A Web Based GIS Database System

by

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This report, submitted by Jing Wang in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisor under whom the work has been done and is hereby approved.

Signature Thomas Wiggen

Date May 5, 2005

This project document meets the standards for appearance, conforms to the style and format requirements of the Computer Science Department of the University of North Dakota, and is hereby approved.

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ABSTRACT

In this report, we describe the design and implementation of Digital-NGP Website, a Web based GIS database system for UMAC clients to download Geospatial Data. This system is a three-tier Web database application. Tier 1 is User Interface. Tier 2 is the Functional Module. This level actually processes data. It consists of Apache web server, Mapserver4.0, PHP programs and C++ programs. Tier 3 is the Database Management System (DBMS).

CHAPTER I

INTRODUCTION

Satellites and airborne cameras provided the ability to capture a massive amount of digital imagery that is of value for agriculture. The Upper Midwest Aerospace Consortium (UMAC), supports a repository for some of this imagery and is developing a delivery system to make this data available to UMAC clients in the upper midwest. This software engineering project analyzes the needs of users and designs and implements an enhanced version of UMAC's initial prototype delivery system.

1.1 BACKGROUND

The goal of the Upper Midwest Aerospace Consortium (UMAC) is to provide information about the environment that enables people to make decisions improving their

- Economic Competitiveness
- Quality of Life
- Educational Preparedness

The primary source of the information is data acquired by satellites and aircraft. Beneficiaries of the information include:

- Farmers practicing Precision Agriculture
- Ranchers seeking Optimum Grazing Capacities
- Foresters engaged in Sustainable Forestry

- Educators teaching Responsible Stewardship
- Students, K through lifelong learners, of Earth System Science

Here are some terms and explanations from UMAC homepage, http://www.umac.org:

1. Partnership: Every UMAC activity is in response to a need expressed by individuals or organizations of stakeholders. The Consortium is distributed geographically to bring information close to its end users. UMAC includes partners in government, private industry, and non-governmental organizations as well.
2. Precision Agriculture: using information technologies to bring data from multiple sources to bear on crop and livestock production decisions.
3. Noxious Weed Eradication from Rangelands: The weed leafy spurge, scourge of the West, can be detected by sensors that see light in many separate colors. The exact pattern in the light signals is different for leafy spurge than it is for grass and other welcome vegetation. Pinpointing its existence from satellites and aircraft is the first step toward eradicating the weed.
4. Disease Scouting for Sugar Beet Producers: In the valley straddling the Red River between North Dakota and Minnesota exists a billion-dollar sugar beet industry. Diseases that cripple beet production can be spotted by airborne sensors detecting radiation the eye cannot see before the disease (e.g., the fungus, rhizoctonia) is visible to a farmer.
5. Fertilizer Applications for Wheat Farmers: In years of adequate rainfall, a wheat crop is limited when nutrients in the soil are exhausted. Soil nutrients can be supplemented by applying nitrogen fertilizer. In years when not enough rain falls,

lack of moisture limits the crop; additional fertilizer will not turn a bad crop into a good one, but the chemicals applied unnecessarily will run off into streams or be released to the atmosphere. By monitoring a wheat crop's growth from a satellite, a farmer can determine whether to add fertilizer during the growing season.

6. Sustainable Forestry: balancing timber extraction and replacement rates for long-term economic and environmental health.
7. Fire Danger Index: Like a fever in a sick person, trees and plants trying to draw water from dry soil have elevated temperatures. Using satellites to read vegetative temperature and to estimate how much of it is being stressed, scientists can highlight tinder-dry areas (red at right) and land managers can take fire-preventive actions.

1.2 PROBLEM STATEMENT

DNGP (Digital Northern Great Plains) project is sponsored by UMAC. The goal of this project is to build an integrated web-based Geographic Information System. This system provides the access to Landsat imagery and Landsat-derived products (NDVI, Green NDVI, Sugar Beet Yield) from the current season and the entire UMAC Landsat archive (over 400 scenes) covering Montana, Wyoming, Minnesota, North Dakota and South Dakota. DNGP can also be used to explore other geospatial data including highways, rivers, lakes, shaded relief, and census data.

The DNGP project is sponsored by the UMAC. The purpose of this project is to provide an easy tool for clients of UMAC to download Geospatial Data. Our clients include farmers, ranchers and researchers. UMAC has built the DNGP Website, which is

an interactive maps system. Through DNGP Website, you can browse and download remote sensing images covering Montana, Wyoming, Minnesota, North Dakota and South Dakota. DNGP Website can also be used to explore other geospatical data including highways, rivers, lakes, shaded relief, and census data.

The current Website is a three-tier Web database application. Tier 1 is User Interface. It runs on a desktop PC or workstation(client) and uses a standard graphical user interface (Web browser). In our application, our web pages act as tier1, which is requested by the user through his Web browser and is sent there from our Web server for display. Then user can use the controls on the web pages to send further queries to Web server, Web server will respond to these queries and send result web pages to user's Web browser. Tier 2 is the Functional Module. This level actually processes data. It consists of several separate modules running on an application server. This tier may be multi-tiered itself. In the existing DNGP, this tier consists of Apache web server, Mapserver4.0, PHP programs and C++ programs. Tier 3 is the Database Management System (DBMS). A DBMS on a host computer stores the data required by the middle tier. In DNGP, this tier is an Oracle 9i database management system in which we store our image data.

The existing DNGP website, which was built in an ad-hoc manner, has some functional and performance drawbacks. To improve this website, we will produce a new software design for DNGP's Tier 1 and Tier2. We expect to integrate JavaScript into Tier 1 of our project and we will re-implement the current PHP programs in Tier2, reusing existing code when possible. In addition, we will seek feedback from our clients about the existing DNGP implementation and use this feedback to determine any additional requirements or features that need to be added to DNGP.

After the implementation is completed, we will test our new system internally for correctness and then we will do satisfaction testing with our clients. Any negative feedback from clients will be to guide a second iteration of the software development life cycle.

1.3 STRUCTURE OF THIS REPORT

The next chapter describes the requirements and specifications of this project. Chapter 3 contains High-level and Low-level Design. Chapter 4 is focused on implementation of this project. Chapter 5 is Verification and Validation. Chapter 6 contains Conclusions. Appendix A includes the user manual and all the code is stored in the CD-Rom attached as Appendix B.

CHAPTER II

REQUIREMENTS AND SPECIFICATIONS

Requirements are the users' need for the system. A requirements specification is an agreement between the end user and system developer, we can view it as a definition of what the implementation must achieve. Xiaodong Zhang, assistant professor in UMAC, provided requirements of DNGP project.

2.1 REQUIREMENTS

Users for the DNGP website are categorized as anonymous user and registered user. Anonymous user could select image layers, select remote sensing image for raster layer, view a product, choose band combination, adjust brightness, choose a color scheme and download a product.

There are three kinds of registered users to our system:

1. Normal User is the registered user who has normal user permission. Normal user should be able to execute all the functions that anonymous user could execute. In addition, he or she can create their Area of Interest (AOI), view an AOI, manage AOIs and manage his or her own account information. Area of Interest is an Area of a map that user is interested in. By storing AOIs in our system, the user could go directly to particular part of the map without searching and zooming.

2. Image Administrator is the registered user who has image administrator permission. Image Administrator should be able to manage his or her own account, manage all the images in our database.
3. Account Administrator is the registered user who has account administrator permission. Account Administrator should be able to manage all the accounts and all the images in our system.

2.2 SPECIFICATIONS

DNGP website features a modularized interface design resembling the Windows environment that most of people are used to. There are user navigation buttons and five independent panels for map, reference map, image list, layers and controls, each of them can be independently moved resized and minimized.

1. Map Panel

   The Map panel consists of the map window to view the images, maps and corresponding legend. The right side of the panel consists of interface icons, which help, in navigating the map, retrieving the map and getting information about specific features. The bottom side of the panel displays the scale at which the map is displayed using scale bar and also displays the corresponding cursor position on the map in Latitude and Longitude.

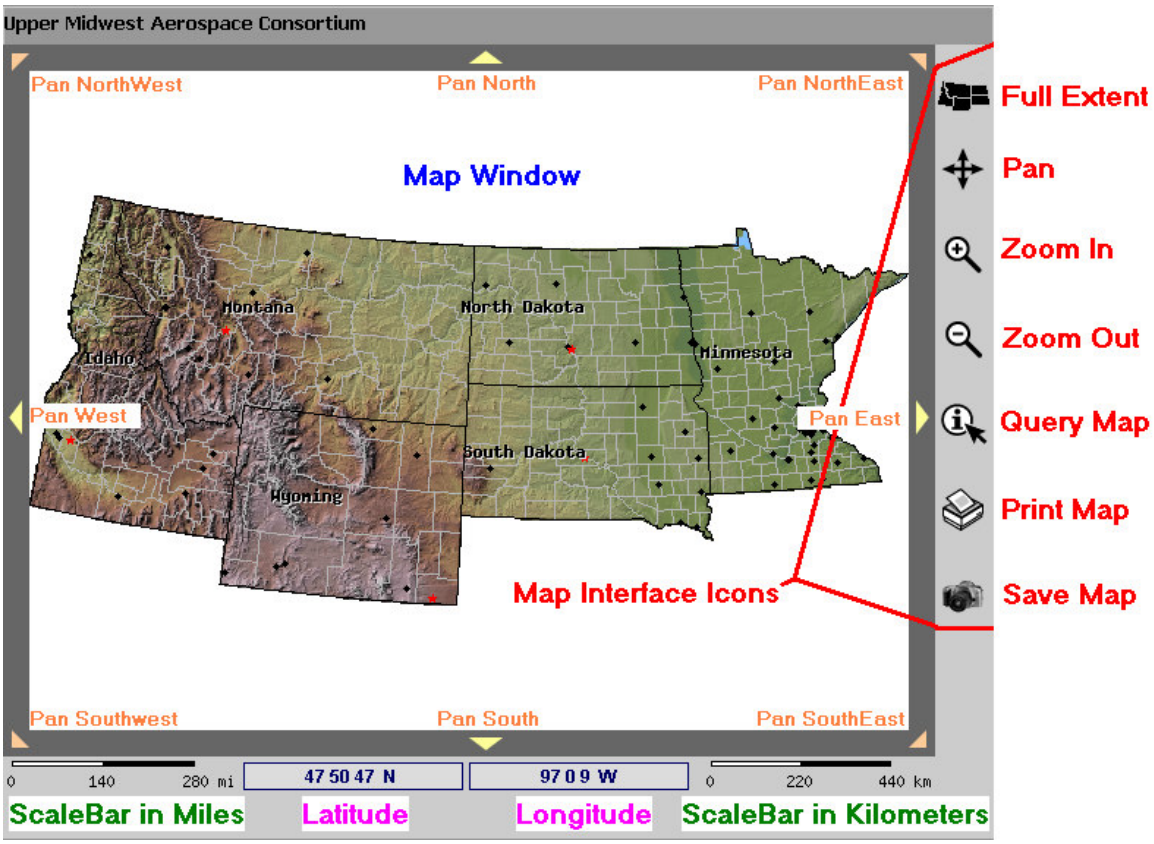

Figure 1. Map Panel

2. Layer Panel

The layer panel features many layers that convey information about various spatial features. The layers are displayed in seven groups: Boundaries, Transportation, Water, Geology, Raster layer, Agriculture and Environment. Multiple layers can be overlaid on one another to make a map according to your needs and can be viewed in the Map window, or printed and saved.

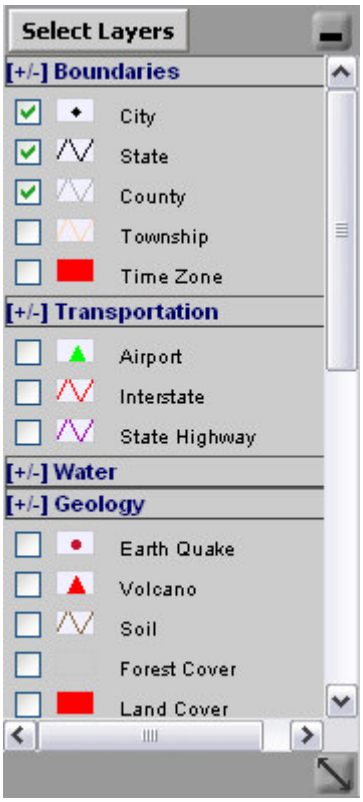

Figure 2. Layer Panel

3. Image List Panel

The Image List panel contains a list of Raster images in GeoTIFF format. Different images cover different areas on the map. The image list varies according to the map extent. At any instance, the list shows images that are covering the area that is viewed in the map window. Each image is shown with a name, which describes the Acquisition Date, Sensor type and Coverage information. If an image covers the current map window completely then is shown as Full otherwise it shown as Partial. The image list can refine by selecting a particular sensor type in the Select box on the top of the panel to view images only from that sensor covering the displayed area in the map window.

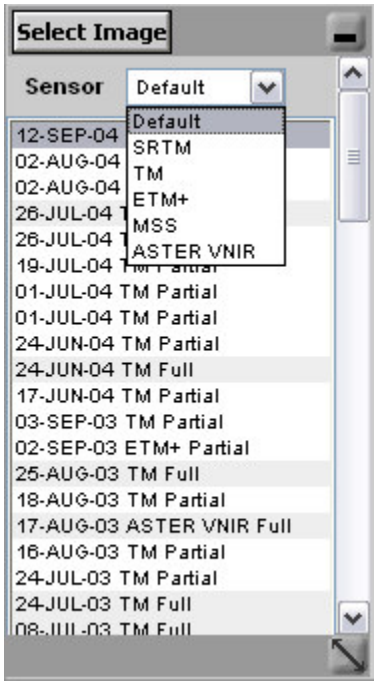

Figure 3. Image List Panel

4. Reference Map Panel

   The Reference Map panel gives a reference of the location that is being viewed in the Map window with respect to the entire UMAC coverage by highlighting with a red colored pointer. You can change the current location displayed in the Map window by clicking on any other location on the reference map.

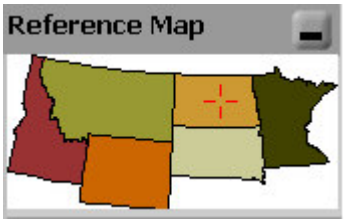

Figure 4. Reference Map Panel

5. Control Panel

This feature allows the user to manipulate and download the chosen raster image. The buttons over the control panel will be enabled only if an image is selected and displayed in the map window.

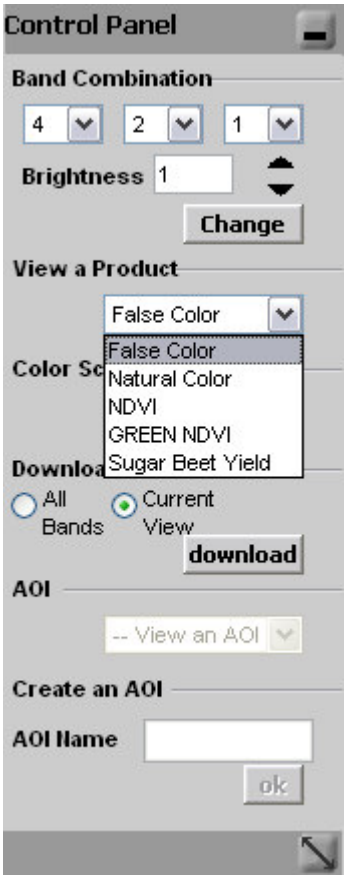

Figure 5. Control Panel

6. Navigation Buttons

The navigation buttons on the Digital-NGP header image provide links to other pages as described by their titles.

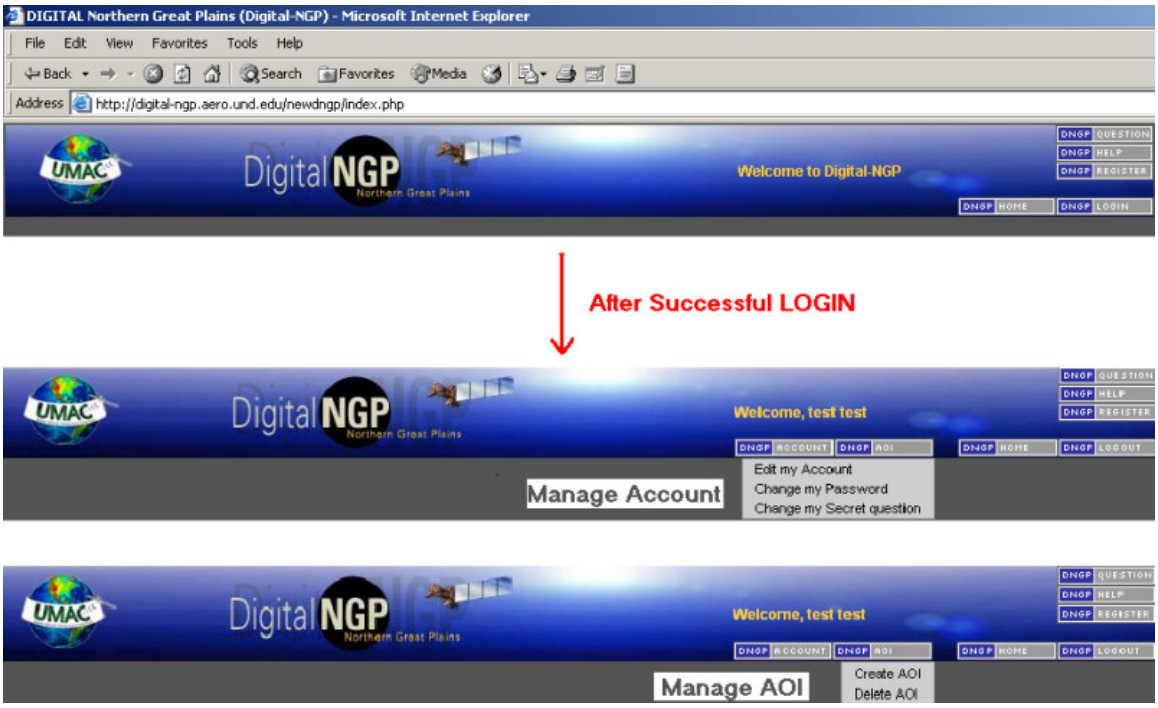

Figure 6. Navigation Buttons

CHAPTER III

HIGH LEVEL AND LOW LEVEL DESIGN

After requirements analysis, I did the high level and low level design.

3.1 HIGH LEVEL DESIGN

System Architecture gives us the overview of the Web database application. The server technology used for this project is PHP [5] with JavaScript [3]. The server side script is written in PHP. The client side script is written in JavaScript.

3.1.1 SYSTEM ARCHITECTURE

The current Website is a three-tier Web database application.

Tier 1 is User Interface. It runs on a desktop PC or workstation (client) and uses a standard graphical user interface (Web browser). In our application, our web pages act as tier1, which is requested by the user through his Web browser and is sent there from our Web server for display. Then user can use the controls on the web pages to send further queries to Web server, Web server will respond to these queries and send result web pages to user's Web browser. In the existing DNGP, this tier consists of html and JavaScript.

Tier 2 is the Functional Module. This level actually processes data. It consists of several separate modules running on an application server. This tier is multi-tiered itself. In DNGP, this tier consists of Apache web server, Mapserver4.0, PHP programs and C++ programs. The Apache web server is the first level of this tier, it receives queries from tier

1, interprets and runs PHP programs. The PHP programs are the second level in tier 2, it accesses database, runs C++ programs and calls mapserver. The output of PHP programs is html and JavaScript, which is the tier1 interface. The C++ programs and Mapserver4.0 are the third level in tier 2.

Tier 3 is the Database Management System (DBMS). A DBMS on a host computer stores the data required by the middle tier. In DNGP, this tier is an Oracle 9i database management system in which we store and maintain our geospatial data. Please refer to Figure 7. System Architecture.

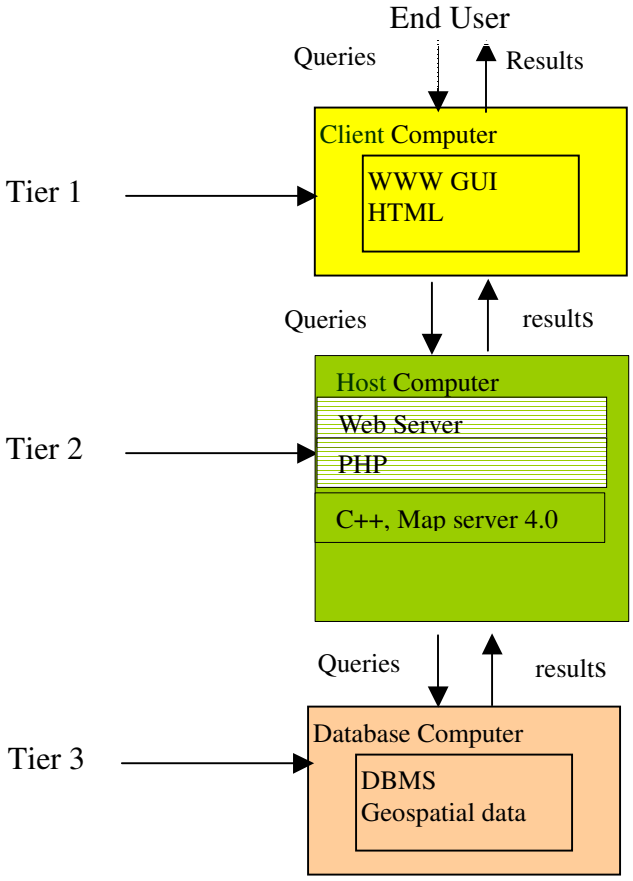

Figure 7. System Architecture

3.1.2 STATE TRANSITION DIAGRAM

A state transition diagram shows the state space of a given context, the events that cause a transition from one state to another, and the actions that result.

The state transition diagram (Figure 8) I use for this project displays all the possible states of the system as circles. An arrow connects one state (state 1) to another state (state 2) if a transition from state 1 to the state 2 is possible. And the arrow is labeled to indicate the event that triggers the state transition.

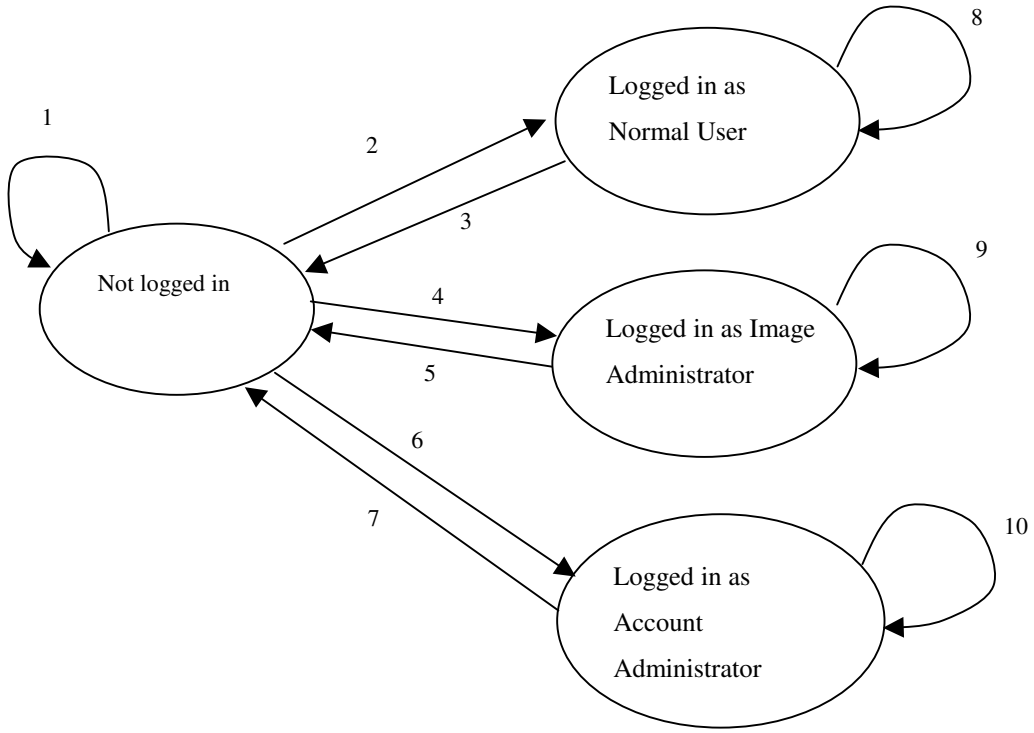

Figure 8. State Transition Diagram

Note:

1. Either user name or password is not correct.
2. Normal user login
3. Normal user logout

4. Image Administrator login
5. Image Administrator logout
6. Account Administrator login
7. Account Administrator logout
8. Normal user process images
9. Image Administrator upload images
10. Account Administrator manage accounts

3.2 LOW LEVEL DESIGN

Data Flow Diagrams show the flow of data from external entities into the system, shows how the data moves from one process to another, as well as its logical storage. Figure 3-3 to Figure 3-10 present DFDs using the Gane and Sarson notation for this project. There are only four symbols:

Squares representing external entities, which are sources or destinations of data. Rounded rectangles representing processes, which take data as input, do something to it, and output it. Arrows representing the data flows, which can either be electronic data or physical items. Open-ended rectangles representing data stores, including electronic stores such as databases or XML files and physical stores such as or filing cabinets or stacks of paper. Here I only list the processes that have been reengineered.

3.2.1 DATA FLOW DIAGRAM

User Registration:

Figure 9. shows User Registration process, remote user sends registration request from homepage, input user name, password, email address and other personal information, User Registration process validates these information and insert the valid user information into database and display registration success message to user, if the username is already in the database, shows error message.

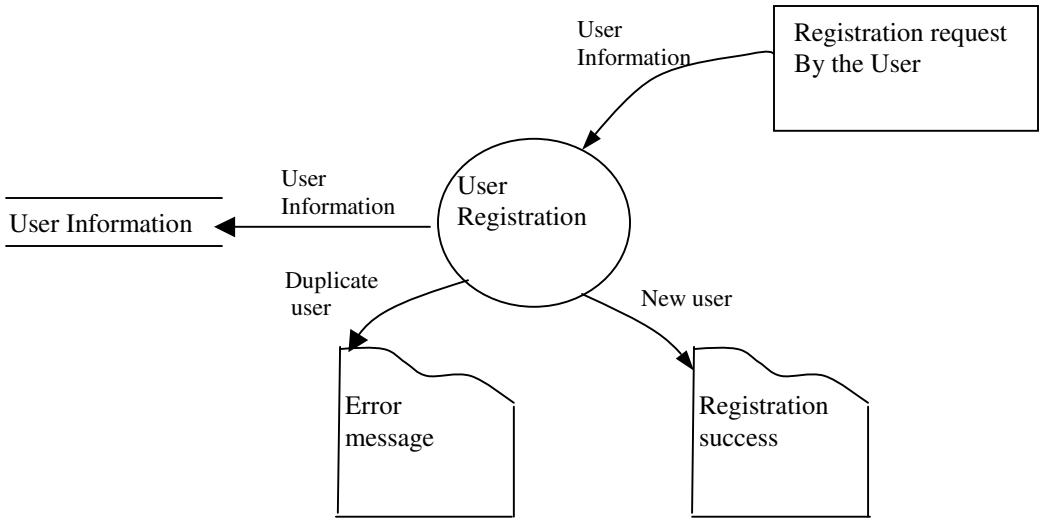

Figure 9. DFD of User Registration

User Login:

User Login process is displayed in Figure 10. User Information is the user table in the database, which stores user's last name, first name, username, password, email address etc. AOI information is AOI table in the database that stores users' AOIs, which could be null when there is no AOI for the user. User session is a set of variables stores current session values.

The login request is sent from homepage, User Login process searches the database for the username and password, if the username not found or password does not match, display error message to user, if yes, it will get user ID, user Permission, AOIs (could be empty if no AOI is stored in database), and update the menu bar on the homepage.

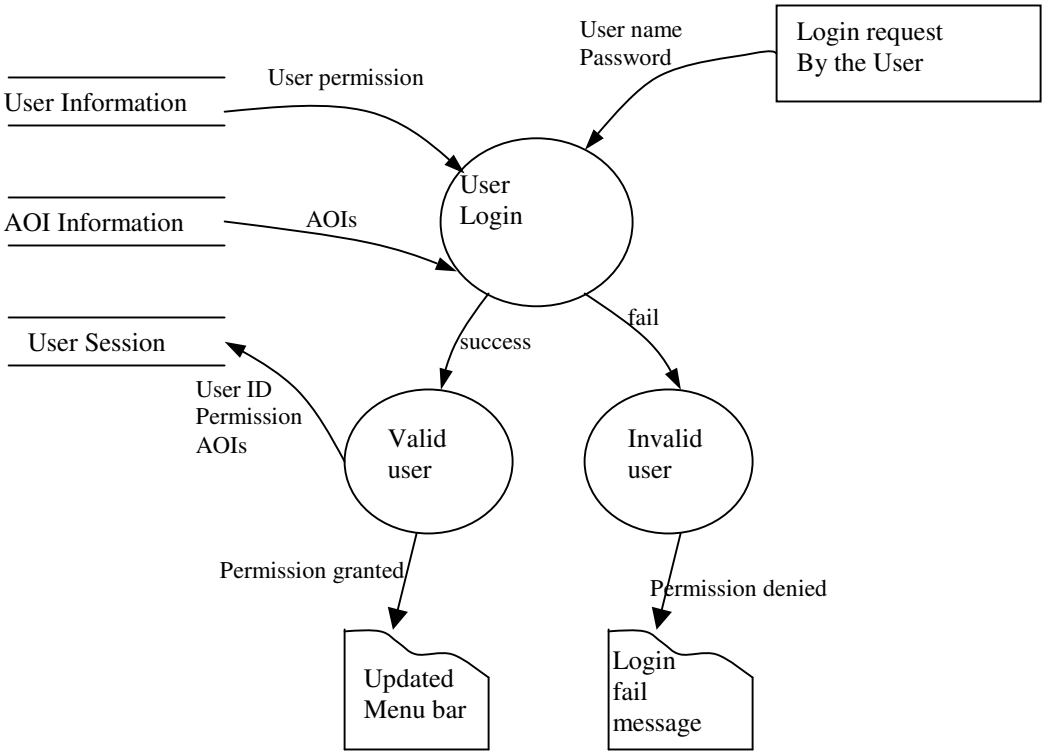

Figure 10. DFD of User Login

Band Combination Selection:

Band Combination Selection process is displayed in Figure 11. User sends Band Combination information change request from homepage. Band Combination Selection process updates the user session information, set Refresh Image flag, Display Image process will get the image information from user session, create an new image and refresh the homepage.

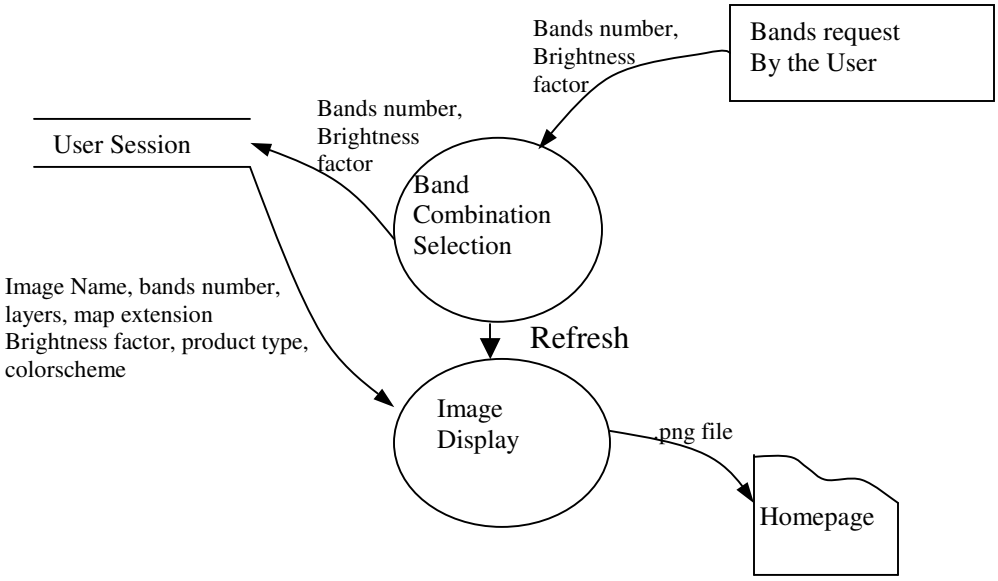

Figure 11. Band Combination Selection

Color scheme selection:

Color scheme Selection process is displayed in Figure 12. User chooses color scheme on the homepage. Color scheme Selection process updates the user session information, set Refresh Image flag, Display Image process will get the image information from user session, create an new image and refresh the homepage.

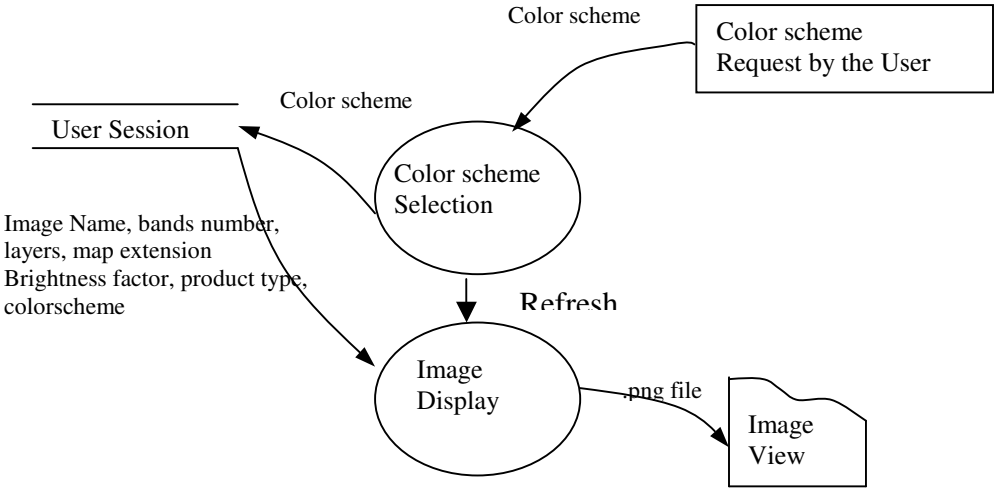

Figure 12. DFD of Color scheme selection

Image Selection:

Image Selection process is displayed in Figure 13. User selects an image on the homepage. Image Selection process updates the user session information, set Refresh Image flag, Display Image process will get the image information from user session, create an new image and refresh the homepage.

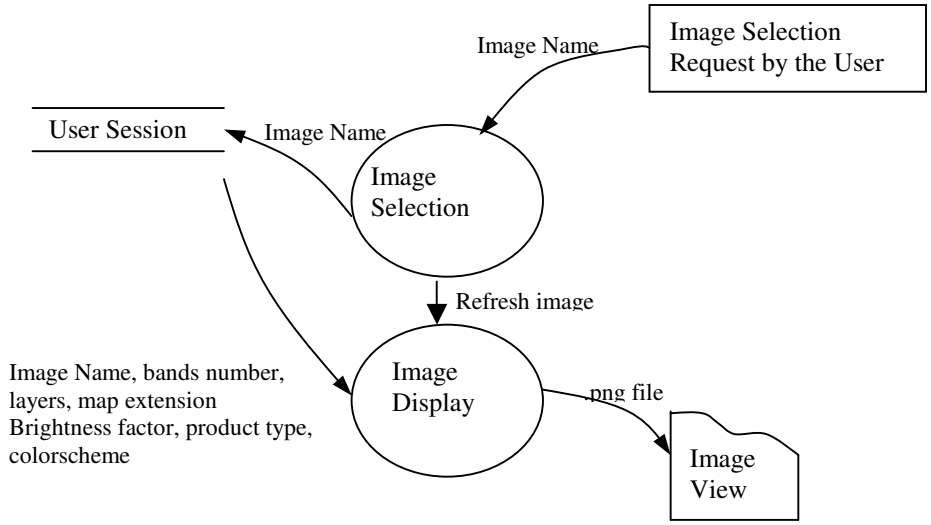

Figure 13. Image selection

Layers Selection:

Layers Selection process is displayed in Figure 14. User selects layers on the homepage. Layers Selection process updates the user session information, set Refresh Image flag, Display Image process will get the image information from user session, create an new image and refresh the homepage.

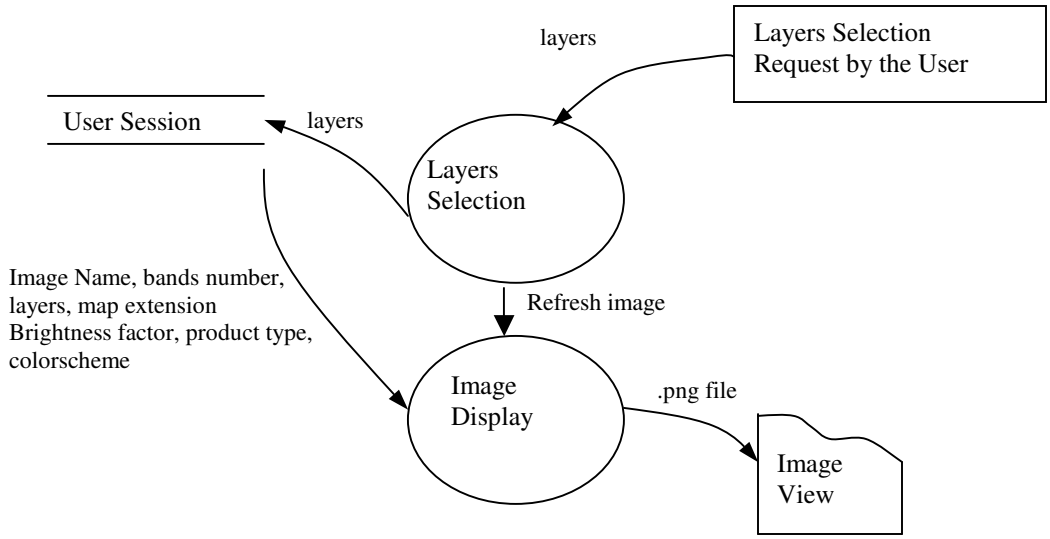

Figure 14. DFD of Layers selection

Product Selection:

Product Selection process is displayed in Figure 15. User selects a product type on the homepage. Product Selection process updates the user session information, create the product, set Refresh Image flag, Display Image process will get the image information from user session, create an new image and refresh the homepage.

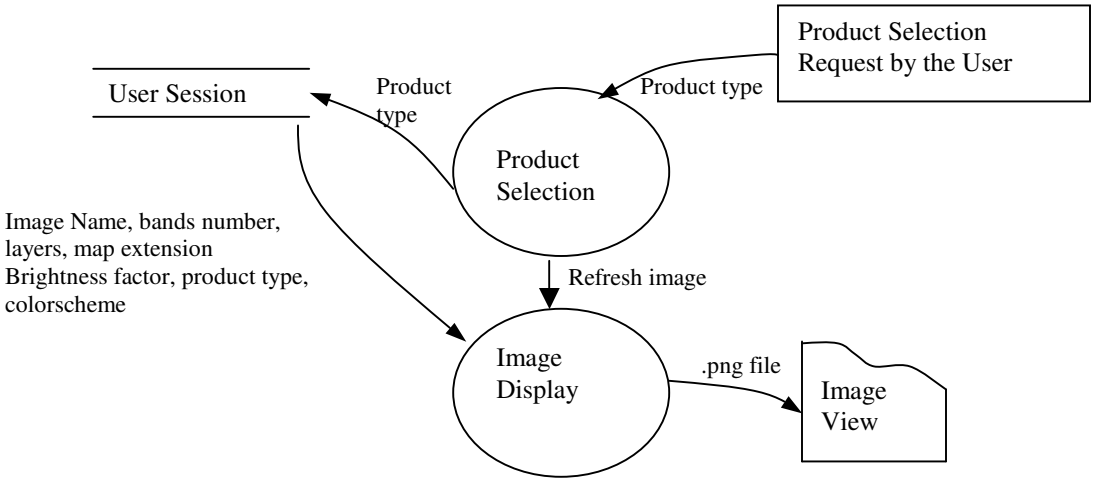

Figure 15. DFD of Product selection

View AOI:

View AOI process is displayed in Figure 16. User selects an AOI on the homepage. View AOI process updates the user session information, set Refresh Image flag, Display Image process will get the image information from user session, create an new image and refresh the homepage.

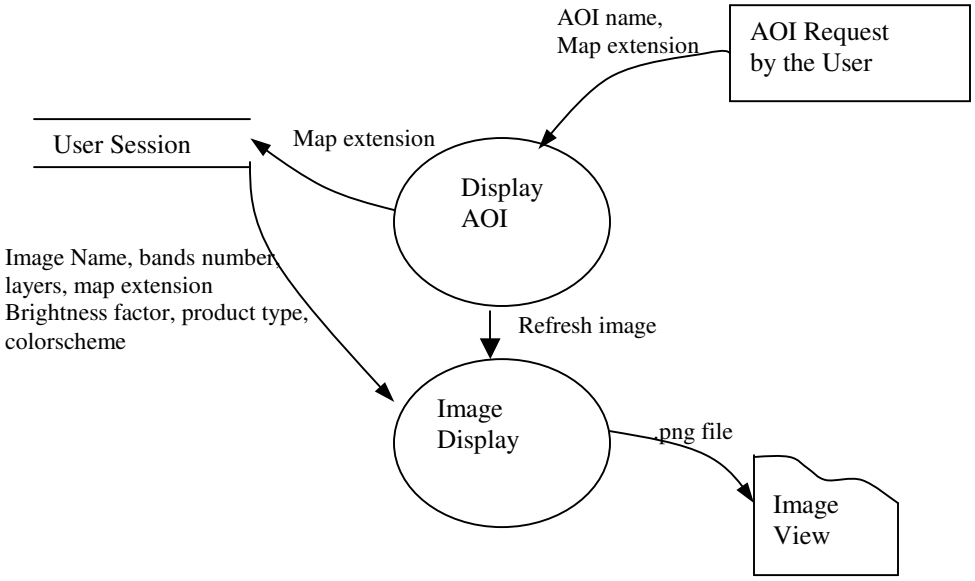

Figure 16. View AOI

Create AOI:

Create AOI process is displayed in Figure 17. User sends the AOI creation request from homepage to Create AOI process, the Create AOI process gets User ID and current map extension from user session, stores User ID, AOI name and map extension into the database, then refresh the AOI list on the homepage.

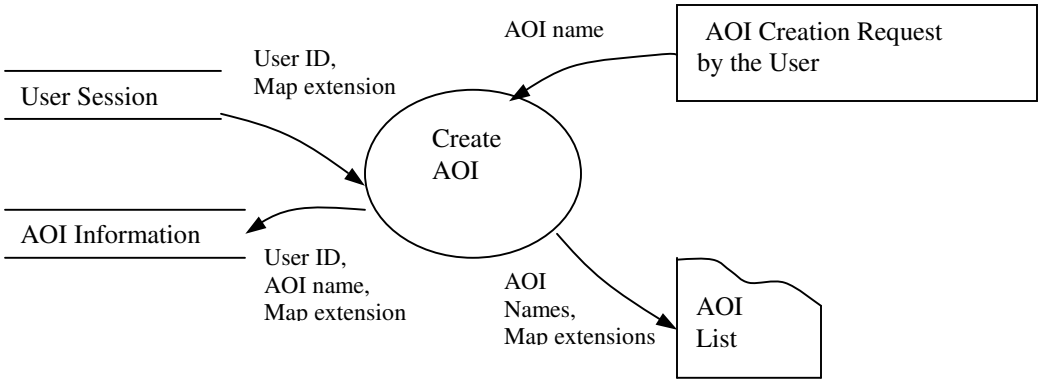

Figure 17. DFD of Create AOI

User Logout:

User Logout process is displayed in Figure 18. Logout process gets the logout request from homepage, reset session information about User ID, Permission and AOIs, and refresh menu bar on the homepage.

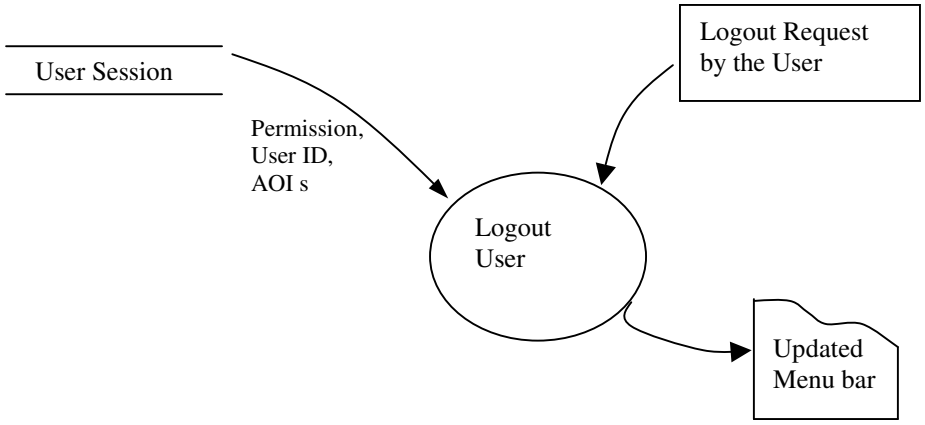

Figure 18. DFD of User Logout

3.2.2 MODULE DESIGN

From these DFDs, I decomposed this project into ten modules:

Module **Login**

Uses ViewAOI

Import username and password from homepage

Export session information for User_ID, Permission, User_AOI, flag of setting menu bar, flag of setting AOI list or flag of setting error message

Module **Registration**

Import First name, Last name, address, city, state, zip, phone, email, username, password, secret question, and secret answer

Export Registration status

Module **Band Combination Selection**

Uses Image Display

Import bands number, brightness and factor

Module **Color Scheme Selection**

Uses Image Display

Import color scheme

Module **Image Selection**

Uses Image Display

Import image name

Module **Layers Selection**

Uses Image Display

Import Layers

Module **Product Selection**

Uses Image Display

Import product type

Module **View AOI**

Import map extension from homepage

Export Session information for map extension

Module **Create AOI**

Import User_ID, map extension, AOI name

Export Session information for User_ID, map extension and AOI name

Module **Logout**

Export flags to reset session information about AOI list

CHAPTER IV

IMPLEMENTATION

After completing the high level and low level design, the functional modules are implemented in PHP, JavaScript and C++. The complete source code is in appendix A. In this chapter, we present the pseudocode for these modules and some code examples.

4.1 MODULES IMPLEMENTATION

The processing steps for each data flow diagram can be formally described using pseudocode. In this section, we use the format

Module **<module-name>**: <file1>, <file2>, …

Implementation

<pseudocode>

To present our pseudocode, where <module-name> is the logical name of the module, <file1>, <file2> etc. are filenames of source code implementing this module and <pseudocode> is our English-like description of the processing that occurs.

Module **Login**: login.php, index.php, hide.php

Implementation

Get username and password from the homepage

Search Username, Permission, user AOIs with the username and password in the database

If Username exists

Set Username

Set user permission

Set user AOIs

Display corresponding menu bar to user

Else

Set login failure flag

Display error message

Module **User Registration**: index.php, register.php, hide.php

Implementation

Get user information from registration form

Search if user exists in database

If the username exists

Display error message

Else

Input user information into database

Display registration success message

Module **Band Combination Selection:** bandcombo.php, hide.php

Implementation

Get bands information from homepage

Set session information about bands combination and refresh image flag

Create new image

Refresh the image on homepage

Module **Color Scheme Selection:** scheme.php, hide.php

Implementation

Get color scheme from homepage

Set session information about color scheme and refresh image flag

Create new image

Refresh the image on homepage

Module **Image Selection:** imagelist.php, hide.php

Implementation

Get image name from homepage

Check if the image is in database

If image exists

Set session information about image name and refresh image flag

Create the new image

Refresh the image on homepage

Else

Display error message

Module **Layers Selection:** legend.php, hide.php

Implementation

Get layers from homepage

Set session information about layers and refresh image flag

Create the new image

Refresh the image on homepage

Module **Product Selection**: product.php, hide.php

Implementation

Get product type from homepage

Create the product

Set session information about product type and refresh image flag, refresh band combination selection flag, refresh color scheme flag, refresh download production selection flag

Refresh the image on homepage

Module **View AOI:** viewAOI.php, hide.php

Implementation

Get map extension from homepage

Set session information about map extension

Create the new image

Refresh the image on homepage

Module **Create AOI:** createAOI.php, hide.php

Implementation

Get User_ID, AOI name, and current map extension from homepage

Search if the AOI name exists in the database

Translate map extension to certain format

Input AOI name and map extension to database

Set session information about AOI list

Refresh AOI list on homepage

Module **Logout:** logout.php

Implementation

Unset session information about User_ID, Permission, AOI list

Refresh menu bar on homepage

Refresh AOI list on homepage

4.2 EXAMPLE SOURCE CODE

The example source code below is from one program of login module: login.php. The Login procedure is activated when the submit button is clicked on the NGP home page form. The parameters passed from this home page are the user's name and password, which are captured and stored in local string variables.

The following paragraph shows the part of code to get username, password from homepage.

```
$username = $_POST['username'];
```

```
$pwd = $_POST['passwd'];
//Encrypt password
$cryptpwd = md5($pwd);
```

An MD5 signature for the password is computed. Then a query is constructed and submitted that search the administrative database and authenticate the user. The following code is for database connection and query to get user ID, permission and user's first name and User AOIs.

```
//connect to oracle database
$db_conn = ocilogon(DBADMIN,DBADMINPASSWD,DBNAME);
//Search database for matching username and password
$query = "SELECT USER_ID,PERMISSION,LASTNAME,FIRSTNAME FROM UMACUSER
WHERE USERNAME = '$username' AND PASSWORD = '$cryptpwd'";
$results = queryDB($db_conn,$query);
//store User_ID, permission and user's first name into session
//variables
if (count($results['USER_ID']) > 0){
      $_SESSION['Suser_id'] = $results['USER_ID'][0];
      $_SESSION['Spermission'] = $results['PERMISSION'][0];
      $_SESSION['Srealname'] = $results['FIRSTNAME'][0].'
'.$results['LASTNAME'][0];
}
//connect to database to get aoi information
$db_conn = ocilogon(DBUSER,DBUSERPASSWD,DBNAME);
$query = "SELECT AOI_NAME, EXTENT FROM  ".DBADMIN.".USERAOI  WHERE
USER_ID = '".$_SESSION["Suser_id"]."'";
$results = queryDB($db_conn,$query);
$rownum = count($results['AOI_NAME']);
```

```
if ( $rownum > 0){
	for($i=0;$i<$rownum;$i++){
		$aoi[$results['AOI_NAME'][$i]] = $results['EXTENT'][$i];
	}
	//store AOI list into session variable
	$_SESSION['Saoi'] = serialize($aoi);
}
```

If the query results in at least one match from the administrative database, session information is stored and area of interest (AOI) information is fetched from the user information database.

CHAPTER V

SOFTWARE VERIFICATION AND VALIDATION

Software Verification refers to the set of activities that ensure that software correctly implements a specific function. Validation refers to a different set of activities that ensure that the software that has been built is traceable to customer requirements. Verification and validation encompasses a wide way of Software quality assurance (SQA) activities that include formal technical reviews, quality and configuration audits, performance monitoring, algorithm analysis, development testing, usability testing, qualification testing and etc.

Testing plays an extremely important role in V&V. Testing does provide the last bastion from which quality can be assessed and more pragmatically, errors can be uncovered. But testing should not be viewed as a safety net. As they say, "You can't test in quality. If it's not there before you begin testing, it won't be there when you are finished testing." Quality is incorporated into software throughout the process of software engineering.

In this project we combined software testing with software reengineering. We published version 3.0.0 of this project after we redesigned our Digital-NGP website on Oct 12, 2004 and posted the release notes as following:

> Digital-NGP version 3.0.0 released
>
> *[12-Oct-2004]* We have completely re-designed our Digital-NGP website and here announce the release of Digital-NGP version 3.0.0.

The new version is significantly faster than any previous versions plus has many additions of new features. We strongly encourage you to test this new version of Digital-NGP and highly appreciate if you can send your suggestions and comments to the development team.

What's new:

1. Fast: The Digital-NGP version 3 discards the use of Java Applet which is slow and has been used in all the previous versions for zoom in and out, pan, and query. Now we use lightweight Javascript to furnish these functions. As a result, an image will show up much quicker than it used to be.
2. Appearance: The new version also features a modulized interface design resembling the Windows environment that most of our users are used to. There are five independent panels for map, reference map, image list, layers, and controls; each of them can be independently moved, resized and minimized. Also there is a status bar showing progress for "impatient" users including ourselves.
3. Interoperability: From the Digital-NGP version 3 website, you can seamlessly access high-resolution aerial photogram (DOQ) and digitized paper map (DRG), both of which are actually hosted at TerraServer USA. However, instead of searching around, you can display a DOQ photograph in

your familiar Digital-NGP environment plus numerous vector layers at your hand to be overlaid.

What's been improved:

1. Redesigned Map window (panel). Your mouse movement over the Map panel is continuously tracked and its location (latitude and longitude) is updated just below the map. Quickly print what you see and download what you see. You can find these two quick access buttons on the right side of Map panel.
2. Expanded layers now contain all kind of information on census, land cover, water, trace metal, and etc. And best of all, we keep adding.
3. More remote sensing sensors. We are now archiving data from SRTM (Shuttle Radar Topography Mission), and ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) on Terra, in addition to the traditional MSS, TM and ETM+ from LandSat series.
4. Improved control panel. You can change band combination for multispectral images and color scheme for single band images, alter brightness, choose various remote sensing products, and download images and products in GeoTIFF format.

Known issues:

1. The new version currently does not function properly under Mac, and we are working on this issue.
2. Under windows Internet Explorer, when you drag the panel around, you may notice some panel components floating above the rest of the panel components. This is a known issue for the Windows Internet Explorer and we are working towards an alternative.
3. There will always be some issues unknown to us now, please report to us once you find one.

Figure 19. displays homepage of version 3.0.0

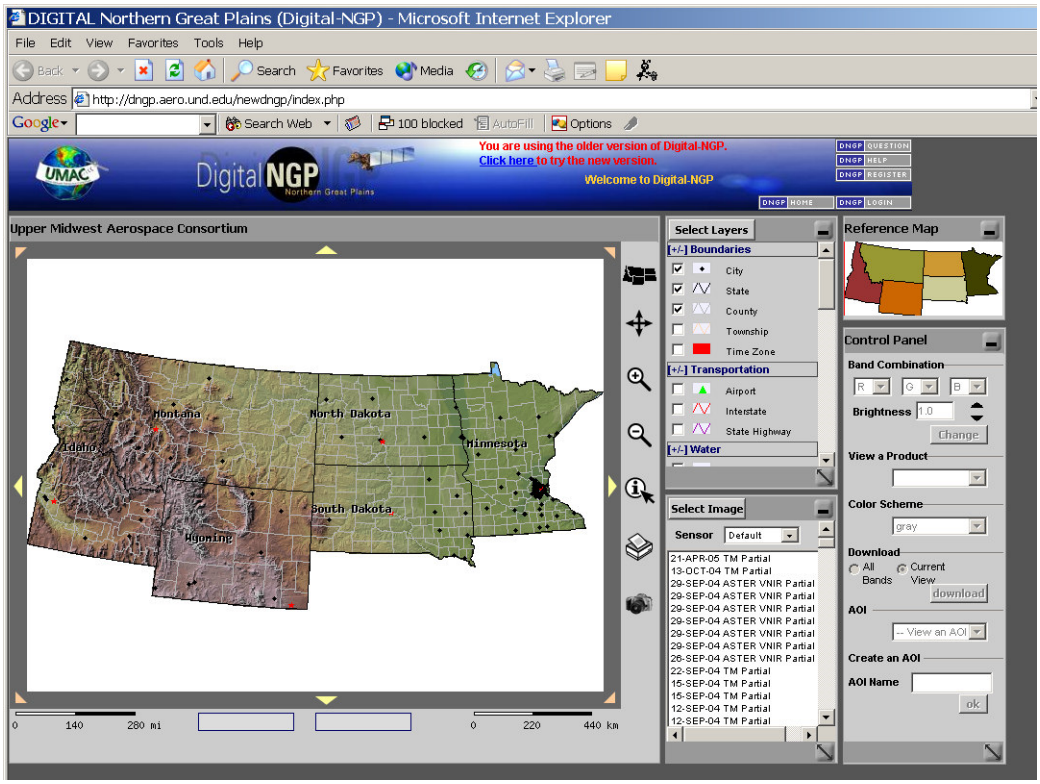

Figure 19. Digital-NGP Version 3.0.0 Homepage

Users, including farmers, ranchers, foresters, educators, students and UMAC faculties tested this version and provided us feedbacks. Based on the user feedbacks, we added few new functions and fixed some minor bugs. On Oct 21, 2004, version 3.0.1 was published. The following is the release notes.

Digital-NGP version 3.0.1 released

[21-Oct-2004] We announce the release of Digital-NGP version 3.0.1. This release is build upon the version 3.0.0 and involves one major change and some minor changes. Again, to help us make the Digital-NGP serving you better, please send your suggestions and comments to the development team.

What's new:

1. The major change: Instead of auto loading the most recent satellite image as a certain scale is reached, what will be auto-displayed is the high resolution (up to 1 meter/pixel) digital photograph (DOQ) that is hosted at TerraServer USA.
2. Instead of using two scale bars (one for miles and one for kilometers), there is only one scale bar showing miles, and the other one showing scales in terms of meters per pixel.
3. The default mode for showing an image is the true color band combination.
4. Some minor bugs are fixed.
5. The code has been cleaned and is tighter than before.

Known issues:

1. The new version currently does not function properly under Mac, and we are working on this issue.
2. Under windows Internet Explorer, when you drag the panel around, you may notice some panel components floating above the rest of the panel components. This is a known issue for the Windows Internet Explorer and we are working towards an alternative.

Figure 20 displays homepage of version 3.0.1.

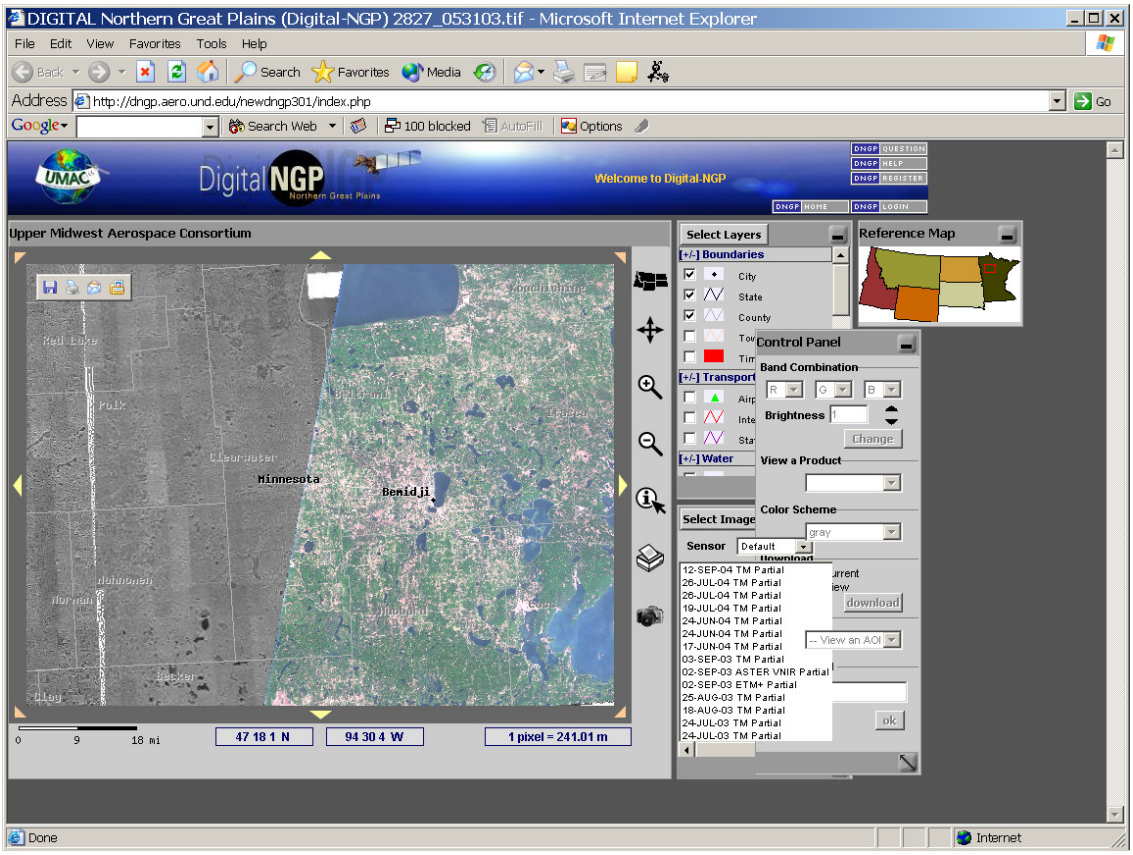

Figure 20. Digital-NGP Version 3.0.1 Homepage

Then we collected feedbacks again from users. We added a new feature and fixed the known issue 2 of version 3.0.1. Digital-NGP version 3.0.2 was published on Dec 10, 2004. The following is the release notes of version 3.0.2.

> Digital-NGP version 3.0.2 released
>
> *[10-Dec-2004]* We announce the release of Digital-NGP version 3.0.2. This release is build upon the version 3.0.1 and involves several minor changes. Again, to help us make the Digital-NGP serving you better, please send your suggestions and comments to the development team.
>
> **What's new:**
>
> 1. When you mouse over through the image list, the boundary of a partial covered image is displayed on the map.
> 2. The layout of the main page is changed.

The homepage of version 3.0.2 is shown in Figure 21.

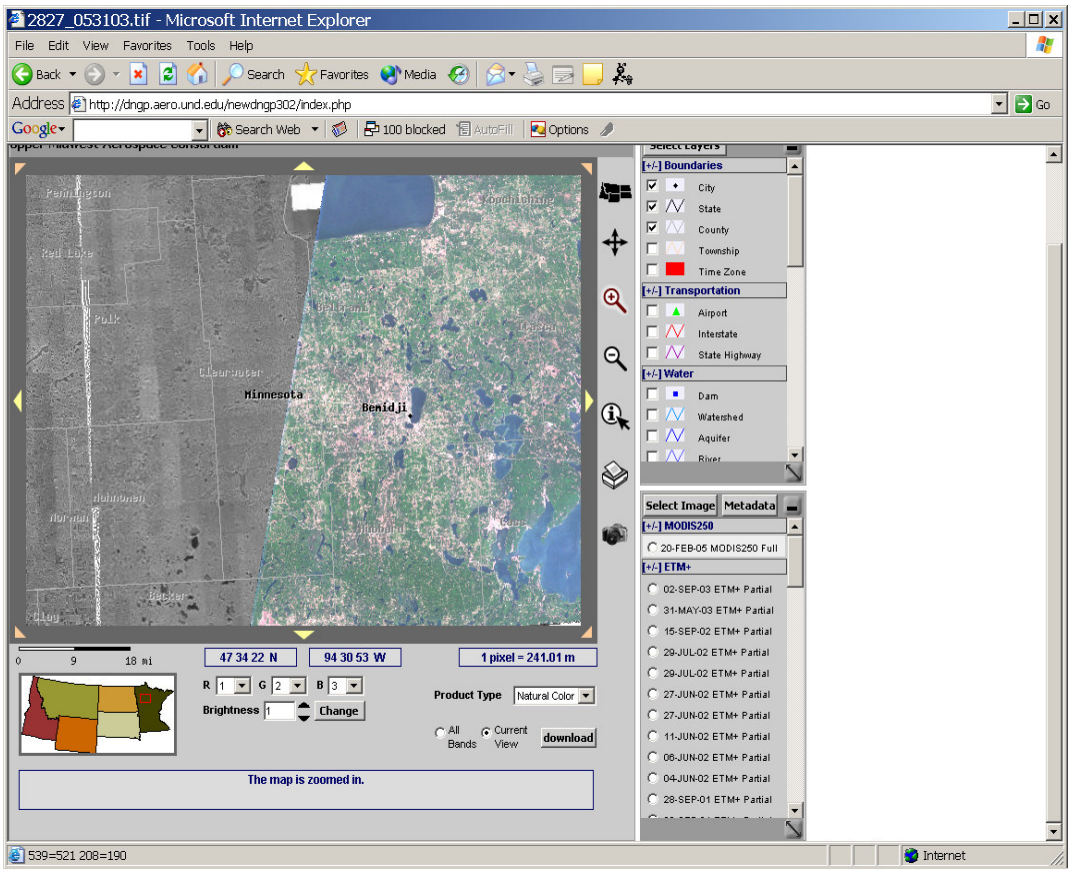

Figure 21. Digital-NGP Version 3.0.2

Users were interested in Version 3.0.2 and sent us comments. Based on these comments, three new features were added and three bugs were fixed. The newest version 3.0.3 was released on Jan 18, 2005.The release notes are as following:

> Digital-NGP version 3.0.3 released
>
> *[18-Jan-2005]* We announce the release of DNGP version 3.0.3. This release is build upon the version 3.0.1 and involves one major change and some minor changes. Please help us make the DNGP serving you better by sending your suggestions and comments to our development team.

What's new:

1. The layout of the interface has been modified to fit into most of the monitor resolutions.
2. A context area is added just above the map window. The information in the context area is dynamically updated according to actions a user takes. The information includes the action taken, what you are currently viewing, and what can be done next, and etc.
3. Improved the tool tips.

Bugs that have been fixed:

1. The check mark for the selected image becomes unchecked once the image is zoomed in.
2. Query returns only county and state information even when additional layers selected.
3. The progress bar was not properly renewed, preventing the time step from being re-initialized after the progress bar was stopped, especially under Mozilla type of browsers.

Figure 22. shows the homepage of Digital-NGP Version 3.0.3

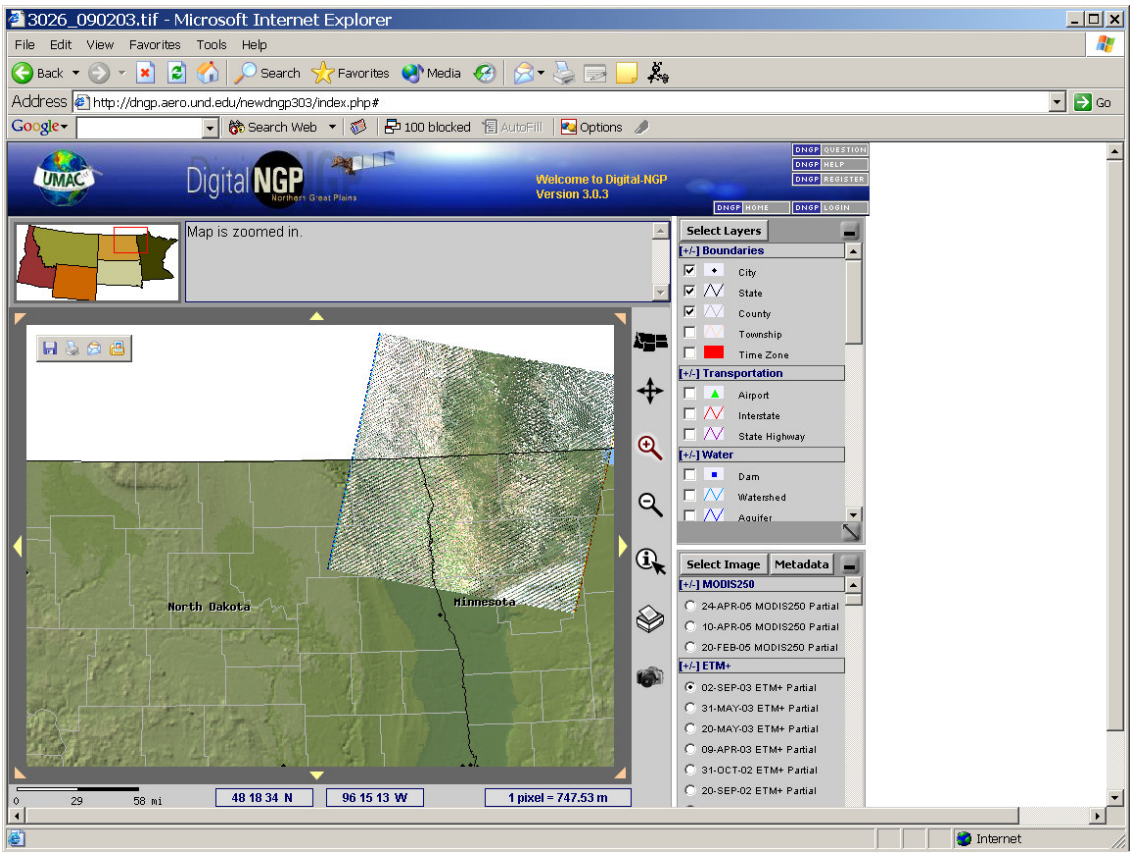

Figure 22. Digital-NGP Version 3.0.3

CHAPTER VI

CONCLUSION

Previous versions of Digital-NGP (Version 2.0 and older) were developed in an ad-hoc manner. It met the original requirements, but the maintenance of the old versions was very hard. The main reasons are: the old versions didn't follow software engineering process; the system design was not scaleable. By applying the software engineering to the project, the website was redesigned, implemented and tested. New versions (version 3.0.0 and newer) have better user interface and are faster and maintenance is easier.

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APPENDIX A: Software Manual

Digital-NGP or DNGP is an online GIS database system for archiving and delivering remote sensing images and geo-spatial information. You can retrieve high-resolution satellite imagery and interactive maps easily from our system but you may not be familiar with all the features for manipulating the images, exploring the maps, their themes and the data contained in the map layers. This document describes the features involved in our system and how you can use them to effectively retrieve the data and information from our system.

The Digital-NGP website features a modularized interface design resembling the Windows environment that most of you are used to. There are user navigation buttons and five independent panels for map, reference map, image list, layers, and controls; each of them can be independently moved, resized and minimized.

1. Map Panel

The Map panel (Figure 1.) consists of the map window to view the images, maps and corresponding legend. The right side of the panel consists of interface icons which help in navigating the map, retrieving the map and getting information about specific features. The icons are black in color by default; when clicked the icon becomes active and will be highlighted in maroon color. The bottom side of the panel displays the scale at which the map is displayed using scale bar and also displays the corresponding cursor position on the map in Latitude and Longitude. The Map Panel can be moved in the web browser according to your convenience.

Zoom In Icon

This button lets you view part of the map in greater detail. You can either just click on the map at the desired location or you can hold the mouse key down to drag a box over an area of interest.

Instructions:

1. Select the Zoom In Icon by clicking on it
2. Position the cursor over the part of the map you want to see in greater detail and click
3. Or Click on a point and drag the mouse to draw a rubber band box defining your area of interest
4. The map will be redrawn to show 2 times more detail when clicked on the map. Or the map will be redrawn to show your area of interest when a rubber band box is drawn

Zoom Out Icon

This button lets you view a larger area with less detail.

Instructions:

1. Select the Zoom Out Icon by clicking on it
2. Click on the spot of the map
3. The map will be redrawn to shown a greater extent centered on the mouse position

Full Extent Icon

This button lets you view the entire region covered by UMAC (North Dakota, South Dakota, Montana, Wyoming, Idaho and Minnesota).

Instructions:

1. Click the Full Extent button
2. The map will be redrawn showing the entire UMAC area. The difference between this button and Home button is the Full Extent button will just change the map coverage to view the entire UMAC area without making any other changes whereas Home button will reset all the settings to default and restart the website

Query Map Icon

This icon shows the attributes associated with the enabled layers in the Layer panel when clicked on any location on the map.

Instructions:

1. Select the Query Map Icon by clicking on it
2. Select the layers in the Layer panel on which you want to perform the query
3. Click on any point of map
4. The attributes of the layers at the point click will be displayed in a new window

Print Map Icon

This icon lets you print the map as it is in the map window on a paper. You can print what you see in the window.

Instructions:

1. Click the Print Map button
2. The system default Print dialog pops up and helps you through the printing process

Save Map Icon

This icon lets you save the map as it is in the map window as an image file (only in PNG format). You can save what you see in the window.

Instructions:

1. Click the Save Map button
2. The system default Save dialog pops up and helps you through the saving process

Pan Icon

This icon allows you to pan (shift) the map to the desired direction.

Instructions:

1. Select the Pan Icon by clicking on it
2. Click on any corner or side of the map you wish to pan
3. The map will pan to the desired direction
4. The Pan icon and the small direction icons (in yellow/orange color) around the map perform the same function of panning the map in a desired direction. The only difference is that with Pan icon you will have to select the icon first by clicking on it and then you have to click on some corner of the map to pan in that direction whereas with the direction icons, clicking on any of those direction icons will pan the map towards that direction

2. Layer Panel

The layer panel (Figure 2) features many layers which convey information about various spatial features. Multiple layers can be overlaid on one another to make a map according to your needs and can be viewed in the Map window, or printed and saved. The layers are categorized into different groups which can be minimized or maximized by clicking on the group names. The layers DOQ, DRG and Shaded Relief are Scale-dependent; they can be viewed only at a particular zoom level. The Shaded Relief layer cannot be viewed at greater zoomed level. The DOQ and DRG layers are obtained from the Microsoft TerraServer using Web Map Service which require you to view them at moderate zoom levels. The Layer Panel can be resized, minimized or moved in the web browser according to your convenience.

Instructions:

1. Enable the layers which you want to display by clicking in the checkboxes next to them
2. To disable the layers, uncheck the boxes next to those layers
3. Click the Select Layers button on the top of the Layer panel
4. The selected layers will be displayed in the map window

3. Image List Panel

The layer panel contains a list of Raster images in GeoTIFF format. Different images cover different areas on the map. The image list varies according to the map extent. At any instance, the list shows images that are covering the area that is viewed in the map window. Each image is shown with a name which describes the Acquisition Date, Sensor type and Coverage information. If an image covers the current map window completely then is shown as Full otherwise it shown as Partial. The image list can refined by selecting a particular sensor type in the Select box on the top of the panel to view images only from that sensor covering the displayed area in the map window. Default Sensor type shows all the images from all the sensors. The Image List Panel (Figure 3) can be resized, minimized or moved in the web browser according to your convenience.

Instructions:

1. Select the image you would like to view
2. Click on the Select Image button at the top of the Panel
3. The image shows up in the map window

4. Reference Map Panel

The Reference Map panel (Figure 4) gives a reference of the location that is being viewed in the Map window with respect to the entire UMAC coverage by highlighting with a red colored pointer. You can change the current location displayed in the Map window by clicking on any other location on the reference map. The Reference Map Panel can be minimized or moved in the web browser according to your convenience.

5. Control Panel

This feature allows the user to manipulate and download the chosen raster image. The buttons over the control panel will be enabled only if an image is selected and displayed in the map window. The Control Panel (Figure 5) can be resized, minimized or moved in the web browser according to your convenience.

Band Combination

These buttons are enabled when an image is selected and displayed in the map window. If the image contains more than 3 bands, then the Red, Blue and Green bands (4,2 and 1 bands) are selected by default. You can change the band combinations depending on the number of bands the image contains to suit your needs. The corresponding bands of the image will be displayed in the map window.

Brightness

This button is enabled when an image is selected and displayed in the map window. The brightness of the image can be increased or decreased from 0.1 to 100 times the original value. Default is 1.

View a Product

This box is enabled when an image is selected and displayed in the map window. You can select from a range of products obtained from the image including Natural color, False color, NDVI, GREEN NDVI, Sugar beet yield. Upon selecting the required product, the image in the map window changes accordingly with the corresponding legend integrated in the map. Then you can either download the current view of the image in the map window or print or save the map.

Color Scheme

This button is enabled upon selection of the specific products like NDVI, GREEN NDVI and Sugar Beet Yield. You can select the grey or color scheme. The image in the map window changes accordingly with legend integrated in the map.

Download

This button is enabled when an image is selected in the map window. You can download either all the bands or the current view of the raster image in the map window (with selected band combinations; default is RGB) in GeoTIFF format.

View AOI

This box is enabled if you are logged into the website. If you have already created AOIs either from the map using the Create an AOI button in the Control Panel or from the Navigation buttons on the DNGP AOI menu, they will be displayed as a list. Upon selecting an AOI name from the list, the map window displays the map covering that AOI.

Create AOI

This box is enabled if you are logged into the website. You can save your AOI for later use by selecting the location in the map window and giving it a name in the box provided.

Note:

After selecting an image, if you refresh the webpage using the Browser Refresh button then the control panel buttons would be disabled. To enable them you will have to reselect the image in the image panel.

6. Navigation Buttons

The navigation buttons (Figure 6) on the Digital-NGP header image provide links to other pages as described by their titles.

The Login button takes the you to login screen, where you can enter username and password to logon to your account. Upon success the login button changes to Logout button.

Instructions:

1. If you don't have an account with Digital-NGP then you need to create an account by clicking the Register Button
2. If you already have an account with us, Click the Login Button
3. A new window pops up and lets you enter the username and password
4. Upon successful logon, you can use the DNGP AOI navigation button to manage your AOI and DNGP ACCOUNT navigation button to manage your ACCOUNT information
5. The DNGP LOGIN button changes to DNGP LOGOUT. You can successfully end your session by clicking the LOGOUT button or by closing the web browser or by refreshing the page
6. If you forgot your password, then you can follow the FORGOT PASSWORD? link on the login interface where you will need to answer your Hint Question created at the time of Registration. If you answer correctly, then we will let you create a new password for your account. If you have any problem with the Login, please contact us through the DNGP QUESTION navigation button and we would be very happy to help you promptly.

NOTE: Once you are logged in to our system and if use the web browser's Refresh button or the DNGP Home button then you will be required to Login again.

The Register button takes you to Registration screen.

Instructions:

1. Click the Register Button
2. A new window pops up where you can Enter the registration details and click Register
3. The rows marked * are required and have to be provided before the process is complete.

The Question button takes you to Comments/Question window where you can send your suggestions, requests, comments, bugs or doubts about Digital-NGP to us.

Instructions:

1. Click the DNGP QUESTION Button
2. A new window pops up where you can Enter your comments or questions about our Website

The Help button brings you to this Help screen.

Instructions:

1. Click the Help Button
2. A new window pops up with this Help page

The Home button restarts the website.

Instructions:

1. Click the Home Button
2. The Digital-NGP website restarts with the default settings.

Only after logging into the Digital-NGP, this button appears. This button allows you to create an Area of Interest (AOI) by entering the bounding coordinates and Delete AOIs.

Instructions:

1. Place the mouse cursor on the DNGP AOI Button
2. A drop down menu appears with the Create AOI and Delete AOI entries
3. Make the selection and click on it to go to desired function

Create AOI

1. Click on Create AOI link.
2. Enter the name of AOI. Enter the values in DMS format and should be either in clock-wise/anti-clockwise format.
3. To enter longitude values you can either enter the values with the hemisphere, for eg., 106 25 34.56 W with a space between degree, minute, seconds and direction. For Latitude the value is 44 29 68.09 N.
4. Alternatively, the values can also be entered with a negative sign in front of it without the hemisphere. For eg., -106 25 34.56 with a space between the degree, minute and seconds but NO space between the '-' sign and the degree value
5. AOI will be created which can be accessed from the View AOI menu in the Control Panel

Create AOI

1. Click on Create AOI with Map link.
2. Zoom in to the desired Area of Interest.
3. Enter the AOI Name and click Create AOI Button.

Delete AOI

1. Click on Delete AOI link.
2. Select the AOI Names you want to delete and click Delete AOI.
3. AOI values deleted are removed permanently from the database and are irrecoverable.

Only after logging into the Digital-NGP, this button appears. This button allows you to manage your account.

Instructions:

1. Place the mouse cursor on the DNGP ACCOUNT Button
2. A drop down menu appears with the Edit my account, change my password and change my secret question entries
3. Make the selection and click on it to go to desired function

Edit my account

1. Click on Edit my account link.
2. A new window pops up showing your current account information. You can change the information in the window

Change my password

1. Click on change my password link.
2. A new window pops up to let you create a new password but it requires you to enter your current password

Change my secret question

1. Click on change my secret question link.
2. A new window pops up to let you change your secret question and answer which would be required if you forget your password

APPENDIX B: Source Code

The source code is not printed. It is stored in the accompany Compact Disk labeled as Digital-NGP Version 3.0.3.