WEBSITE FOR FREEWAY EVOLUTION IN SAN DIEGO COUNTY

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DEDICATION

I would like to dedicate my thesis to my family and all my dear friends for their motivation, support and love.
The design of the California freeway system began as early as 1947 and some of the major freeways, which are mostly interstates, were open to the public as early as 1970. Motivation for this thesis is to develop an interactive GIS tool and an informative website for San Diego freeway system evolution. This tool and a website with freeway information will help historians and people who are more interested in knowing the details of freeway evolution in and around San Diego County. This website serves as a source for information and pictures of freeways present in San Diego County. A web link is provided for each freeway present in the GIS tool. GIS tool is made with the help of Map Objects Java Objects (MOJO) provided by Environmental Systems Research Institute (ESRI) and the website is developed using Drupal (open source content management system).
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This is an opportunity to thank my family for showering unconditional love and care as always. Last but not least, I would like to thank my friends who have helped me through thick and thin during the course of my project.
CHAPTER 1

INTRODUCTION

In this chapter we will briefly discuss about how freeways started and also about geographic information systems (GIS), map objects for java (MOJO). We will also discuss about the main idea of this informative tool on freeways in San Diego.

The Dwight D. Eisenhower National System of Interstate and Defense Highways (commonly known as the Interstate Highway System, Interstate Freeway System or the Interstate) is a network of limited-access roads including freeways, highways, and expressways forming part of the National Highway System of the United States of America. The system, which is named for President Dwight D. Eisenhower, who championed its formation, connects 209 of the 237 cities having a population of 50,000 or more. Construction was authorized by the Federal Aid Highway Act of 1956 and the original portion was completed 35 years later. The network has since been extended and as of 2006 it had a total length of 46,876 miles (75,440 km). The cost of construction has been estimated at $425 billion (in 2006 dollars), making it the largest public works project in history.

A geographic information system (GIS) is designed to capture, analyze, manage and display various forms of geographically referenced data or information. It uses maps to display graphical data where users can visualize and use it. Modern GIS technologies use digital information, for which various digitized data creation methods are used. The most common method of data creation is digitization, where a hard copy map or survey plan is transferred into a digital medium through the use of a computer-aided design (CAD) program, and geo-referencing capabilities. The GIS tool stores the feature data related to maps in an ESRI shape file format. Each layer of an application represents one specific type of data e.g. roads, land use, elevation, trees, waterways, cities, countries etc.

An application that displays a layer also contains attribute data of that particular layer which can give lot of information. ESRI provides a lot of layers for public usage and for the academic usage of GIS; students can enhance their critical thinking, improve global awareness and develop a sense of community.
GIS Tool is developed using Map Objects Java Objects (MOJO) which is distributed by ESRI. MOJO is an API which is based on java. This is used to build custom map applications by different users or developers. Map functionality can be leveraged by software developers to meet their own requirements.

San Diego Association of Governments (SANDAG) is an association of local San Diego county governments. This public agency serves as the forum for regional decision-making. SANDAG builds consensus, makes strategic plans, obtains and allocates resources: plans, engineers, public transportation, and provides information on a broad range of topics pertinent to the region's quality of life.

My thesis is about an informative tool on San Diego freeway systems. The idea of this tool is to provide information regarding San Diego freeways and their evolution.

This information tool comprises of a tool and a website. The tool is designed using Map Objects for JAVA (MOJO) and it revolves around a single freeway shape file that has all the freeways in and around San Diego County. The hotlinks navigate the user to a web link that provides information about that particular freeway. For each freeway a web page is created with information and pictures.
CHAPTER 2

SOFTWARE TECHNOLOGY

This chapter focuses on the software technology used to design and develop the tool. This tool is developed using Map Objects for Java (MOJO) which is licensed by Environmental Systems Research Institute (ESRI) and the Java SDK. For website development a content management system (CMS) Drupal is used. Both Java SDK and Drupal are open source platforms (distributed under GNU General Public License).

Java is robust, platform independent and it is a widely taught language. Java technology’s versatility, efficiency, platform portability and security make it the a very useful technology [1]. Java is a general-purpose, concurrent, class-based, object-oriented language that is specifically designed to have as few implementation dependencies as possible. Java derives most of its syntax from C and C++ but has a tighter object model and fewer low-level facilities. Java applications are typically compiled to bytecode so that they run on any Java Virtual Machine (JVM) regardless of the computer architecture. Its platform independency characteristic encourages programmers to lean toward Java in developing an application. The Graphical User Interface (GUI) of this tool is built using java’s Abstract Windowing Toolkit (AWT) along with Java Swing. AWT is a general interface between Java and a native windowing system, and has many events and layout managers [2]. Java swing is a set of class libraries that support building GUIs and graphics functionality for applications [3]. Swing can set a native look and feel for the user interface, and its look and feel is more consistent than with Java AWT. Our GIS is mainly built using Map Objects Java Edition. Map Objects essentially consists of a number of JAR files containing UI java beans (extensions to java swing) and an API of mapping components. Some of the important things that we are going to discuss about Map Objects Java Edition are cited at [4].

2.1 Java Programming Language

The primary features of the Java language are listed as follows:

- Simple and object-oriented.
• Robust and secure.
• Platform independent.
• High performance.
• Interpreted, multi-threaded, and dynamic.
• Easily deployed.

The main features of Java which made the language most widely used are:

• Object-Oriented: Java is an object-oriented language as it deals with modular object-oriented units called classes. Programming in Java mainly deals with objects and their classes. Instantiation is the process of creating an object; any class could be instantiated from within the code as needed by the application, thus supporting extensibility. Everything must be defined in classes, each of which described from the Object class.

• Multithreaded and Dynamic: Java provides built-in support for multithreaded programming. A multithreaded program contains two or more parts that can run concurrently. Each part of such a program is called a thread, and each thread defines a separate path of execution. Multithreading is a specialized form of multitasking. Multitasking threads require less overhead than multitasking processes. Multithreading is the ability to support and efficiently execute multiple threads. Some features in the Transportation tool use threading as it effectively reduces the wait time on a resource. The number of java applications taking advantage of threads is not as high as it should be.

• Portability and Reusability: An application is portable if it is significantly easier to modify the product as a whole to run it on another compiler–hardware–operating system configuration than to recode it from scratch. In contrast, reuse refers to using components of one product to facilitate the development of a different product with a different functionality. In Java, applications developed are portable as they could be executed on any Java virtual machine. A package can be created by combining a group of classes which could be reused to achieve a particular functionality without having to implement the application from scratch.

2.2 Map Objects Java Objects (MOJO)

MOJO is the core Java Application Programming Interface (API) used for building GIS applications. MOJO is a developer’s tool kit; it includes a set of JAR files containing pure Java components that can be used to develop a usable stand-alone GIS application or to add maps or map functionality to other applications [5]. Since it is written in Java, an application using MOJO is platform independent. Classes supplied by ESRI in MOJO makes it easy to integrate Java classes and components.
The following are some of the core features available through map objects [5]:

- Displaying maps with dynamic, real time geographic data.
- Navigation and zooming through maps layers.
- Performing queries on shape files (to access attribute data).
- Labeling and customizing map interfaces to enhance usability.

2.3 Drupal

Drupal is a free and open-source content management system (CMS) and content management framework (CMF) written in PHP and distributed under the GNU General Public License [6]. It is used as a back-end system for at least 1.5% of all websites worldwide ranging from personal blogs to corporate, political, and government sites. The standard release of Drupal, known as Drupal core, contains basic features common to content management systems. These include user account registration and maintenance, menu management, RSS-feeds, page layout customization, and system administration.

Any user is allowed to upload modules to the already existing module repository. Certain modules called “Core” modules co-exist along with user defined modules. Drupal is secure, scalable, usable content management system and hence it is widely used.
CHAPTER 3

THE REQUIREMENTS

The Transportation tool is developed for SANDAG and it will be available for public access. It will serve as an informative tool for historians and for anyone interested in getting to know about the freeway system and its evolution in San Diego.

The requirements are classified into the following types:

- Data Requirements
- Platform Requirements
- Functional Requirements

3.1 DATA REQUIREMENTS

Data requirements comprise of the essential data chunks necessary for the application as agreed upon prior to the start of implementation. Prof Dr. Carl Eckberg suggested the following data requirements in accordance with the idea proposed by SANDAG:

- Freeway Name
- Year completed
- Length in miles
- Web link
- Brief Description

3.2 PLATFORM REQUIREMENTS

The section below lists and describes the platform requirements for the design and development of the Transportation tool:

- JAVA
- Map Objects Java Edition
- Drupal
- Windows OS

The Tool is designed and developed using the Java programming language and the predefined classes in Map Objects. Though a vast variety of IDEs that incorporate Java exist,
such as Net beans, Eclipse is preferred, owing to its ease of use for this project. Since Java is used as the core programming language in this implementation, the tool could be obtained as a JAR file that could run on any machine. Website is developed using Drupal which serves as an information repository for the freeways mentioned in tool. Java 1.6 was the Java version chosen for the tool.

### 3.3 Functional Requirements

Functional requirements for the Transportation tool gradually evolved from a series of discussions with Mr. John Hofmockel, GIS Analyst from SANDAG. However, Dr. Carl Eckberg’s suggestions fine tuned the functionality of the tool with timeline considerations.

The functional requirements identified are:

- The tool by its entirety comes up with the latest freeway map on top of a San Diego County border map.
- The application should provide tools to zoom in and zoom out and it should be capable of adding more layers e.g. countries, states, counties, rivers etc.
- The application should provide information regarding each freeway that might include geographic pictures of the freeway, year built and other statistics such as the length of the freeway.
- The application should also provide links to a website which should contain data related to each freeway in separate pages.
CHAPTER 4

WEB SITE INSTALLATION

In this chapter we will go through the step-by-step procedure of the Drupal and other modules installation.

4.1 WEB-SERVER

A Web-Server primarily delivers web pages based on the client’s requests using Hypertext Transfer Protocol (HTTP). Client can be a web-browser or web crawler. It can request a page or resource (e.g., images, style sheets, document, scripts, audio, video), and the server responds with the content of the resource. If the page is not found it will send an error message (404 error). The web-servers support server-side scripting. The next section will explain about the installation of the xampp server.

4.2 XAMPP SERVER SETUP (CROSS-PLATFORM, APACHE HTTP SERVER, MYSQL, PHP, PERL)

XAMPP is a free and open source cross-platform web server solution stack package, consisting mainly of the Apache HTTP Server [7], MySQL database [8], [9], and interpreters for scripts written in the PHP [9] and Perl programming languages. Once xampp is installed our local machine can act as a remote host or web-server by connecting using an FTP client. Using a program like FileZilla has many advantages when installing a content management system (CMS) like Drupal. This can be used for the initial setup of the website.

Xampp server can be downloaded from [10]. After downloading, unzip the folder, then run the XAMPP control and start the Apache, MySQL and FTP controls. Then we can see control window shown in Figure 4.1.

By clicking on the http://localhost/ or typing http://localhost/ in a web-browser we can see Figure 4.2 showing that the server is running successfully. We can select the language and after doing that from Figure 4.2 we can see Figure 4.3, shows that the installation is successfully completed.
We can click phpMyAdmin link on the bottom left of Figure 4.4 or http://localhost/phpmyadmin/ to open the sql server. We can create our database tables which are used by our website.

A name should be given to the database, then click create to create the database. I have given sdfreeways. Then we can create all the database tables by giving the table name,
Figure 4.3. Showing successful installation of the xampp server.

Figure 4.4. MySql server-creating new database.
number of columns, the type of data for each column etc. The screen shots are given in Figure 4.5.

![Figure 4.5. Creation of tables and fields.](image)

### 4.3 Drupal Installation

In this section we will go through the Drupal installation. We can download Drupal from [8]. Download the zip file and unzip the contents to a folder. We can rename the folder and place it under ..XAMPP/xamppfiles/htdocs/sdfreeways (renamed the Drupal folder to sdfreeways to reflect it on website). Then rename the file default.settings.php located in ..XAMPP/xamppfiles/htdocs/sdfreeways/sites/default/ to settings.php. Change all the permissions of settings.php to read-write. This is required as the installer writes some
contents to this file when installing drupal. Once the installation is done we can change the permissions to original on the file.

Then create a folder under ..sites/default/Files. All the files which we create in our website will be created under this folder. If we miss these steps it will show an error as shown in Figure 4.6. Figure 4.7 shows the screen which appears after solving the errors.

Figure 4.6. Drupal installation errors.

Figure 4.7. Drupal installation page.
We can select standard installation or minimal installation according to our requirements. Drupal would verify the requirements of the installation like the read-write permissions on the settings.php file and the presence of the Files folder under ..sites/default/. If either of them were not satisfied it would show us an error with the message as shown in Figure 4.6.

Once we have followed the above instructions we can create the database. Here we will give the database name, which we created in Figure 4.4. By default the user name of database is root and password is empty. We can even change the user name and password if it is required. Figure 4.8 shows database setup in Drupal installation.

![Database configuration](image)

**Figure 4.8. Database setup in the Drupal.**

Figure 4.9 shows the successful installation of Drupal standard modules screen. Then we have to setup the administrator account and the website email.

Figure 4.10 show the screen that appear once we have successfully created the administrators account and Figure 4.11 show the Drupal installation successful screen. Once we click the link it will take us to our newly created website (see Figure 4.12).

### 4.4 THEMES INSTALLATION

We can use themes in Drupal to give the same appearance to all the pages in our website. We can use default themes given with installation or download the themes from the Drupal website [11]. A sample theme is shown in Figure 4.12.
Figure 4.9. Successful installation of Drupal standard modules.

All the downloaded themes from the Drupal website should be unzipped and copied to the folder ..xamppfiles/htdocs/sdfreeways/themes. We can select a default theme or downloaded theme by going to the appearance window as shown in Figure 4.13. In the Drupal site select the theme and apply it. The look and feel of the website is changed. We can even edit the .css file according to our requirement. See Figure 4.14 for the newly selected theme.
Figure 4.10. Administrators username and password set-up.
Figure 4.11. Drupal installation successful.

Figure 4.12. First page of the website.
Figure 4.13. Changing theme of the website.

Figure 4.14. New theme of the website.
CHAPTER 5

WEB SITE DESIGN

The website contains information regarding all the freeways which are part of San Diego. In this chapter we will go through the website design and also the linking of the website and GIS tool.

The Administrator (Admin) has the complete control of the web-site. Admin has permissions to add users and authenticate them, add or modify content to the website, install modules (Drupal), install themes and other miscellaneous activities of the website.

The login page is the same for everyone; it requires a user name and the password. A password can contain alphanumeric characters and it cannot be empty. The following Figure 5.1 shows how the login page is laid out.

Figure 5.1. Login page.

Once an admin gives credentials and completes the login successfully, the resulting page looks like the page shown in Figure 5.2. This page contains options for content management, user management, site building, site configuration. Only admin’s home page has all the links to website configuration.
5.1 ROLE OF WEBSITE ADMINISTRATOR

Administrator is responsible for managing content of the website and other website configurations. There can be more than one administrator for the website. All we need to do is giving admin privileges to an user as shown in Figure 5.3. We can go to “people” and select a user and edit the permissions of the user. We can give admin permissions by selecting “administrator” under “Roles” and then save the changes. The administrator is granted permission to access all modules. Regular users can only view the content of website.

5.2 CONTENT MANAGEMENT

Website content can be created, modified or deleted by administrators according to the requirements. Figure 5.4 shows how to create a basic page with content. Content is created by going to “people” and selecting “Basic page”. Then admin can enter title and content of the page. There will be options for providing menu link for the page etc. which we can select based on the requirement.

We can edit the page content as shown in Figure 5.5. By selecting “Edit” option we can edit the title, content or any other option related to the page. This Edit option is available to only users with admin privileges.
Figure 5.3. User management.
Figure 5.4. Creating a basic page.
5.3 EMBEDDING HTML CONTENT IN PAGES

We can embed HTML (Hyper Text Markup Language) content in the web pages we created. By changing “Text format” to “Full HTML” we can embed HTML tags by which can include images, videos, audio content in our web pages [12]. See Figure 5.6 which shows a page created with HTML content.
We used HTML tag `<img>` for embedding images in our website [13]. In this tag we specify a source for an image and additionally we can even mention the image height, width and alignment.

**5.4 MENU LINKS AND THEIR ORDERING**

In our website we created four different menus i.e., Home, Interstates, State Routes and Points of Interest. In each menu we have different menu links. For e.g., in interstates we
have different menu links for interstate freeways listed. These can be created as shown in Figure 5.7. When a page is created we can specify a menu link title for that and a parent item (under which it should be listed).

![Figure 5.7. Creating a menu link.](image)

We can even change menu link orders based on our requirements as shown in Figure 5.8. We can select “weight” for the menu item. Menu links with smaller weight are displayed before links with larger weights.

### 5.5 Freeways Mentioned in Website

All the freeways which touch San Diego are mentioned in the website. The Admin can easily add new freeway information when required. In our website we divided freeways into two categories i.e., Interstates and State Routes. There are four interstate freeways and nine state routes mentioned in the website. For each freeway we have given useful information and also pictures based on their availability. Figure 5.9 and Figure 5.10 shows one interstate and one state route freeway page from website.

Apart from these we also included points of interest of San Diego. In this menu we included some of the most popular places in San Diego. We mentioned useful information regarding those places. Figure 5.11 shows the main menu of points of interest.
Figure 5.8. Changing menu link orders.

Figure 5.9. Interstate freeway page with picture.
Figure 5.10. State route page with picture.

Figure 5.11. Points of interest menu page.
5.6 Website Links from GIS Tool

The main functionality of the website is to provide information about all the freeways included in the GIS tool. Figure 5.12 shows the GIS tool for displaying freeways in San Diego map.

Figure 5.12. GIS tool for freeways in San Diego map.

This tool has different functionalities and two of the major functionalities are:

- A Hot link tool is given in the tool bar which helps in finding the information regarding a freeway. Hot link icon is shown in Figure 5.13. When we select hot link icon and click on a freeway it opens a dialog box as shown in Figure 5.14. The dialog box contains a button “WEB LINK”. When we click that button it opens the webpage of that particular freeway as shown in Figure 5.15.

- All the freeway chunks constructed in a certain period of time will be highlighted when a year button is selected from the toolbar of the GIS tool. The year toolbar is shown in Figure 5.16.

Figure 5.13. Hot link icon in the toolbar.
Figure 5.14. Dialog box in which a weblink is provided.

Figure 5.15. Webpage opened when web link button is clicked.
5.7 LICENSE FOR PICTURES USED IN WEBSITE

All the images or pictures used in our website are licensed under Creative Commons Attribution-NonCommercial 2.0 Generic License. So on each page we use the pictures of freeways we specified the license information which is shown in Figure 5.17.

![Creative Commons License](image)

This work is licensed under a Creative Commons Attribution-NonCommercial 2.0 Generic License.

Figure 5.17. Licensing for pictures used.

5.8 MAIN USERS OF THE WEBSITE

Main users of GIS tool and website are discussed below:

- Historians who are interested in the history of freeways.
- San Diego Association of Governments (SANDAG) as an informative tool.

Further many users can use this website as an information repository as it is publicly available. The link for the website is sdfreeways.com.

5.9 HELP PAGE FOR TOOLS IN GIS APPLICATION

A Help web page is provided in website where each tool present in GIS application is explained briefly. This will help users who use the tool for first time. Screenshot of the help web page is shown in Figure 5.18. All the tools used in GIS application are discussed in the respective web pages. For each toolbar, a different web page is created. Web page for Custom toolbar is shown in Figure 5.19.
Figure 5.18. Help web page for GIS tool.

Figure 5.19. Help page for custom toolbar.
CHAPTER 6

CONCLUSION

The main purpose of this thesis is to build an informative tool for the San Diego freeway evolution. Dr. Carl Eckberg and Mr. John Hofmockel, GIS Analyst from SANDAG, played very important roles in shaping up this software. The whole point of building this software is to provide users an easily usable informative tool which gives a lot of information about different freeways present in San Diego. The requirements changed over time and the software is built according to those requirements.

The design of California Freeway System began as early as 1947 and some of the major freeways which are mostly interstates were open to the public as early as 1970. As this data was not stored electronically until 1990, the earliest data obtained from the attribute table of the freeway shape file started from 1990. The tool is designed using Map Objects for JAVA (MOJO) and it revolves around a single freeway shape file that has all the freeways in and around the San Diego County. To make it San Diego-centered, a San Diego shape file is used as the base layer on top of which the freeway shape file is placed. Here, each freeway is marked using hotlinks which derive their attributes from the fields defined in a CSV file. The hotlinks navigate the user to a web link that provides information about that particular freeway. Lots of effort was put in to collect the maps and information regarding freeways. A timeline tool is provided to show the freeways in the range of 1990 to 2011.

A website is developed to provide more information about freeways. Drupal is used to develop the website. GIS tool and webpages is related using Java buttons, MOJO hotlink tool. So when a user selects hotlink icon and click on a freeway, a dialog box appears and user can click a button called “Web Link” which opens web page with freeway information. Making the hotlink cursor work properly and opening the html links in any available internet browser on any type of machine were some of the challenges faced in development of the software. This tool works on Internet Explorer, Firefox, Chrome and Safari.
CHAPTER 7

FUTURE WORK

This GIS tool is built using Map Objects Java and Java Swing, so adding additional features or modifying the features can be comfortably done with this software. Most of the code contains Java classes and these classes can be reused or extended easily. It is also easy to write new classes using Java.

There is always room for future enhancements for any project. Some of the ideas that can be considered for future enhancements are:

- This tool is only developed for freeways in and around San Diego. This can be extended to all freeways in California. For that more data need to be collected and CSV files should be prepared.
- Website can be made more efficient informative tool by providing videos related to freeways.
- More pictures of freeways can be provided in web links.
- User accounts can be created for using website.
- Allowing users to save particular information from website in their accounts.
- Giving permissions to users to add more legitimate information. The data can be posted to the website once it is reviewed by admin.
- Adding self-test quizzes on the freeway information which allows users to test their understanding.
- Enhancing the timeline facility with a linear grained time scale.
BIBLIOGRAPHY