **Figure 6.9** shows the results of a place name search for "cagayan de oro," a city in the Philippines. **Figure 6.10** shows a zoomed-in map of Cagayan de Oro City, Philippines, with the place of interest identified by a white dot at the center of the map. This map was generated when the "Get Map" button of Cagayan de Oro City on the results list was pressed. Interactive lite utilizes the same place name database that EasySearch™ utilizes.

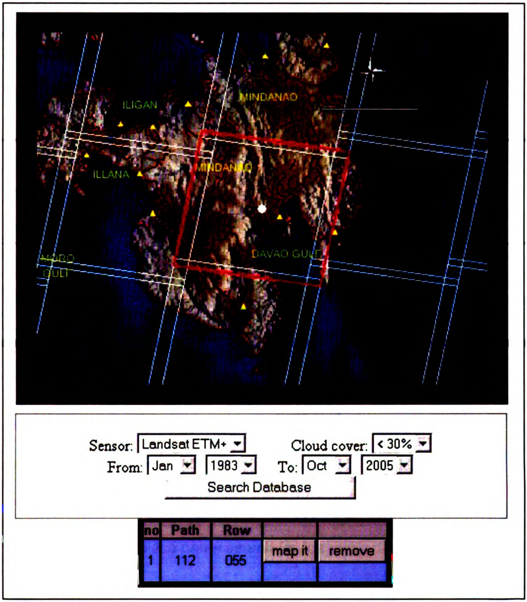

Figure 6.8. The “map it” function highlighting a tile.

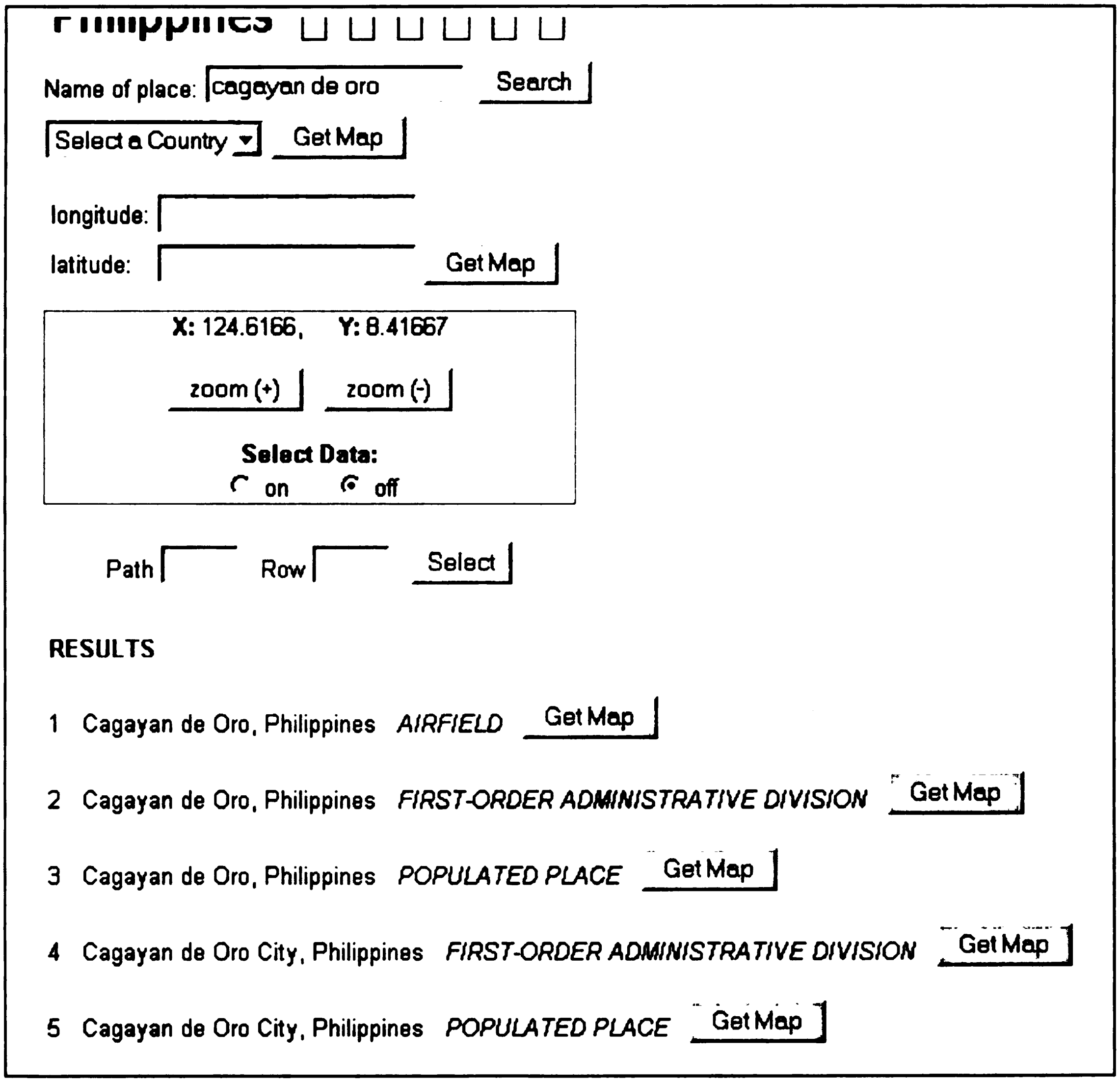

Figure 6.9. Results of a place name search for "cagayan de oro," a city in the Philippines.

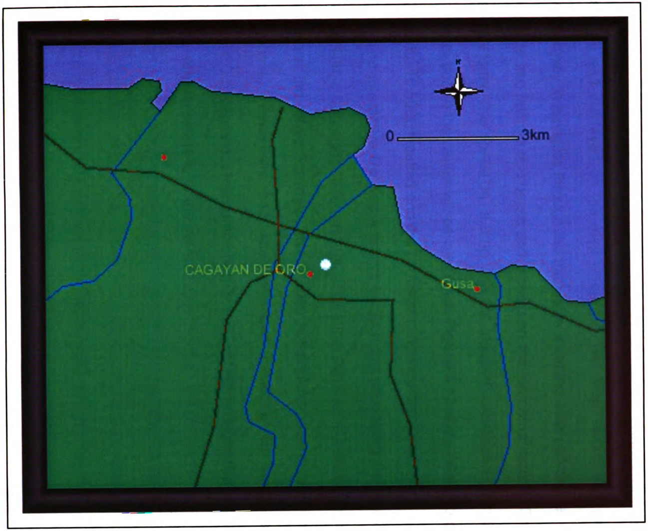

Figure 6.10. Zoomed-in map of Cagayan de Oro City, Philippines.

Interactive lite also allows users to navigate through the map by selecting a country from a drop down list. **Figure 6.11** shows the country of Brunei as selected and displayed on the map when the "Get Map" button was pressed. Another way to navigate through the map is by inputting map coordinates on the longitude and latitude text boxes and clicking on the "Get Map" button. Once the user performs this operation, a map with the inputted coordinates identified by the white dot on the center will be displayed. **Figure 6.12** shows the coordinates 121.5000, 18.5000 inputted and the corresponding map displayed.

The interactive lite was a recent addition to Landsat.org Philippines and was available on version 3.0 onwards. The initial purpose of interactive lite was to replace the interactive map, which does not perform well on slow internet connections. Eventually, both interactive and interactive lite were used on version 4.0 because each interface has its own set advantages that contributed to the overall functionality of the system.

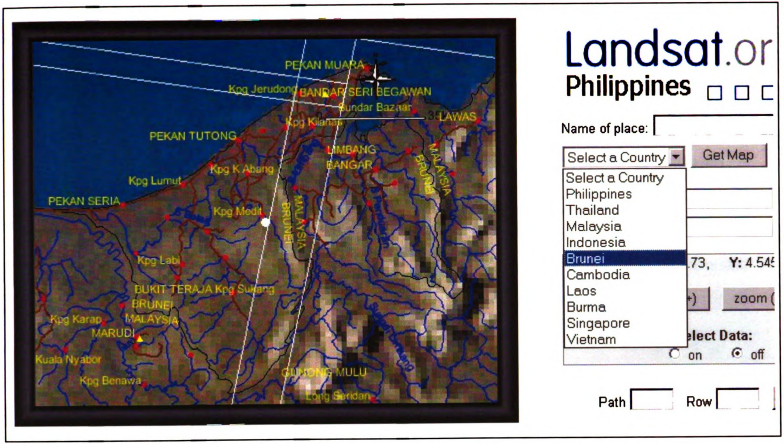

Figure 6.11. The country of Brunei as selected and displayed on the map when the "Get Map" button was pressed.

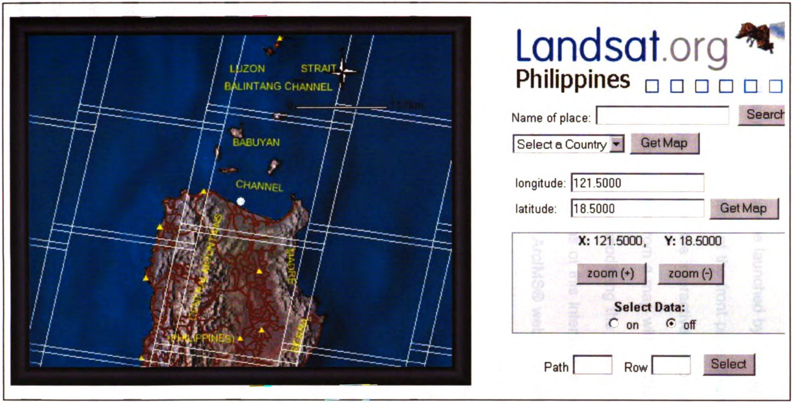

Figure 6.12. The coordinates 121.5000, 18.5000 inputted and the corresponding map displayed.

6.6.4 Interactive Map Web Page

The interactive map page can be launched by clicking on the "Interactive" link on the data search method menu of the front page. **Figure 6.13** shows the interactive map web page. Similar to the interactive lite page, this page allows users to visually select Landsat tiles from a map with WRS2 tiles overlain. The interactive map page was created by modifying the default ArcIMS® generated web pages. One of the major strengths of this interface is the highly functional toolbar. ESRI has equipped its default ArcIMS® web page with a toolbar similar to that of ArcView™ and ArcExplorer™, with associated baseline functions available on most GIS packages. Users familiar with ESRI® GIS software may find it more convenient to use the interactive map because it has functionalities most GIS users are accustomed with. Also, because many offices around the world utilize ArcIMS® and its default web page to serve their maps, the interactive map could be more attractive to other ArcIMS® default web page users because of the signature look and feel and functions common to these web pages. **Figure 6.14** shows the interactive map toolbar and the name/function of each icon.

The interactive map is more suited for users with fast internet connections. The interface utilizes frames and may not work properly with browsers that disallows pop-ups and frames. Because of the many functions imbedded on this interface, complete loading of the pages takes longer than the interactive lite because of the numerous algorithms and variables that computers, both server and client, will have to perform and load into their memories.

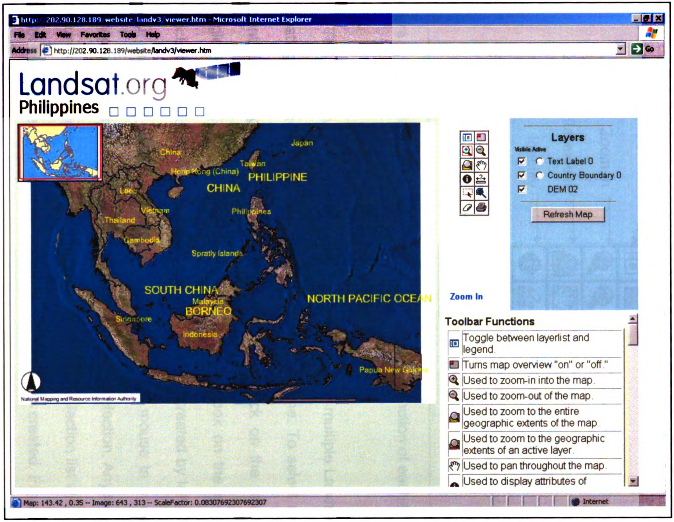

Figure 6.13. The interactive map web page.

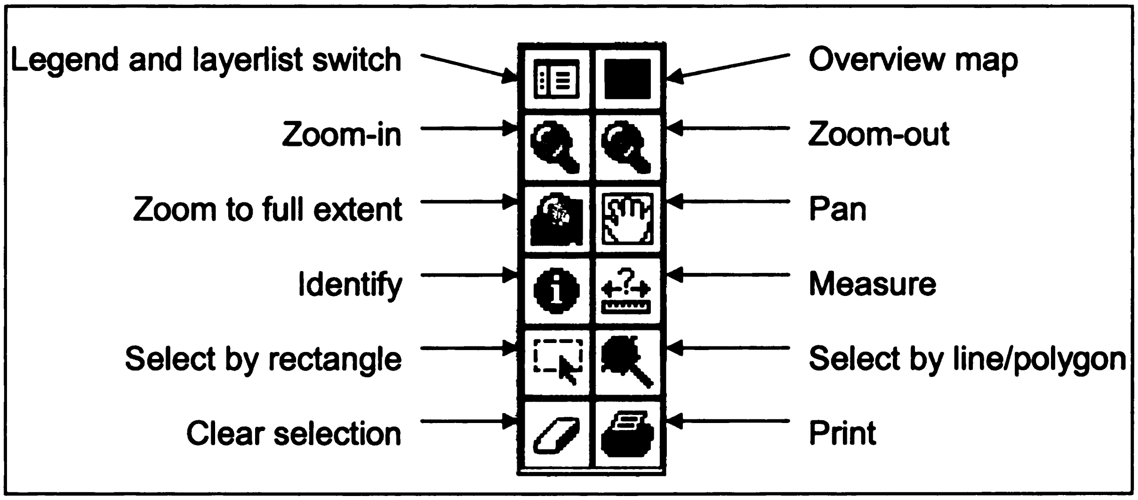

Figure 6.14. The interactive map toolbar and the name/function of each icon.

The interactive map allows users to select single or multiple Landsat tiles by creating a bounding box, an irregular polygon, or a line. To select multiple adjacent tiles using a bounding box, the user must click on the "select by rectangle" icon on the toolbar and create a bounding box on the map that intersects the Landsat tiles of interest. A bounding box is created by left clicking (without releasing) on a place on the map, dragging the mouse to create the bounding box, and releasing the left button to finalize the selection. Any tile within the bounding box gets included in the selection list. The selection list will appear at the bottom of the map once the bounding box has been created. **Figure 6.15** shows four Landsat tiles selected using a bounding box. The selection list is at the bottom of the map.

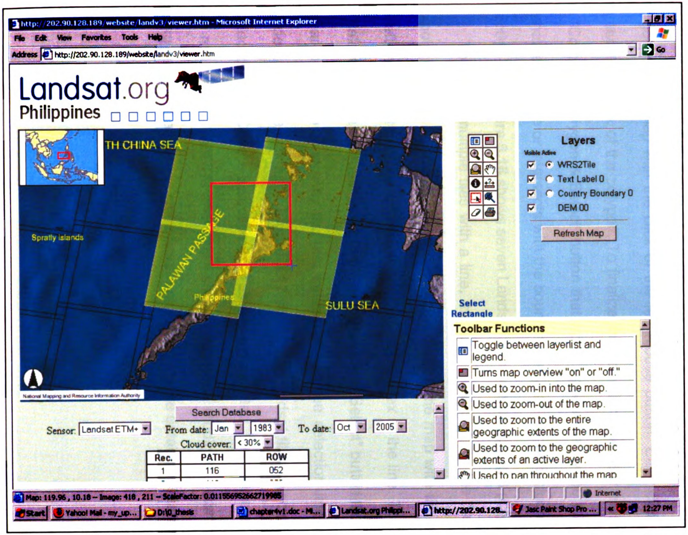

Figure 6.15. Four Landsat tiles selected using a bounding box, with the selection list at the bottom of the map.

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To select multiple tiles with a non-square or non-rectangular polygon, the user must click on the "select by line/polygon" icon on the toolbar and draw the polygon on the map with the click of the left mouse button. Each click would represent a vertex of the polygon. To finalize the selection, the user must press the "Complete Polygon & Select" button that would appear below the map. Any tile that falls inside or intersects with the bounding polygon will be included in the selection list. **Figure 6.16** shows seven Landsat tiles selected using a polygon.

To select multiple tiles with a line, the user must click on the "select by line/polygon" icon on the toolbar and draw the line on the map with the click of the left mouse button. Each click would represent a vertex of the line. To finalize the selection, the user must press the "Complete Line & Select" button that would appear below the map. Any tile that intersects with the selection line will be included on the selection list. **Figure 6.17** shows six Landsat tiles selected using a selection line. Once a selection list has been generated, the user can set to have results from both TM and ETM+ sensors returned, modify the starting and ending date, and adjust the cloud cover before starting the database search.

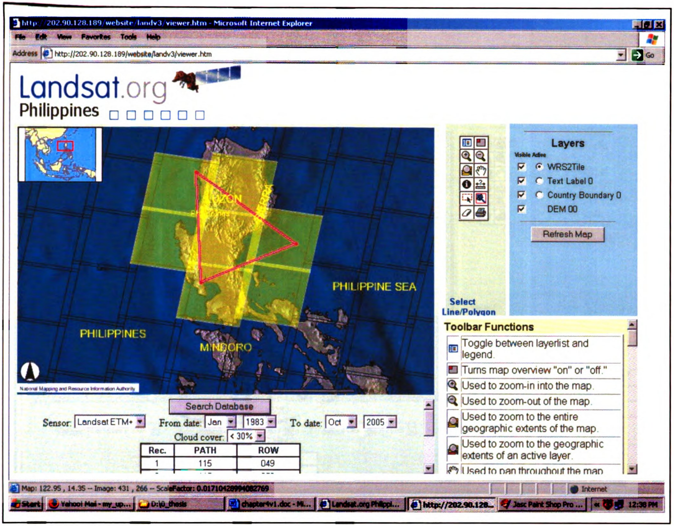

Figure 6.16. Seven Landsat tiles selected using a polygon.

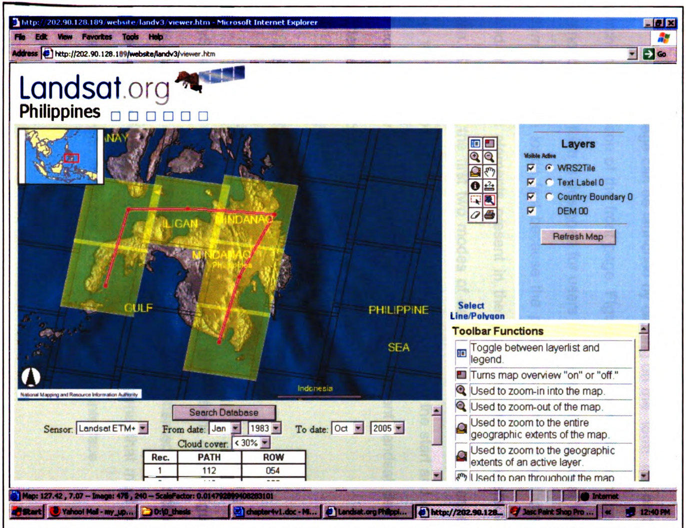

Figure 6.17 Six Landsat tiles selected using a selection line.

6.6.5 Form Page

The form page can be launched by clicking on the "form" link on the data search method menu of the front page. **Figure 6.18** shows the form page. The advanced search form is designed for users familiar with the Landsat WRS2 tile system. The form loads fast because the page has simple algorithms and is devoid of graphic elements present in the interactive lite and interactive web pages. Similar to the first two modes of data searching, the form page allows users to search for both TM and ETM+ sensors, modify the start and end dates, and adjust the percentage cloud cover. Up to ten different Landsat tiles may be inputted and searched using this form.

6.6.6 EasySearch™ Page

The EasySearch™ page can be launched by clicking on the "EasySearch™" link on the data search menu of the front page. **Figure 6.19** shows the EasySearch™ Page. EasySearch™ was patterned after the search engine type of information search available on the internet that most computer users are familiar with and is one of the strengths of this interface.

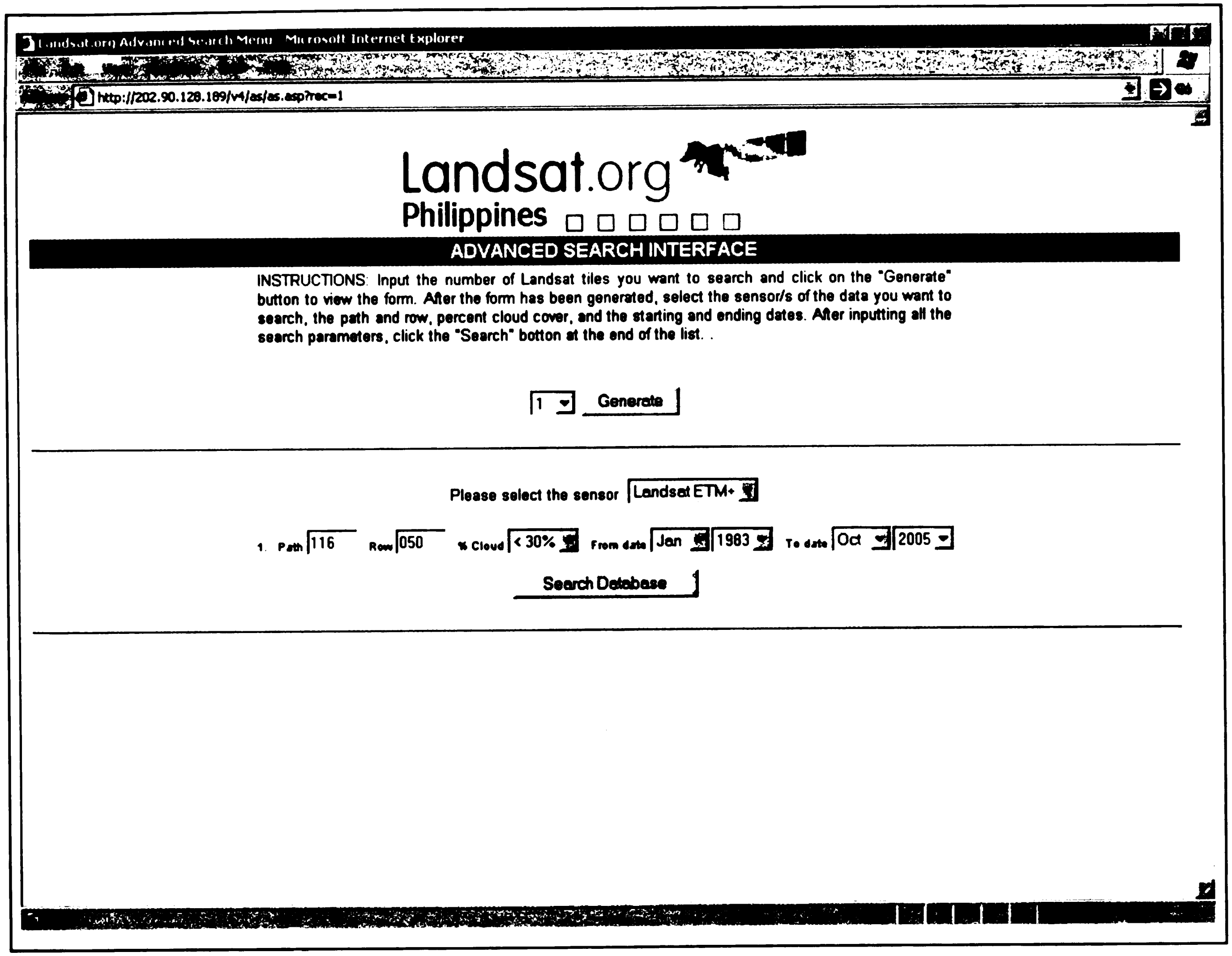

Figure 6.18. The form page.

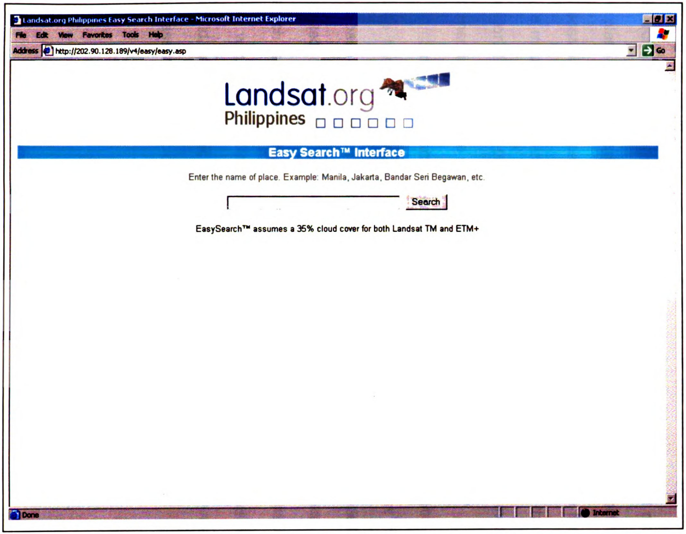

Figure 6.19. The EasySearch™ Page.

EasySearch™ was designed for users who are not familiar with the WRS2 tile system, but have an idea of the place where they want a satellite data. By inputting the name of the place of interest on the text box and pressing the "Search" button, the system will search for records in its database that matches the place name the user inputted and returns the results to the user. From the list of possible place name matches, the user is given the option to locate the area on a map or start searching for the Landsat data. **Figure 6.20** shows the place locator. The zoomed-out map on the left is the Island of Jolo, Philippines. The zoomed-in map on the right is a place on the Island of Jolo called "Jolo."

Since EasySearch™ started using the more comprehensive version of the place name database, more place names that were not available in the old database became available for searching. The new database also provided more detailed descriptions of place name results. **Figure 6.21** shows place name search results for Jolo, Philippines. EasySearch™ returned different entries for Jolo, with corresponding descriptions like if it is a populated place, an island, airfield, etc. By default, EasySearch™ searches for both TM and ETM+ sensors and assumes a 35% cloud cover.

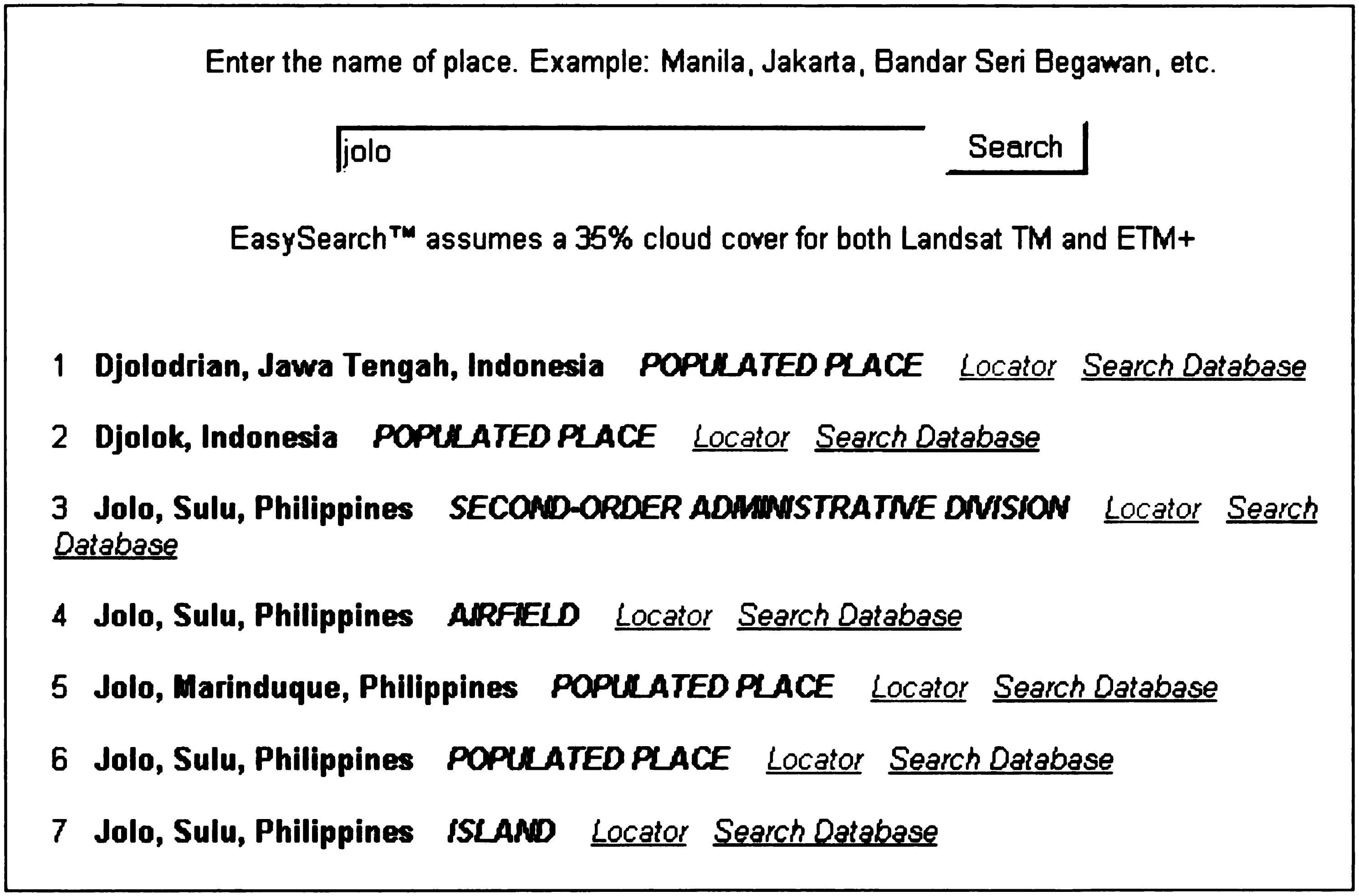

Figure 6.20. Place name search results for Jolo, Philippines.

Figure 6.21. Place locator showing the Island of Jolo, Philippines. The zoomed-out map of the island on the left and the zoomed-in map on the right showing a place named Jolo.

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6.6.7 GateKeeper3

GateKeeper3 is the component of Landsat.org Philippines that receives all search details from either interactive lite, interactive, form, or EasySearch™ and accesses and searches the distributed databases for Landsat data. GateKeeper3 displays the results to the users in a paged format with Landsat browse images shown as thumbnails. Next to each thumbnail image are the details about the Landsat data such as sensor, date, path and row, cloud cover, price, and archive location. GateKeeper3 also provides links to a data coverage viewer and to the list of available ancillary data. From GateKeeper3 an image may be selected for purchase and will be added to the shopping cart. GateKeeper3 also provides a link to ZoomImage, a component of Landsat.org Philippines that allows users to zoom in and out of the browse product. ZoomImage is activated by clicking on the Landsat image thumbnail. **Figure 6.22** shows GateKeeper3 with search results for Hundred Islands, Pangasinan, Philippines. **Figure 6.23** shows a Landsat image thumbnail with associated information and links to the data coverage viewer and ancillary data viewer. **Figure 6.24** shows the data coverage viewer. **Figure 6.25** shows the ancillary data list viewer. **Figure 6.26** shows the ZoomImage page.

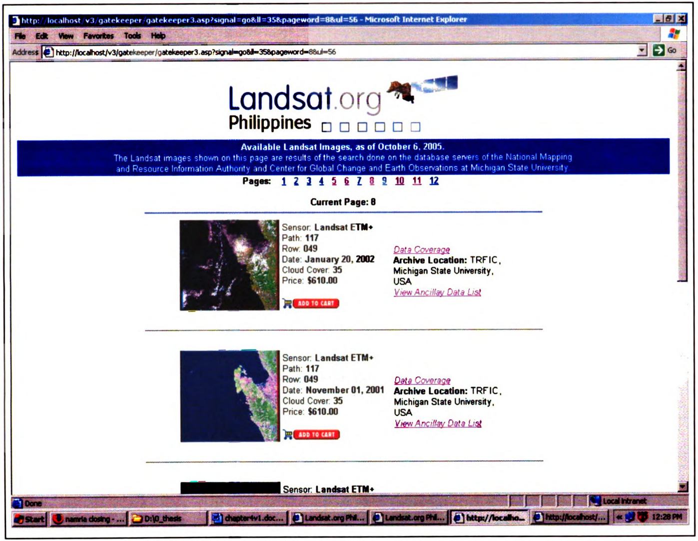

Figure 6.22. GateKeeper3 with search results for Hundred Islands, Pangasinan, Philippines.

Figure 6.23. Landsat image thumbnail with associated information and links to the data coverage viewer and ancillary data viewer.

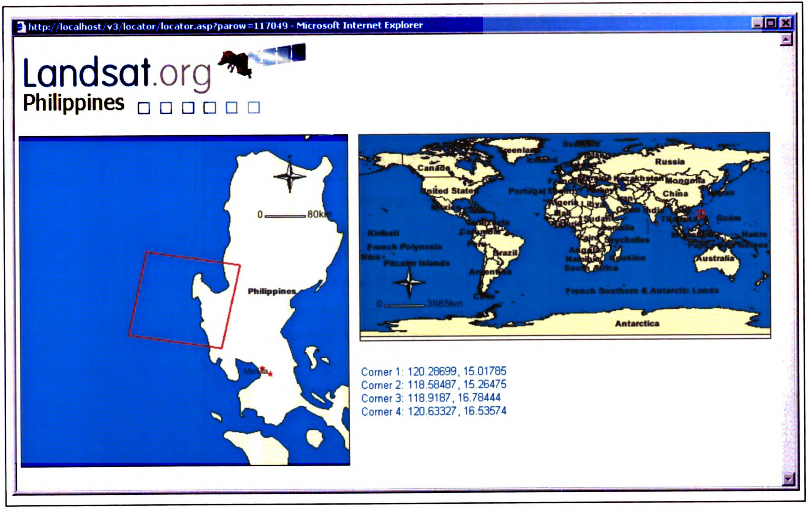

Figure 6.24. The data coverage viewer.

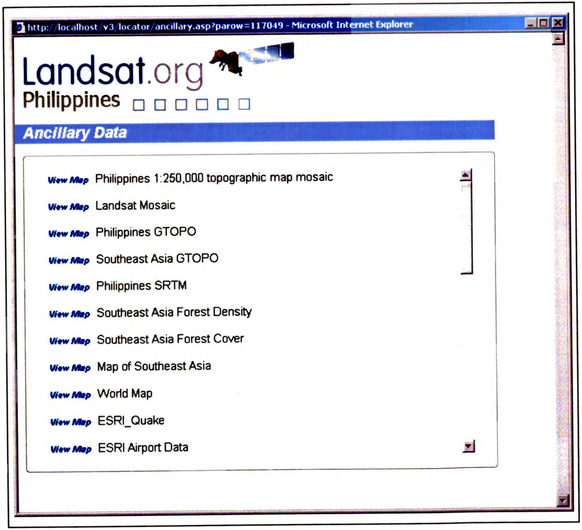

Figure 6.25. The ancillary data list viewer.

Figure 6.26. The ZoomImage page.

GateKeeper3 was written in ASP and cannot be activated without going through any of the four available data search methods. The needed variables and proper syntax will have to be posted by any of the four to GateKeeper3 to make it run. GateKeeper3 holds the access key to the distributed Landsat databases. Codes of GateKeeper3 are hidden from the users because they run only on the server. The user can only see the HTML codes generated by the server from running the ASP program. GateKeeper3 is designed to access five databases: the local TM and ETM+ databases and the remote TRFIC classic TM, EDC TM, and ETM+ databases. The local databases are accessed using ODBC, the classic TM and EDC TM using web services written in C#, and the ETM+ using map service "library." These databases are of different manufacturers, generations, mode of connections, and security requirements. These diverse characteristics are typical of the world's database environment. Having been able to successfully connect to different types of database software using different modes of connection, GateKeeper3 is a working model for an open, seamless, distributed, different generations database access envisioned by scientist to serve the community. Three years ago, this task would have been difficult to accomplish. But with the continued development and adoption of the web services technology as a standard for server to server communication, what was once difficult is now possible to accomplish.

GateKeeper3 handles both Landsat TM and ETM+ data. The sequence at which the Landsat image thumbnails are displayed are based on their priority, determined by the geographic proximity of the database to the host agency.

Landsat data available locally and whose records are in the local databases are given display priority over data records available on remote databases where the actual data is held. After following this rule, GateKeeper3 follows another rule: ETM+ data are displayed first before the TM data. GateKeeper3 then sorts the data according to their date, with the latest image being displayed first and the oldest displayed last. Retrieval of similar data from different databases cannot be avoided, as this is a characteristic of the world's databases. As with finding the same product on different stores with different prices, the same is true for the prices of similar data found on the databases of different data centers. When GateKeeper3 encounters duplicate data, it eliminates the duplicate entry by giving priority to the data on the local database. The user does not get results of similar data from different sites with different prices. Discrepancy in the price of similar data could result to confusion on the part of user/client.

6.6.8 Shopping Cart

The shopping cart is the e-commerce component of Landsat.org Philippines. **Figure 6.27** shows the shopping cart. The shopping cart can be accessed only from GateKeeper3 and cannot be run by typing its URL on the browser. Shopping cart utilizes a session id posted by GateKeeper3 when the user clicks on the orange "ADD TO CART" graphics button. This mechanism prevents the shopping cart from being used to add garbage entries to the database. A user must be registered to utilize the shopping cart and will have to input his/her email for the system to check if the user is registered. If the user is registered, the system will retrieve the user's profile and display it. The shipping address is one of the information included in the user's profile. If the user wishes to change some information in the profile, he/she is provided the option to edit them. If all the information in the profile is correct, the user has the option to checkout or to continue browsing for Landsat images. **Figure 6.28** and **6.29** shows the login form the user needs to fill-up to access the update user profile form. Once the user submits his/her updated profile, a confirmation message is sent to the user. **Figure 6.30** shows this confirmation message. If the user is new, the system will prompt the user to register. After the registration process, the system sends a message to the user confirming the registration. **Figure 6.31** and **6.32** shows the user registration form and the confirmation message.

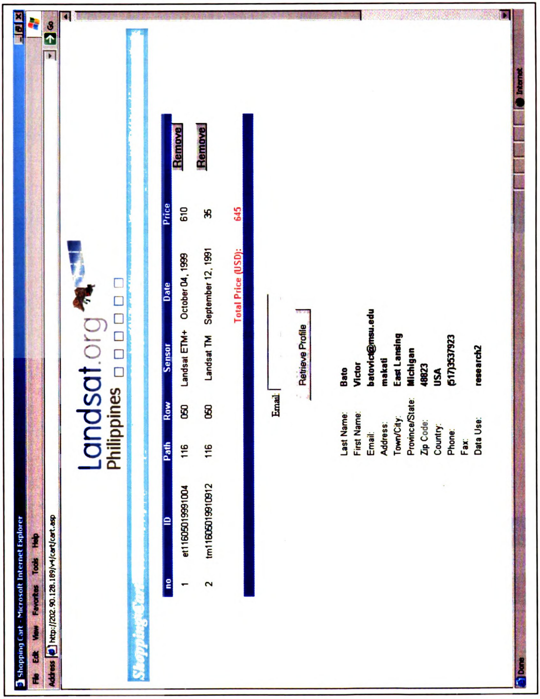

Figure 6.27. The shopping cart.

Figure 6.28. The user login form.

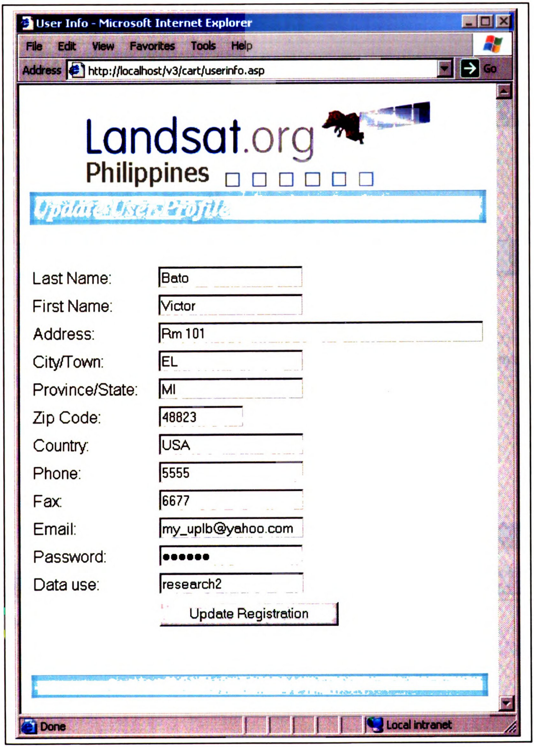

Figure 6.29. The update user profile form.

Figure 6.30. The user update profile confirmation message.

Figure 6.31. New user registration form.

Figure 6.32. The user registration confirmation message.

As Landsat images are added to the shopping cart, the total price the user has to pay gets updated automatically and are displayed in a highlighted manner. Once the user is finished choosing images, the user can checkout and a confirmation message will be sent to the user's browser. The confirmation message not only serves to inform the user of the end of his/her order session, but also provides the user with additional information on the steps to take to finalize his/her orders. **Figure 6.33** shows the order confirmation message.

The shopping cart component of Landsat.org Philippines utilizes two MySQL databases, the userinfo and userorder databases. Userinfo stores all information related to the user. Userorder stores the order history of each user. The two tables are linked with a unique customer id, composed of the user's session ID and last name.

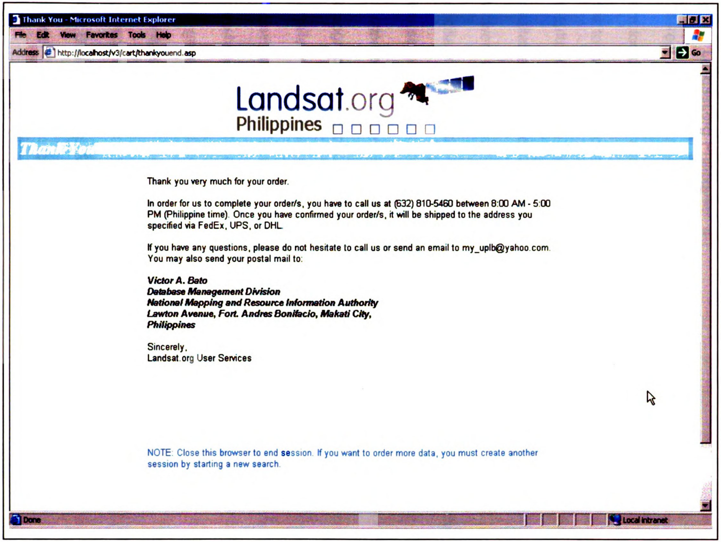

Figure 6.33. The order confirmation message.

6.6.9 Ancillary Data

Landsat.org Philippines has a collection of ancillary data that could be of interest to GIS data users. These data exists as ArcIMS® map services, some are located locally and others are found on servers outside the Philippines. The link to the list of ancillary data is found on GateKeeper3 when it generates search results. Clicking on the link opens up a new browser window with the list of the available ancillary data and their links. **Figure 6.25** shows the ancillary data list viewer. Clicking on the "View Map" link displays a static map of the chosen ancillary data with the Landsat tile footprint overlain. All listed ancillary data share the same image dimension and extents when displayed and thus, can be easily compared with one another side by side. **Figure 6.34** shows the 1:250,000 topographic map ancillary data and **Figure 6.35** shows the Landsat mosaic ancillary data. These static maps may be viewed interactively by clicking on the "View Interactive Version" link found at the top center of every map. Depending on where the ancillary data is being hosted, if the map service is locally hosted, the generic map viewer will be used. If the map service is being hosted on a remote server, the Sternberg Map Viewer will be used. **Figure 6.36** shows the generic map viewer showing the Philippines' SRTM mosaic. **Figure 6.37** shows the Sternberg Map Viewer showing the minimum temperature for a 10-day period. The Sternberg Map Viewer was called as such because the map viewer was created by Sternberg (2005) and was modified for use in Landsat.org Philippines.

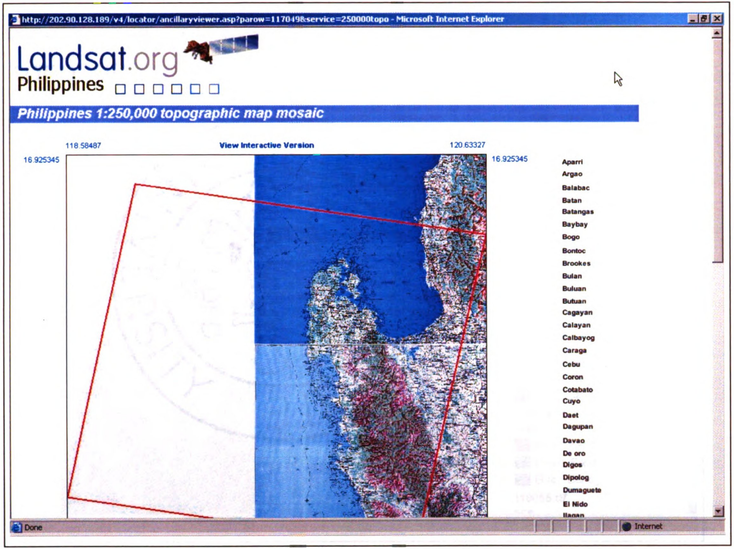

Figure 6.34. The 1:250,000 topographic map ancillary data.

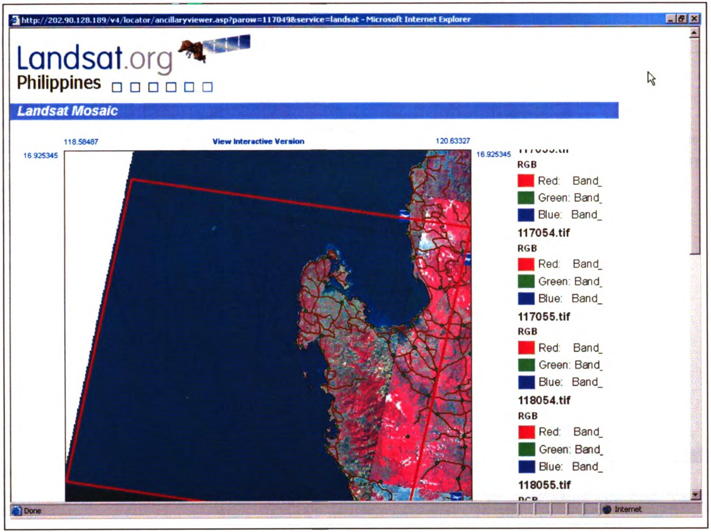

Figure 6.35. The Landsat mosaic ancillary data.

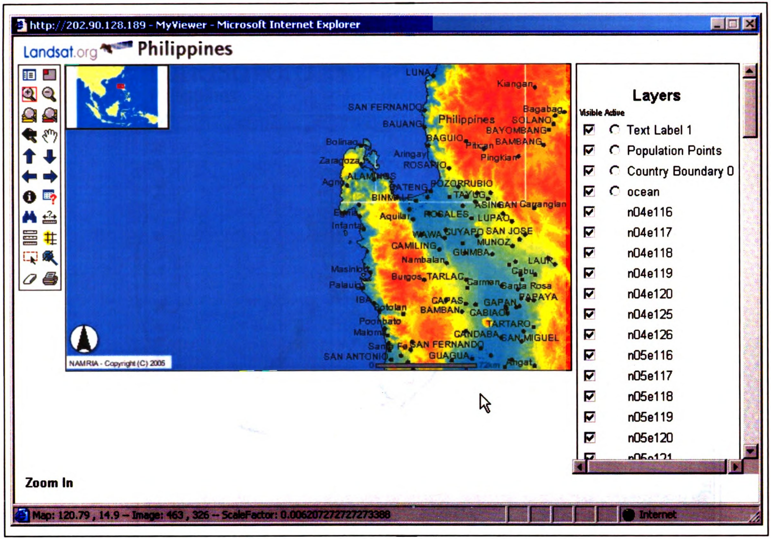

Figure 6.36. The generic map viewer showing the Philippines' SRTM mosaic.

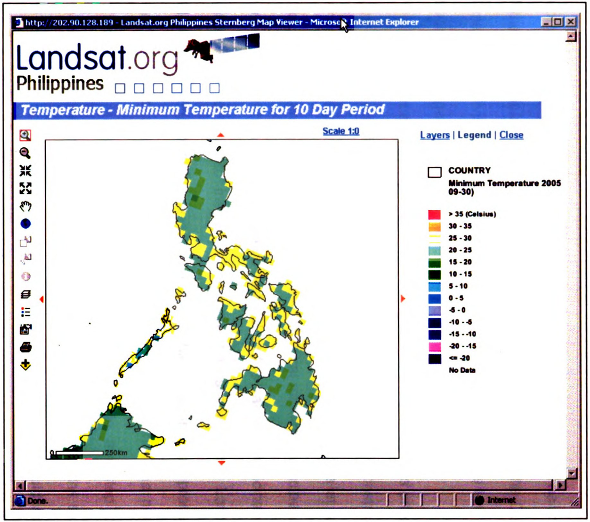

Figure 6.37. The Sternberg Map Viewer showing the minimum temperature for a 10-day period.

6.7 Technical Training

A technical training was conducted at the National Mapping and Resource Information Authority from January 4 to 6 and from 10 to 12, 2005. The schedule of the training is attached as **Appendix F**. Five technical staff of the Database Management Division participated in the training. The pictures of the training are attached as **Appendix G**.

A system overview presentation was given to the participants prior to the start of the training. This presentation included a live demonstration of Landsat.org Philippines and a short talk on how the system works at a higher level. This presentation was followed by the technical training. Participants were given a handout to serve as reference material for the training. Participants were given the opportunity to install the software necessary to run Landsat.org Philippines. Some participants encountered problems during this process and were instructed to start over using a different computer. Once the necessary software were installed, the participants were guided to the step by step procedure of configuring the system components. Configuration of the system is the most difficult part of the training because each computer would require a unique configuration. The participants were told of things they need to consider when adjusting the configuration of the system. Because this is the first time the technical staff of the Database Division has handle a low level technical training, the participants were closely guided during the most difficult part of this exercise. Questions were answered during the course of the training.

A talk on the possible use of Landsat.org Philippines' technology to start the NGII project was given to the participants. Overall, the training went as planned. Managers at NAMRIA showed a positive response on the training and benefits it can give to the technical staff and the agency.

6.8 The E-commerce Approach

Landsat.org Philippines has an e-commerce component through the shopping cart. Landsat.org Philippines chargers its clients a minimal amount to cover data delivery and hardware maintenance. The purpose of this charge is not to make a profit, but to make the information system sustainable. Sustainability will ensure the availability and continuity of the service and will foster further advancements and innovations. The majority of the operating cost of Landsat.org Philippines is being shouldered by NAMRIA, in essence the data the client receives is mostly subsidized by the agency. TRFIC follows an e-commerce model and is the major reason for its continuous service.

6.9 Landsat.org Philippines, a Model Information System for Southeast Asia.

Landsat.org Philippines is a model information system for the Southeast Asian region. Southeast Asia has a developing economy and countries have a good telecommunication and internet system. An ODGISDAS like Landsat.org Philippines will be highly useful in bringing information to some corners of the region where information and science and technology is in demand. Countries maintaining ground receiving stations like Thailand, Singapore, and Taiwan will also benefit from this information system because it will expose to people their products and services. But the end beneficiary is the people of Southeast Asia. People will get to choose from different types of satellite data, some are expensive, but most are free. Bringing information to the people of the region through an information system like Landsat.org Philippines will give them more knowledge of their environment, which if they use correctly will improve the quality of life.

6.9 Speed Testing of Landsat.org Philippines

The speed of some components of Landsat.org Philippines was tested on different computers located at different places and with different internet connection speeds. The purpose of the speed test is not to draw a conclusion on the average speed and how user friendly the system and its components are nor to perform a statistical analysis of the different speed measurements, but to show that the system performs at a reasonable speed for people to use. **Table 6.1** shows the speed test results for some components of Landsat.org Philippines. The interactive map and GateKeeper3 performs the slowest among the components tested. GateKeeper3's slow performance is not because the program just runs too slow, but because GateKeeper3 has to access several databases at different parts of the globe. The interactive map is slow because as a result of it being fully functional, the interface is loaded with many algorithms that the server and the client's computer will have to perform. This interface also requires back and forth communication with the server and the client while the pages are loading and when any operation on the map is being performed.

Table 6.1. Speed test results for some components of Landsat.org Philippines.

IP Address	**Front page** (0' 00")	**Interactive lite** (0' 00")	**Interactive** (0' 00")	**Easy Search™** (0' 00")	**Gate Keeper3** (0' 00")
198.242.23.9 *office LAN (Ann Arbor, MI)*	0' 07"	0' 24"	1' 08"	0' 13"	1' 19'
35.10.89.140 *university internet (MSU, East Lansing, MI)*	0' 21"	0' 38"		0' 11"	1' 34"
128.211.179.108 *university internet (Purdue University, IN)*	0' 17"	0' 29"	1' 09" *	0' 11"	1' 09"
35.11.49.139 *Cable (MSU, East Lansing, MI)*	0' 38"	0' 36"	2' 30" **	0' 14"	1' 30"
24.11.171.5 *Cable (Okemos, MI)*	0' 06"	0' 33"	2' 22"	0' 15"	1' 10"
68.40.51.23 *Cable (Ann Arbor, MI)*	0' 06"	0' 26"	0' 58"	0' 12"	1' 28"
65.43.35.79 *DSL (East Lansing, MI)*	0' 05"	0' 11"	0' 57"	0' 20"	1' 07"

* Map and overview map did not load.
** Retried because browser was closed prematurely

6.10 Issues Concerning Landsat.org Philippines

6.10.1 Cooperation

For an open, distributed GIS data archive system like Landsat.org Philippines to succeed, a low level cooperation between different data archive centers is necessary. Each data archive center should allow access to its data collection by using standard protocols and technologies. But because each data center's databases are setup differently and uses different data schemas, a translator is necessary to comply with the standard protocols. A web service can serve as translator for the database. This technology was successfully used in Landsat.org Philippines. For the interconnectivity between data archive center to happen, each center should cooperate and be willing to transform and/or adapt their systems to allow interconnectivity. Depending on the level of sophistication of the data archive center, some centers may require more work than others. Institutional issues will definitely surface and will have to be resolved internally by each data center.

6.10.2 Terrorism

One of the great issues on making spatial data available to everybody over the internet is that these data can be used by terrorist in planning their attacks. But even if these data are not online, terrorists can easily purchase, by various means, high resolution images from private companies. Not making these spatial data available to the public will only hinder world development.

CHAPTER VII

CASE STUDY

7.1 The Tragedy

The entire barangay of Guisaugon, Saint Bernard, Philippines, was covered in mud when a portion of the nearby mountain collapsed. The mudslide occurred on February 17, 2006. Very few people survived the incident because it occurred in a swift manner. The majority of the residents of the barangay perished, with very few bodies recovered. The recovery operation was hampered by the thick and unstable mud, which prevented the use of heavy equipment. Continuous rainfall made the retrieval operation more difficult. The rescue and retrieval operations were later stopped due to the impossibility of finding someone still alive. **Figure 7.1** shows a CNN report of the Guinsaugon Landslide.

Many speculations exists as to what have caused this tragedy. Politicians blame the illegal loggers and miners. Logging and mining activities removes forest cover and disturbs the soil, making the area susceptible to landslides. Scientists from PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration) reported above normal rainfall events in the area brought about by the La Nina. Scientists from the (PHIVOLCS) Philippine Institute of Volcanology and Seismology recorded a minor earthquake with an epicenter near the area before the landslide occurred. An eyewitness of the tragedy reported hearing rumblings and feeling an earthquake during the event.

http://edition.cnn.com/2006/WORLD/asiapcf/02/17/philippines.landslide/

Yahoo! Mail - my_uplb@yahoo.com | CNN.com - Rescue resumes after 1,... | (Untitled)

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Rescue resumes after 1,500 missing

Rescue effort in Philippines slowed by blackout, ground instability

Saturday, February 18, 2006 Posted: 0346 GMT (1146 HKT)

(CNN) -- Rescuers have resumed searching for 1,500 people estimated missing after a massive mudslide buried a village in the southern Philippine island of Leyte.

The head of the Philippine Red Cross Richard Gordon said that as many as 300 people may have died and estimated 1,500 villagers are missing.

But other officials said it was still unclear exactly how many were missing from the village of 1,875 people because they don't know how many fled after warnings to leave.

About 24 hours after mud buried hundreds of homes on Friday morning, 20 villagers were confirmed dead, and 56 people were found alive, including a child, said Rosette Lerias, provincial governor of Leyte.

Rescue efforts had to be called off overnight because of unstable earth and a lack of electricity, said Defense Secretary Avelino Cruz, who is leading the rescue

(AP PHOTO)

A rescuer carries a young child to safety on Friday.

Image: PREVIOUS START OVER

RELATED

Gallery: Villagers feared buried under mudslide

• Interactive: Location of village hit by mudslide

Figure 7.1. A CNN report about the landslide tragedy at Barangay Guinsaugon, Saint Bernard, Philippines.

7.2 The Problem

During tragedies, similar to what happened to Guinsaugon, the availability of geospatial information is essential to search and rescue operations and to assess the damage caused by the event. Such geospatial information are currently not available for the village of Guinsaugon. Maps, satellite images, and GIS data are present, but are stored in the offices and archives of agencies. People who need these data most, like the local government of Saint Bernard, have no access to them. Experts who can analyze, study, and perform modeling on the data will have to search for these data from different sources. The value of an information system that serves as a decision support tool by integrating different types of data are noticed only whenever a catastrophic event like the Guinsaugon Mudslide occurs. If such an information system is present back before the tragedy occurred and if the available data in the system have been used by experts in planning, Geography, Geology, Meteorology, etc., an early warning system could have been developed and many lives would have been spared from the mudslide.

7.3 Applying Landsat.org Philippines to the Guinsaugon Mudslide

Many residents of the Philippines, are not familiar with the location of Barangay Guinsaugon, though many could probably locate the Island of Leyte. Barangay Guinsaugon is just a small village and is not listed in any of the mapping services available in the Internet. Very little is known about this village, until after the tragedy. Using Landsat Philippines' EasySearch™, I was able to determine the location of Guinsaugon. **Figure 7.2** shows results of EasySearch™ for "guinsaugon." **Figure 7.3** shows the map of Guisaugon, Saint Bernard. **Figure 7.4** shows the available Landsat data for the area. Examining available June 29, 1992 Landsat TM data, path 113, row 053, (**Figure 7.5**) revealed that the mountain next to Guinsaugon is covered by vegetation. The image also shows some patches of bare to grassy areas, an evidence of human disturbance. This disturbance could have been caused by illegal logging at a small scale and not the large scale type. A photograph taken after the mudslide occurred showed the area surrounding the mudslide scar thickly covered with vegetation (**Figure 7.8**). Ancillary data for the area is also available for Landsat.org Philippines users. **Figure 7.6** shows an elevation map based on the SRTM and **Figure 7.7** shows the 1:250,000 topographic map of the area. A post disaster study conducted by a team of experts from the University of the Philippines, Diliman, and Ateneo de Manila, visited the site and performed a detailed study. One of the data used by the team of experts is the Landsat TM data shown in **Figure 7.5**. The team of experts reached a conclusion of *the factors suspected to have triggered the Guinsaugon rockslide-debris avalanche are rainfall and a 2.6 magnitude earthquake* (Lagmay, A. M. A. *et al.*, 2006).

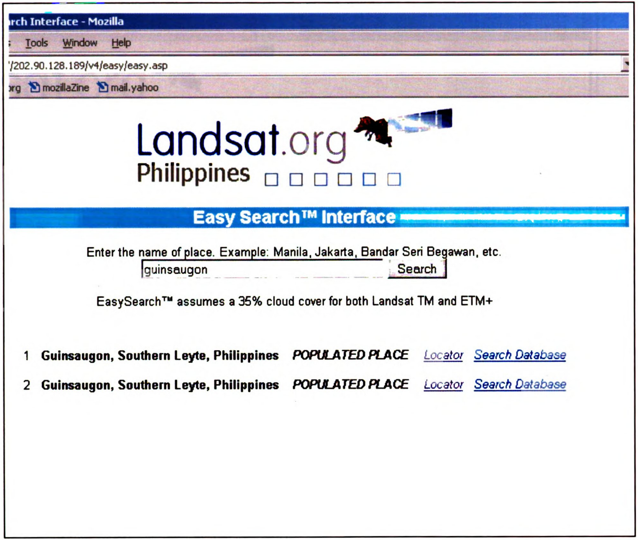

Figure 7.2. EasySearch™ results for "guinsaugon."

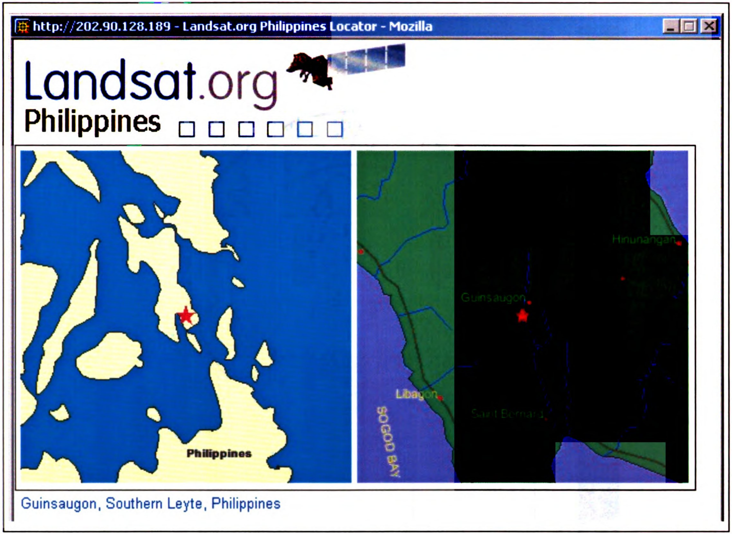

Figure 7.3. Locator map showing Barangay Guinsaugon.

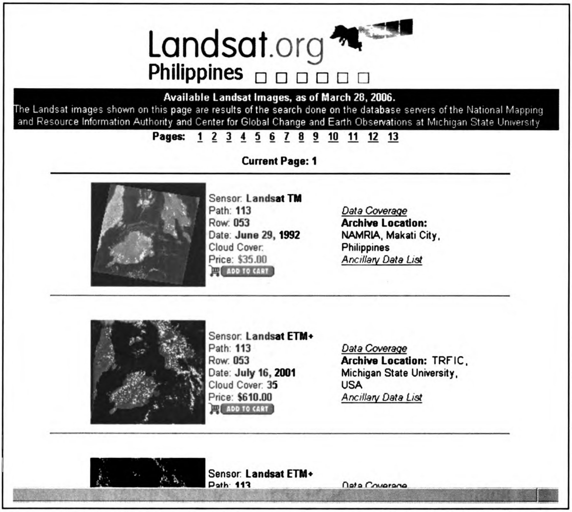

Figure 7.4. Availiable Landsat data for Barangay Guinaugon.

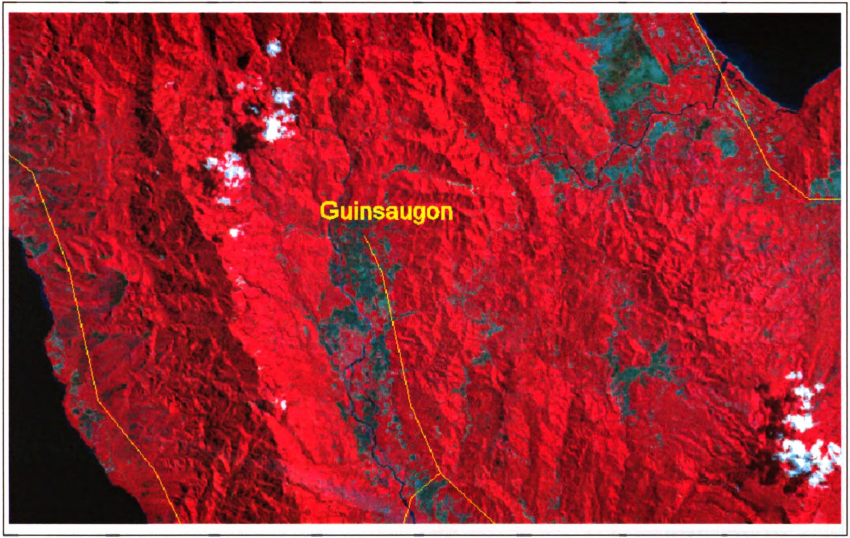

Figure 7.5. June 29, 1992 Landsat TM (path 113, row 053) image of Barngay Guinsaugon.

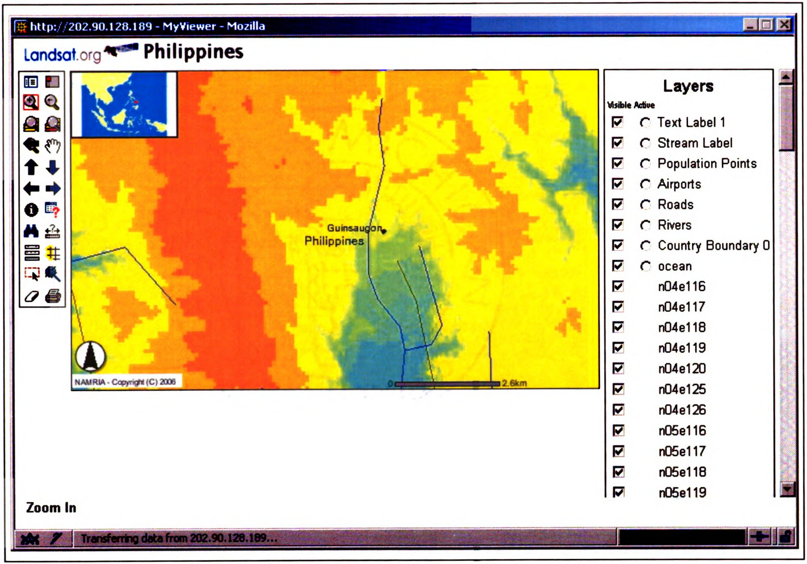

Figure 7.6. SRTM elevation map of Barangay Guinsaugon.

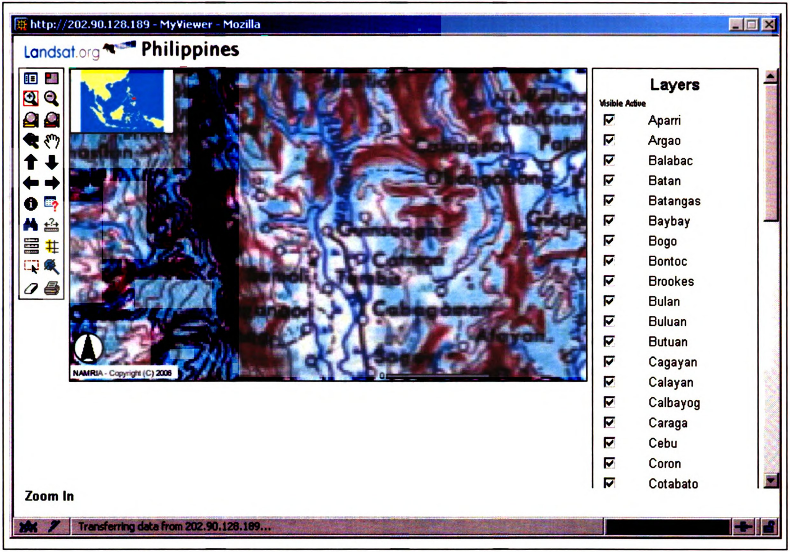

Figure 7.7. 1:250,000 topographic map of Barangay Guinsaugon.

Figure 7.8. Photograph of Barangay Guinsaugon covered with mud.

CHAPTER VIII

CONCLUSION

The open, distributed GIS data archive system (ODGISDAS) Landsat.org Philippines is the final result of this research and can be accessed using the URL http://202.90.128.189. This system answers the need to develop an ODGISDAS that would serve GIS data users in the Philippines. The system is being hosted at the NAMRIA (National Mapping and Resource Information Authority), Makati City, Philippines.

Landsat.org Philippines is a ODGISDAS for Landsat data and was created using a combination of generic and off-the-shelf technologies for GIS, web, and database management. Though the system is designed to utilize commercial, off-the-shelf software, the system can run independent of them or can be made to utilize open source software to replace commercial ones.

Landsat.org Philippines is the Southeast Asian node of Landsat.org. The system brings together Landsat data from five databases, two of which are located locally in the Philippines and the remaining three are located overseas at Michigan State University. The system takes advantage of recent advances in web services technology to communicate with remote database systems. This technology makes server to server communication easier and direct because it utilizes ordinary HTTP post and get communications, does not require special syntaxes, or utilize specialized ports usually closed by firewalls.

Landsat.org Philippines is the answers the NRC's recommendation to NASA for an adaptive and distributed information systems that would allow scientists to seamlessly interact with data from different servers across the globe. The system does this by finding and linking spatial ancillary data with every Landsat data search performed. These ancillary data are fetched from different map servers across the globe. To cater to the needs of local users, ancillary data deemed important to local users are also linked to every Landsat data search.

Landsat.org Philippines enjoys some degree of independence from Landsat.org. The system can be easily retooled, upgraded, and customized to cater to user's needs. The system's wordings have been translated into Tagalog, one of the local mainstream languages in the Philippines. Translation of the wordings to the local dialect makes the system attractive to users who are not comfortable in using the English language. In effect, the system effectively brings Landsat data and other geographic information to different sectors of society through the web.

Landsat.org Philippines brings geographic information closer the people who need them. These information are beneficial to different levels of society. Scientists and students would benefit from understanding and learning more about the environment. Planners and decision makers would be able to make sound decisions on environment related issues. People, not within the mentioned categories, would develop a better appreciation of the environment. In essence, democratizing geographic information would pave the way for development and a better quality of living.

Landsat.org Philippines is the realization of the Philippines' NGII (National Geographic Information Infrastructure). Many problems have stalled the implementation of the NGII. Landsat.org Philippines is a working system that fulfills some of the functions envisaged for the NGII. Development teams can utilize Landsat.org Philippines' technology to create the NGII and can take advantage of the lesson learned from creating this system.

Landsat.org Philippines embodies some of the expectations of the National Research Council for an adaptive and distributed information systems and fulfills the needs of the National Mapping and Resource Information Authority for its National Geographic Information Infrastructure. An open, distributed GIS data archive system similar to Landsat.org can be implemented easily using generic technologies or off-the-shelf software installed on hardware with descent computing capabilities.

APPENDIX A

Lists of ESIPs

Appendix Table A1. List of Type 2 ESIPs

No.	Type 2 ESIPs
1	TRFIC - Tropical Rain Forest Information Center
2	ARIA - Arizona Regional Image Archive
3	Climate Rainfall Data Center
4	DODS - Distributed Oceanographic Data System
5	EOS-WEBSTER - WEB based System for Terrestrial Ecosystem Research
6	ESP2net - Earth Science Partners' Private Network
7	ESSE 21 - Earth Systems Science Education 21st Century
8	ESSW - Earth System Science Workbench
9	GENESIS - GPS Environmental & Earth Science Information System
10	GLCF - Global Land Cover Facility
11	GP RESAC - Great Plains Regional Earth Science Applications Center
12	IBM Watson
13	IEF - Ecological Forecasting
14	ISCCP - International Satellite Cloud Climatology Project
15	NTSG - Numerical Terradynamic Simulation Group
16	Ocean ESIP
17	PM-ESIP - Passive Microwave Earth Science Information Partner
18	RADARSAT Geophysical Processor System
19	Scatterometer Climate Record Pathfinder
20	SERVIR
21	SIESIP - Seasonal to Interannual Earth Science Information Partner
22	SnowHydro
23	SnowSIP
24	SW RESAC - Southwest Regional Earth Science Applications Center
25	TerraFly
26	UNIDATA

Appendix Table A2. List of Type 3 ESIPs

No.	Type 3 ESIPs
1	BASIC - Basic & Applied Spatial Information Collaborative
2	Border Spatial Decision Support System
3	CalSIP - California Land Science Information Partnership
4	CLEAR - Center for Land use Education And Research
5	DLESE - The Digital Library for Earth System Education
6	EDAC - Earth Data Analysis Center
7	ELIS - Environmental Legal Information Systems
8	Earth Data Discovery Consortium
9	The GLOBE Program
10	Kentucky Landscape Census
11	MA RESAC - Mid-Atlantic Regional Earth Sciences Application Center
12	MuTPE - Museums Teaching Planet Earth
13	MY NASA DATA
14	NatureServe
15	Project 3D-VIEW
16	RITI - Reading Information Technology Inc.
17	SciFish - Scientific Fisheries Inc.
18	SCWHC - Southern California Wildfire Hazard Center
19	Stormcenter Communications
20	Tactical Geographics, L.L.C
21	TERC
22	TerraSIP
23	UMAC - Upper Midwest Aerospace Consortium
24	Veridian, Inc.

APPENDIX B

List of Ground Receiving Stations

Appendix Table B1. List of ground receiving stations.

Country	Ground Receiving Station
Argentina	Comision Nacional de Actividades Espaciales
Australia	GEOSCIENCE AUSTRALIA - National Mapping Division
Brazil	Instituto Nacional de Pesquisas Espaciais
Canada	Canada Center for Remote Sensing
Ecuador	Centro de Levantamientos Integrados de Recursos Naturales Por Sensores Por Sensores Remotos
Germany	German Aerospace Center
Italy	European Space Agency
India	Nationa Remote Sensing Agency
Indonesia	Lembaga Penerbangan Dan Antariksa Nasional
Japan	National Space Development Agency
Japan	Hiroshima Earth Environment Information Center
Malaysia	Malaysian Center for Remote Sensing
Pakistan	Space and Upper Atmosphere Research Commission
China	China Remote Sensing Satellite Ground Station
Singapore	Center for Remote Imaging, Sensing, and Processing
South Africa	CSIR Satellite Applications Centre
Saudi Arabia	Saudi Center for Remote Sensing
Taiwan	Center for Space and Remote Sensing Research
Thailand	Geo-Informatics and Space Technology Development Agency
US	Puerto Rico
US	USGS EROS Data Center
US	University of Hawaii at Manoa

APPENDIX C

Database Schemas

Appendix Table C1. Landsatetm database schema.

Field	Type
Entityid	Varchar(50)
Path	Int(6)
Row	Int(6)
Year	Varchar(4)
Month	Char(2)
Day	Char(2)
Date	date
Yrday	Int(3)
Cloud	Int(3)
Parow	Varchar(10)
url	Varchar(255)
Loc	Int(5)
Uniqueid	Varchar(50)
Archive	Varchar(255)
info	Varchar(255)

Appendix Table C2. Landsattm database schema.

Field	Type
Entityid	Varchar(50)
Path	Int(6)
Row	Int(6)
Year	Varchar(4)
Month	Char(2)
Day	Char(2)
Date	date
Yrday	Int(3)
Cloud	Int(3)
Parow	Varchar(10)
url	Varchar(255)
Loc	Int(5)
Uniqueid	Varchar(50)
Archive	Varchar(255)
info	Varchar(255)

Appendix Table C3. Newetm database schema.

Field	Type
uniqueid	Varchar(100)
Parow	Varchar(100)
Path	Int(11)
Row	Int(11)
Date	date
Cloud	Int(11)
Filename	Varchar(100)
url	Varchar(255)

Appendix Table C4. Newtm database schema.

Field	Type
Uniqueid	Varchar(100)
Parow	Varchar(100)
Path	Int(11)
Row	Int(11)
Date	date
Cloud	Int(11)
Filename	Varchar(100)
url	Varchar(255)

Appendix Table C5. Parowcorner2 database schema.

Field	Type
objectid	Int(11)
Wrs2path	Int(11)
Wrs2row	Int(11)
Parow	Varchar(100)
Xcoord	double
Ycoord	double
1x	double
1y	double
2x	double
2y	double
3x	double
3y	double
4x	double
4y	double
5x	double
5y	double

Appendix Table C6. Seaplaces database schema.

Field	Type
Ycoord	double
Xcoord	double
Country	Varchar(100)
Place	Varchar(100)
Province	Varchar(100)
Featdesc	Varchar(100)

Appendix Table C7. Places database schema.

Field	Type
Place	Varchar(100)
Country	Varchar(100)
Xcoord	double
ycoord	double

Appendix Table C8. Userinfo database schema.

Field	Type
Email	Varchar(30)
Customerid	Varchar(50)
Lastname	Varchar(30)
Firstname	Varchar(30)
Address	Varchar(200)
Town	Varchar(30)
Province	Varchar(30)
Zipcode	Varchar(20)
Country	Varchar(30)
Phone	Varchar(30)
Fax	Varchar(30)
Date	Date
Password	Varchar(20)
Datause	Varchar(200)

Appendix Table C9. Userorder database schema.

Field	Type
Orderno	Varchar(50)
Orderdate	date
Email	Varchar(50)
No	Int(11)
Iniqueid	Varchar(50)
Path	Varchar(10)
Row	Varchar(10)
Sensor	Varchar(50)
Date	Varchar(50)
Customerid	Varchar(50)
price	Float(20,2)

Appendix Table C10. Ancillary database schema.

Field	Type
detdesc	varchar(250)
publisher	varchar(100)
priority	int(2)
service	varchar(100)
path	varchar(100)
querytype	varchar(100)
version	varchar(100)
description	varchar(100)
minx	Double
maxx	Double
miny	Double
location	varchar(50)
maxy	Double

APPENDIX D

The slope computation code imbedded in the EasySearch™ parse.asp.

```
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<title></title>
<meta name="description" content="">
<meta name="keywords" content="">
<meta name="author" content="batovict@msu.edu">
<meta name="generator" content="AceHTML 5 Freeware">
<script language="JavaScript" type="text/javascript">
<!--
-->
</script>
</head>
<body>
<!--submits the form-->
<script>
function submit() {
document.parseform.submit();
}
</script>
<%
tempx = CDbl(request.querystring("x"))
tempy = CDbl(request.querystring("y"))

dim parowin(100000)
gencnt = 0

set objConn = Server.CreateObject("ADODB.Connection")

objConn.Open "driver={MySQL ODBC 3.51 Driver};"_
                                            & "SERVER=127.0.0.1;"_
                                            & " DATABASE=parowcorner2;"_
                                            & "UID=*****;PWD=*****;"

StrQ = "SELECT * from parowcorner2;"
Set objRS = objConn.Execute(StrQ)
response.flush

While Not(objRS.EOF)

ind1 = ind1 + 1
x1 = objRS("1x")
y1 = objRS("1y")
x2 = objRS("2x")
y2 = objRS("2y")
x3 = objRS("3x")
y3 = objRS("3y")
x4 = objRS("4x")
y4 = objRS("4y")
slope1 = (y2-y1)/(x2-x1)
```

```
slope2 = (y3-y2)/(x3-x2)
slope3 = (y4-y3)/(x4-x3)
slope4 = (y1-y4)/(x1-x4)

decide = 0
'computing for segment1 (x1,y1 and x2,y2)
seg1x = x1+((tempy-y1)/slope1)
if seg1x < tempx then
decide = decide +1
end if
'computing for segment2 (x2,y2 and x3,y3)
seg2y = y2 + (slope2*(tempx-x2))
if seg2y > tempy then
decide = decide +1
end if
'computing for segment3 (x3,y3 and x4,y4)
seg4x = x3+((tempy-y3)/slope3)
if seg4x > tempx then
decide = decide +1
end if
'computing for segment4 (x4,y4 and x1,y1)
seg4y = y4+(slope4*(tempx-x4))
if seg4y < tempy then
decide = decide +1
end if
'getting parows that fall within the coordinates, polygons, etc.
if decide = 4 then
gencnt = gencnt + 1
parowin(gencnt) = objRS("parow")
starter = objRS("parow")
end if

objRS.MoveNext
Wend

objRS.close
objConn.close
Set objRS = Nothing
Set objConn = Nothing

if len(starter) = 0 then
response.end
end if

mydate = Date
mydatelength = len(mydate)
todayyear = right(mydate,4)
tempdate1 = left(mydate,3)
```

```
tempdate2 = instr(tempdate1,"/")
tempdate3 = tempdate2 - 1
tempdate4 = mydatelength - (tempdate2 + 5)
tempdate5 = tempdate2 + 1
todaydate = mid(mydate,tempdate5,tempdate4)
if len(todaydate) = 1 then
todaydate = "0" & todaydate
end if
todaymonth = left(mydate,tempdate3)
if len(todaymonth) = 1 then
todaymonth = "0" & todaymonth
end if

'response.write "<form action="&chr(34)&"../gatekeeper/requestsniffer.asp"&chr(34)&"
method="&chr(34)&"post"&chr(34)&" name="&chr(34)&"parseform"&chr(34)&">"
response.write "<form action="&chr(34)&"../gatekeeper/gatekeeper3.asp"&chr(34)&"
method="&chr(34)&"post"&chr(34)&" name="&chr(34)&"parseform"&chr(34)&">"
response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"dummy"&chr(34)&" value="&chr(34)&"var"&chr(34)&">"
response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"recnum"&chr(34)&" value="&chr(34)&gencnt&chr(34)&">"
response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"sensor"&chr(34)&" value="&chr(34)&"both"&chr(34)&">"
response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"format"&chr(34)&" value="&chr(34)&"1"&chr(34)&">"
response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"cloud"&chr(34)&" value="&chr(34)&"35"&chr(34)&">"

response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"bd"&chr(34)&" value="&chr(34)&"01"&chr(34)&">"
response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"bm"&chr(34)&" value="&chr(34)&"01"&chr(34)&">"
response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"by"&chr(34)&" value="&chr(34)&"1984"&chr(34)&">"

response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"ed"&chr(34)&" value="&chr(34)&todaydate&chr(34)&">"
response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"em"&chr(34)&" value="&chr(34)&todaymonth&chr(34)&">"
response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"ey"&chr(34)&" value="&chr(34)&todayyear&chr(34)&">"

ind = 0
while gencnt > 0
ind = ind + 1
response.write "<input type="&chr(34)&"hidden"&chr(34)&"
name="&chr(34)&"parow"&ind&chr(34)&" value="&chr(34)&parowin(ind)&chr(34)&">"
gencnt = gencnt - 1
wend

response.write "</form>"
```

```
response.write "<script>submit();</script>"
%>


</body>
</html>
```

APPENDIX E

The Maintenance and Implementation Plan

Versioning and Improvement Plan

Improvements of the Landsat.org Philippines codes regularly occur due to feature and/or cosmetic upgrades, regular maintenance, and removal of bugs. Though upgrading of the system is no doubt a must, the older version of the software must be preserved on the web server and should be kept alive (continue running). Thus, versioning is an integral part of any improvement or upgrade. Versioning will apply to three major groups of the system, namely:

1. ArcIMS group
2. Core codes group
3. Database group

The ArcIMS group includes all Shapefiles, images, AXL files, map services, and web pages generated by ArcIMS. All the Shapefiles and image files necessary to create a map service is stored on *D:\newlayers*. Shapefiles and image files are reusable and not often edited. In an event a Shapefile or imagefile in the *D:\newlayers* directory needs to be edited, a copy of the file, bearing a new name will be the one edited. Any new Shapefile or image file needed by Landsat.org Philippines may be added to the *D:\newlayers* directory as long as it does not overwrite any existing file.

A new AXL file can be generated using different combinations and configurations of the Shapefiles and image files. The AXL files used by the Landsat.org Philippines are all stored in the *DVnewlayers* directory. An newer version of any existing AXL file may be created by creating a copy of the old version and naming the copy with the original name plus a suffix of the version. For example, we have an AXL file with a name of *seamap.axl* already existing in the *D:\newlayers* directory. A newer version will bear the name of *seamapv2.axl*. A much newer version will have a name of *seamapv3.axl*, and so on down the line. The idea behind versioning of the AXL file is to preserve the older version. Though AXL files are read only when the map service is being created, their preservation becomes important if the map service will have to be recreated.

The core codes includes the ASP, HTML, and JSP files that runs and integrates the entire Landsat.org Philippines system. Because we want to preserve older versions of the system, the newer version will be placed on a new physical and virtual directory. For example, in the fist release of Landsat.org Philippines, all of the core code files were in the *C:\Inetpub\wwwroot* directory, has no virtual directory, and can be accessed on the web using http://202.90.128.189/. Version 2 was placed on *C:\Inetpub\v2*, has a virtual directory of *v2* and can be accessed using http://202.90.128.189/v2/index.html. Subsequent versions will follow the same pattern as version 2. All core codes will be placed at *C:\Inetpub\v3..n,* will have a virtual directory of v..n, and can be accessed using http://202.90.128.189/v..n/index.html. Because the newer version of the core codes reside in a directory different from the old one, the same file names can be used for the core codes files without the danger of overwriting old files. Preserving filenames helps lessen work by also preserving the references and links to different web pages.

The database group includes all the MySQL database tables used by the Landsat.org Philippines System. Just like the Shapefiles and image files, the database tables are reusable by different versions of the core codes. The database tables require very little editing. If a table will be edited or a new one will be placed as a replacement on an old one, the new table will assume the name of the old table plus a suffix of the version. For example, we have a table called *landsatetm*, a newer version of this table will be named *landsatetmv2* and a much newer will be named *landsatetmv..n*. All the MySQL database tables are located in *C:\mysql\data*.

With every new release of Landsat.org Philippines, a back-up of the new version will be created on CD. Files that will be backed-up includes the core codes files (ASP, HTML, and JSP), the database tables (everything inside *C:\MySQL\data*), and the ArcIMS group of files (everything inside *D:\newlayers* includes all the Shapefiles, image files, and AXL files). Older versions of the system would have already been backed-up when they were installed.

In order to back-up the files into CD, the group of files or the entire directory that needs to be backed-up will be compressed into a single archive file using WinZip. Due to the difficulty in transferring large files remotely, the big archive file will be further broken down into small 1,200 KB chunks using the Arj Software. The individual chunks will be transferred to a computer in CGCEO using PCAnywhere's file transfer utility. Once the transfer of all necessary files is complete, the individual archive files will be reconstituted to form the bigger archive file (using the Arj Software) and will be burned into a CD.

Security Plan

Anti-Virus - As a standard security measure Norton Anti-Virus and BlackIce Defender firewall was installed on the server. The anti-virus protection of the server is sufficient, as of now. The virus definition file of the anti-virus will be updated every Friday of the week. Updating is done by clicking on the "Live Update" button on the Norton Anti-Virus console. Norton will automatically download the updates from Symantec's website. Updating of the definition file will be done every Friday because the latest virus definition file is released every Thursday. Although the Norton Anti-Virus Software is satisfactorily performing its task, a new license for the anti-virus is needed. The currently installed Norton Anti-Virus is licensed to MSU and used to be freely available to students and staff.

Firewall - The firewall BlackIce Defender is also performing satisfactorily on the server. The firewall was also able to catch activities/viruses such as "CodeWorm" and saved it as an event file. Every now and then, an update of BlackIce Defender is released by its manufacturer. On the event of an update release, the updates will be downloaded and installed on the server. Just like the anti-virus software a firewall licensed to the server is needed. BlackIce Defender seemed to be performing satisfactorily, but a better firewall can surely be used to take advantage of its more advanced features.

Microsoft Update - Every now and then, Microsoft Corporation releases updates and patches for its Windows™ operating system. Weekly checks to the Microsoft update website will be done and necessary updates will be downloaded and installed.

Services and Ports - The default installation of the Windows 2000 Server has many unnecessary services turned "on," by default. Disabling or turning "off" of these unnecessary services will prevent them from being used or exploited by hackers to gain access to the server. Closing of ports not needed to run Landsat.org Philippines will also be done as these ports may server as "bridge" for hackers to exploit and access the server.

By default, the firewall that has been installed, BlackIce Defender, closes all ports and disables all services for all IPs (internet protocol) addresses. Ports and services necessary to run and gain access to Landsat.org have been opened and turned-on on the firewall's configuration.

ArcIMS Configuration - The default installation of ArcIMS includes an HTML administrator webpage that can be accessed via the World Wide Web. This webpage can be utilized by hackers to access ArcIMS and modify the configurations on the server. This HTML administrator webpage has been disabled by removing its virtual directory from the virtual directory's listings on Windows's Internet Information Services.

Also, by default, ArcIMS enables directory browsing on the c:\ArcIMS subdirectories. Enabling directory browsing for webpage directories is not a good practice because it allows the users and potential hackers to see the directories and files. These information, complimented with other information and hacking techniques, could be used to gain unauthorized access to the server.

MySQL Security – The MySQL database, when installed, does not automatically configure itself like Microsoft's IIS (Internet Information Services). Access to "root" and the databases will have to be configured manually, otherwise they cannot be accessed at all. This kind of non-automatic configuration that MySQL has ensures that unnecessary services and permission are not turned-on, by default and provides more security control for the "root" user or administrator. MySQL has been setup such that "root" access is limited to the localhost. The database tables of MySQL cannot be edited by the ordinary user when accessed by the Landsat.org program. Database table access via Landsat.org is limited to query and selection, except for the tables required by the shopping cart.

Files and Directory Browsing – To ensure that the codes, files, and directories are safe from being accidentally exposed to users, all webpage directories were set such that they cannot be browsed by the user.

Shopping Cart Security – So that the shopping cart cannot be abused by curious users, the shopping cart utilizes "POST" to send information, rather than "GET." Also, the shopping cart cannot be run or activated by just typing the ASP file on the browser. The shopping cart gets the "session" value from the previous page. If the shopping cart does not find the session value, it does not run. This feature prevents the shopping cart from being activated without a valid shopping session and the database from being ruined and abused by users who just want to put spurious entries.

Long-term security plan - The long-term security plan is to put the server behind a hardware firewall. A hardware firewall will provide better protection in conjunction with the software firewall.

Operation and Monitoring Plan

Anti-virus log - The anti-virus log will be examined to see if there is any virus attack on the server. If a virus is found on the server, the file will be cleaned or deleted. Caution will be taken when deleting files because these files could be necessary in the operation of the server.

Firewall logs – The firewall log will be examined to identify attacks from hackers. Hackers may use automated techniques to gain access to the server and the number of times attempted to access the server gets log into the firewall. A typical attack would show several failed access attempt from an IP address. Once the IP address of an attacker is identified, it will be added to the blocked IP list of the firewall.

Recovery Plan

In the event that the server gets compromised (hacked) the following steps or a combination of the following steps will be taken:

1. Examine the Windows log files, which can be found at c:\winnsystem32\logfiles. Among the series of log files, identify the IP address the hacker is using to get into the server. Identifying which IP

address to block requires examining each entry in a log file. Usually, a hacker trying to access the server would have made a series of previous failed attempts. These attempts are registered in the log files and are easily identifiable because they are a series of requests originating from one IP. Once you have identified the IP, also take note of the port the hacker used to get into the server. On the firewall settings, block the IP and close the port the hacker used to gain access to the server.

2. Examine the firewall log file. If the Windows log files have been examined before and the IP and the port number the hacker is using have been identified, compare these values with the entries on the firewall log file. Block the suspected IP and close the port/s that is being used, if closing would not affect the operation of the server.
3. If the server needs rebuilding, the backup files of the site will be used to restore the server. The IP address used by the hacker will be entered into the block list of the firewall. The port of entry used will also be closed, if it would not hamper the operation of the server. The domain of the hacker will be determined by using the Network Tools website (http://www.nwtools.com) and an email about the abuse will be sent to the administrator of the domain (abuse@domainname.com).

Hardware Operation and Improvement

The server will inevitably deteriorate through time and will have to be repaired or replaced. Continuous backup of files will be done on the server, through another server connected to the network. The backup files will be used in rebuilding the new server, if the old one needs replacement.

UPS

An uninterrupted power supply (UPS) is needed to keep the server running during times of power fluctuations. Right now, because of the absence of a UPS, the server is shut down if a power fluctuation occurs to prevent it from being damaged. Powering down the server will surely prevent damage, but will make the Landsat.org Philippines site unavailable from that time being.

APPENDIX F

The Training Program

AGENDA

Web-enabled, Geo-spatial Data Systems and Services

Implementing a Decision Supports System Application at NAMRIA

January 4 – 6 & 10 - 12, 2005

Victor Bato
Dept. of Geography, Michigan State University
APN Project 2004-04 CMY

Jan. 4, 2005 (morning)	**Presentation of System Application Overview**	Bobby Crisostomo and Dept. staff
Jan. 4 – 6, 2005	**Software Installation** Installation and testing	Technical staff from Systems Development and Programming Division and Database Management Division
Jan. 10, 2005 9:00 – 12:00	**Training (I)** Overview and system requirements Installation	Technical staff from Systems Development and Programming Division and Database Management Division
Jan. 11, 2005 9:00 – 12:00	**Training (II)** Operation Customization	Technical staff from Systems Development and Programming Division and Database Management Division
Jan. 12, 2005 9:00 – 11:00	**Training (III)** Maintenance and development	Technical staff from Systems Development and Programming Division and Database Management Division
Jan. 12, 2005 (afternoon)	**Formal Presentation to Management** w/Bobby Crisostomo	Upper level management

A first-run installation may occur in December in order to ensure a successful final application. A formal installation with NAMRIA technical staff will be completed January 4 – 6, 2005.

APPENDIX G

The Training Pictures

Figure G1. Training conducted at NAMRIA, Philippines.

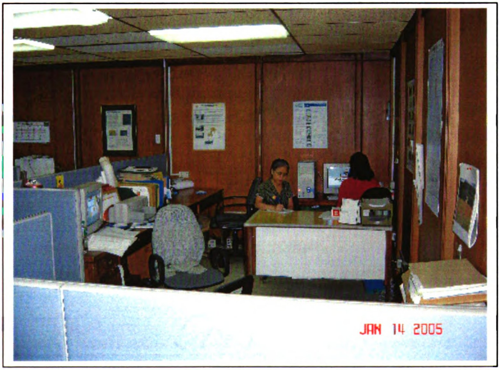

Figure G2. Training conducted at NAMRIA, Philippines.

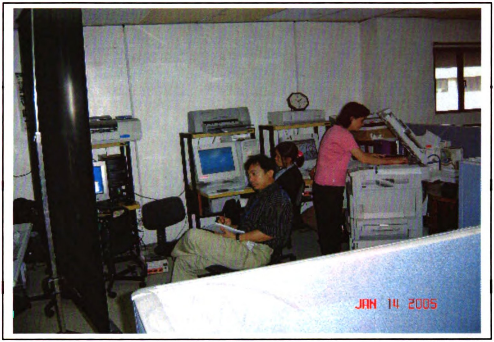

Figure G3. Training conducted at NAMRIA, Philippines.

Figure G4. Training conducted at NAMRIA, Philippines.

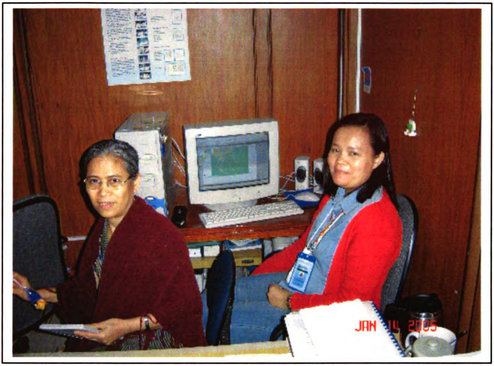

Figure G5. Training conducted at NAMRIA, Philippines.

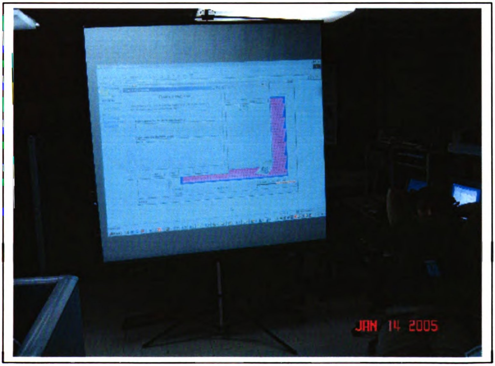

Figure G6. Training conducted at NAMRIA, Philippines.

APPENDIX H

List of Acronyms

ArcIMS – Arc Internet Map Server

ASCII – American Standard Code for Information Interchange

ASF – Alaska Satellite Facility

ASP – Active Server Pages

BSRSI – Basic Science and Remote Sensing Initiative

CAN – Cooperative Agreement Notice

CD – Compact Disc

CGCEO – Center for Global Change and Earth Observations

CNN – Cable News Corporation

DAAC – Distributed Active Archive Centers

DOI – Department of the Interior

ECS – EOSDIS Core System

EDC – Eros Data Center

EOS – Earth Observing Systems

EOSDIS – Earth Observing System Data and Information System

ESDIS – Earth Science Data and Information

ESRI – Environmental Systems Research Institute

EROS – Earth Resources Observation Systems

ERTS 1 – Earth Resource Technology Satellite 1

ESE – Earth Science Enterprise

ESIP – Federation of Earth Science Information Partners

GES – GSFC Earth Science

GHRC – Global Hydrology Resource Center

GIS – Geographic Information Systems

GML – Geography Markup Language

GOES – Global Observatory for Ecosystem Services

GSFC – Goddard Space Flight Center

HTML – Hypertext Transport Language

IMS – Information Management System

IIS – Internet Information Services

JPEG – Joint Photographic Experts Group

Landsat ETM+ - Landsat Enhanced Thematic Mapper Plus

Landsat TM – Landsat Thematic Mapper

LaRC – NASA Langley Atmospheric Sciences Data Center

LP – Land Processes

MPAA – Motion Picture Association of America

NAMRIA – National Mapping and Resource Information Authority

NASA – National Aeronautics and Space Administration

NGII – National Geographic Information Infrastructure

NRC – National Research Council

NSDI – National Spatial Data Infrastructure

NSIDC – National Snow and Ice Data Center

OASIS – Organization for the Advancement of Structured Information Standards

ODBC – Open Database Connectivity

ODGISDAS – Open, Distributed GIS Data Archive System

OGC – Open GIS Consortium (Open Geospatial Consortium)

ORNL – Oak Ridge National Laboratory

PAGASA - Philippine Atmospheric, Geophysical and Astronomical Services Administration

PC – Personal Computer

PHIVOLCS – Philippine Institute of Volcanology and Seismology

PO – Physical Oceanography

REASoN – Research, Education and Applications Solution Network

RIAA – Recording Industry Association of America

SEDAC – Socioeconomic Data and Applications Center

SEEDS – Strategic Evolution of ESE Data System

SOAP – Simple Object Access Protocol

SQL – Standard Query Language

SRTM – Shuttle Radar Topography Mission

TRFIC – Tropical Rain Forest Information Center

UDDI – Universal Description, Discovery, and Integration

UK – United Kingdom

URL – Universal Resource Locator

US – United States

USA – United State of America

USGS – United States Geological Survey

W3C – World Wide Web Consortium

WGS84 – World Geodetic System 1984

WSDL – Web Services Description Language

WRS1 – Worldwide Reference System 1

WRS2 – Worldwide Reference System 2

WWW – World Wide Web

XML – Extensible Markup Language

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