ABSTRACT

AN INTERNSHIP WITH
ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE

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This paper reports on a six-month internship with a research and development institute called Environmental Systems Research Institute (ESRI) from June 4th 2007 to November 16th 2007. This internship focused on various projects involving GIS technologies, which strived to make the clients, as well as the end users, aware of the importance of GIS technologies in today’s world. The importance of this internship was to release projects that would help the clients to organize their logistics in a proper way and to efficiently deliver their day-to-day work by using the applications developed by ESRI.
# TABLE OF CONTENTS

OVERVIEW OF ESRI ................................................................. 1  
GOALS OF ESRI .................................................................. 1  
RESPONSIBILITIES AND WORK PERFORMED DURING INTERNSHIP .... 3  
CHAPTER 1 ............................................................................... 4  
  SUNSTATE EQUIPMENT COMPANY ...................................... 4  
    1.1 DYNAMIC DISPATCH SYSTEM ........................................... 4  
    1.2 DYNAMIC DISPATCH GRAPHICAL USER INTERFACE REQUIREMENT .... 5  
    1.3 DATA REQUIREMENTS .................................................... 6  
    1.4 TRANSACTION .............................................................. 6  
    1.4.1 JOB ASSIGNMENT TOOL ................................................. 6  
    1.5 GEO-CODING REQUIREMENTS ......................................... 7  
    1.5.1 HATS and GEO-CODING PROCESS .................................. 8  
    1.6 SOFTWARE TESTING ..................................................... 9  
CHAPTER 2 .............................................................................. 12  
  SEMPRA GAS COMPANY ...................................................... 12  
    2.1 DATA PROCESSING ....................................................... 12  
    2.1.1 MODEL BUILDER .......................................................... 13  
    2.2 GDT DATA PROCESSING ............................................... 14  
    2.2.1 DELETE REDUNDANT DATA .......................................... 15  
    2.2.2 UPDATE SPEED IN DATA ............................................ 15  
    2.3 NETWORK BUILDER ..................................................... 15  
LESSONS LEARNED .............................................................. 16  
REFERENCES ................................................................. 18
LIST OF FIGURES

Figure 1 Dynamic Dispatch Graphical User Interface showing the tool selecting the best job for the truck within its radius (Source: ESRI) .......................................................... 5
Figure 2 Explaining the HATS Studio and HATS Application (Source: IBM) ............... 8
Figure 3 HATS and Geo-coding Services (Source: ESRI) .................................................. 9
Figure 4 showing the model builder (Source: ESRI) ............................................................... 13
Figure 5 showing the graphical user interface for the GDT process (Source: ESRI) ....... 14
Figure 6 showing the graphical user interface for GDT network builder (Source: ESRI) 15
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My appreciation to all of those with whom I have had the opportunity to work during my internship at ESRI and during my graduate school at Miami University. A special thanks to Ms. Elizabeth R Haven and Mrs. J Christine Ingham for their valuable help during my two years of stay at Miami University.

Finally, I would like to thank my Family and Ranjit, whose love and guidance are with me in all walks of my life.
OVERVIEW OF ESRI

Environmental Systems Research Institute (ESRI) was established in 1969 with its headquarters in Redlands, CA. It is a privately owned organization and designs and develops the world’s leading geographic information systems (GIS). ESRI serves the needs of its user community with 10 regional offices, more than 80 international distributors, and users in more than 150 countries.

GOALS OF ESRI

- “ESRI’s main focus is on the principles of organizing and analyzing geographic information.
- ESRI project concepts involve processes and tools that could be applied in an automated environment.
- ESRI resources are devoted to developing a core set of applications that could be applied in a computer environment to create a geographic information system”.

ESRI was founded by Jack and Laura Dangermond in 1969. ESRI emerged as a consulting firm that focused in land use analysis projects and today it is the largest research and development organization in GIS. Jack Dangermond, in one of his messages to the press, said that “ESRI’s conservation program was started to change the way non-profit organizations carried out their missions of nature conservation and social change”. This further helped ESRI to provide GIS software, data, training and as well as helping to coordinate multiorganizational efforts.
The first modern GIS software that was designed to run on minicomputers called the ARC/INFO was launched by ESRI in 1982. With the changing technology from UNIX to various other operating systems, ESRI developed software tools that were platform compatible. In 1986, ESRI launched its higher end GIS software, the PC ARC/INFO, a stand-alone PC-based GIS station. With the launch of PC ARC/INFO and Arc View, ESRI became the world leader in GIS and found its way for more innovation.

ArcGIS 9, which was recognized as the next generation software for building a complete GIS, was released in May 2004. This release included two new products: ArcGIS Engine and ArcGIS Server. ArcGIS Engine is used for embedding GIS functionality into desktop, while ArcGIS Server is a centrally managed framework serving enterprise GIS applications.

The company's focus remains on producing excellent software and delivering exceptional service to users. Having worked in ESRI, I understand that better information makes for better decisions. “ESRI believes that its reputation is built on contributing technical knowledge, special people, and valuable experience to the collection, analysis, and communication of geographic information”.

2
RESPONSIBILITIES AND WORK PERFORMED DURING INTERNSHIP

My position as an intern with ESRI, Redlands, California was Programmer/GIS analyst in professional services. ESRI’s Professional Services and consulting members go hand-in-hand to help their customers in converting their GIS needs into real time application. The Professional Services Division is divided into four groups to provide a variety of services to its customers:

- “Consulting Services provides applications and systems development solutions within a variety of different markets
- Database Services supports database design, data automation, data conversion, and quality assurance services
- Programming Services supports application design, development, prototyping, testing, and documentation
- Implementation Services provides onsite user-defined technical assistance at any point during the implementation”.

I was assigned to do a dispatch application called the Dynamic Dispatch (DD) for Sunstate Equipment Company and Data processing for Sempra Gas Company. I was involved in the development phase of both of the projects and was mainly working with the Sunstate Equipment Company team in developing the server-side and client-side applications using my programming skills in C# and with my GIS knowledge in ArcObjects. I was also involved in testing the Dynamic Dispatch application and in developing the Test plan and Test reports for Sunstate Equipment Company. With respect to Sempra Gas Company I was involved in upgrading the Graphical User Interface (GUI) using VB6 to match the current version of ArcGIS i.e., ArcGIS 9.2. My duty as a programmer/ GIS Analyst was to analyze various ArcGIS tools and to develop the application, using C#, VB6 and ArcObjects.
CHAPTER 1

SUNSTATE EQUIPMENT COMPANY

Sunstate Equipment Company was established on January 1, 1977 with headquarters in Phoenix, AZ. “Sunstate facilitates construction, industrial and special event companies with rental tools and equipments”™. Renting high quality and well-maintained equipment tools helps their clients to get their job done safely and on a timely basis. Sunstate provides a wide range of services in California, Utah, Colorado, Arizona, New Mexico, Texas and Oklahoma. This renting company requested ESRI to develop a DD application which will help them in efficiently assigning their renting equipment to a job in an automated environment and assist the dispatchers in completing their job on time.

1.1 DYNAMIC DISPATCH SYSTEM

The Sunstate Dynamic Dispatch System was built based on the ESRI ArcGIS COTS software platform and technologies. Commercial off-the-shelf (COTS) is a computer product and is available to be used as an alternative to in-house developments. The purpose of using COTS components is that they reduce overall system development costs and involve less development time.

The Dynamic Dispatch application assists the dispatchers in assigning transactions efficiently to a suitable trucks or drivers, so that the customers can meet their expectations within the timeframe and yet keep the operational cost low. The DD system at high levels will include basic mapping functionality and geo-coding functionality using Host Access Transformation Services (HATS) application.
1.2 DYNAMIC DISPATCH GRAPHICAL USER INTERFACE REQUIREMENT

The Dynamic Dispatch graphical user interface in Fig 1 was developed to satisfy the dispatch requirements of the application. The application developed differentiates between the types of transactions such as delivery, pick up and exchange. Every transaction is tagged with a status such as completed, deleted, On-transit etc. As every transaction should have only one transaction status, the system tracks the status of the transaction too. The system displays dispatch records by filtering them based on criteria such as driver, customer, equipment, time, area, branch, transaction type and status.
1.3 DATA REQUIREMENTS

To effectively perform the dispatching tasks, ESRI’s Geodatabase technology was used in order to store the spatial data such as dispatch locations, truck locations, branch locations etc and other non-spatial data. The system also uses two databases, the Sequential Query Language (SQL) server database and a DB/2 database. The WBI-JDBC adapter is used to pull data from or push data into the DB2 database and that way synchronization is maintained between the two databases.

1.4 TRANSACTION

One of the important tools of the application, to which I was assigned, is the “select best job” or “select best truck” tool. The system provides the user with two modes of transaction or vehicle assignments. The advantage of this tool is that a dispatcher at Sunstate Equipment Company can utilize this function to assign jobs to trucks, or trucks to jobs, manually as well as automatically.

1.4.1 JOB ASSIGNMENT TOOL

This function assigns jobs for same-day pickup and delivery operations. Once the current truck finishes its job for pickup or delivery, the tool assigns further jobs for a truck or driver. It utilizes real-time information, including current truck locations and capacities; equipment availability, rental requirements; including the quantity and types of equipment; to make decisions about how the jobs should be assigned. The system calculates the travel time and the cost for assigning the jobs and trucks. The algorithm picks up the solution which will minimize the overall cost. The goal of the dynamic job assignment function is to assign incoming jobs to the most suitable trucks that will result in the minimal overall cost.

1.4.1.1 Best truck – The “best truck” logic finds the best truck to service a given set of jobs. If a set of jobs and trucks are selected, then the system will return the best trucks to service that set of jobs.
1.4.1.2 **Best job** – The “best job” logic finds the truck to service the given job. The dispatcher assigns a new job to the driver once the current job is completed. The dispatcher allows the system to search all pending jobs to pick the best jobs for the driver or will allow the system to find the best jobs from a selected set of jobs.

1.5 **GEO-CODING REQUIREMENTS**

“**Geo-coding** is the process of assigning geographic identifiers, geographic coordinates such as latitude and longitude, to map features and other data records, such as street addresses”.

Sunstate, being a dispatching company, needs the addresses of various job locations in different regions to assign the most suitable equipment for a particular job. Geo-coding helps in identifying the correct address of the job location on the application and helps Sunstate to assign the trucks automatically. The geo-coding application was developed to meet the geo-coding functional requirements for the Dynamic Dispatch process. In the application, the user has the ability to type in an address to derive a geographic location. If multiple addresses, relative to the originally typed address, are returned, the user picks the most suitable result. The results from the geo-coding process are returned to the location data that is stored in the DB2 database. The information stored:

- Lat/Lon coordinates
- Territory Identifier
- Five Digit Zip Codes
- County Name
1.5.1 HATS and GEO-CODING PROCESS

Host Access Transformation Services (HATS) application is used to create web and client applications that provide an easy-to-use Graphical User Interface (GUI). “HATS application is used to transform the screens of a host application into Web pages that are part of a Web Sphere application that is running on a Web server. End users access these pages from their Web browsers and use the pages to send and receive data from the host application”. The end users might not even know that they have been constantly interacting with a host application.

The HATS application as shown in Figure 3 is used to geo-code addresses:

1. A geo-coding web service is called by a given address. If one or more geo-coded locations are returned then HATS application handles the result set.
2. If there are no return values after the geo-coding web service call, a web based geo-coding map application is invoked by the user and after selecting a geo-coded location a JavaScript function in the HATS application is called from the geo-coding web-based application to send the geo-coded result back to the GUI.

Figure 2 Explaining the HATS Studio and HATS Application (Source: 6)
1.6 SOFTWARE TESTING

After the entire application was developed, before deploying it into the client’s environment, the Graphical User Interface (GUI) was required to undergo testing. Testing the GUI falls under the Functional testing category. Functional testing is also called Black box testing where the testing takes place with no knowledge of the internal workings of the item being tested to derive test cases. The test designer selects valid and invalid input and determines the correct output. In black box testing the user input is always checked for validation to conform to expected values. Prior to testing the GUI, a software test plan was developed that served as a testing guide for both ESRI and Sunstate Equipment Co. The test plan had details as to what tests should be performed by ESRI and the client, test schedules, software for testing and a template for test cases. Test case is a set of conditions based on which a quality analyst will determine if a requirement for an application is partially or fully satisfied.
My primary role revolved around helping the Transportation team with application development and data processing. For the first half of my internship, I helped the Sunstate development team in both Server side and Client side application. On the client side application, I developed the dynamic job assignment tool for the Sunstate Dynamic Dispatch application based on the best job/best truck logic. The Sunstate Equipment & Co Dynamic Dispatch project’s design documents were reviewed and my responsibilities for the Sunstate Equipment Co were assigned. My first task was to develop a toolbar and to add a user interactive tool, the job assignment tool, to the toolbar which would perform the basic task of selecting the trucks and jobs in and around its radius using the X and Y coordinates of the trucks and the job when a mouse click event is performed. I also created map layers for the trucks and the jobs.

After the best job tool was developed and deployed into the interface, I assisted the web services team in the server side application of geo-coding. The addresses of the dispatch locations in Arizona were given to ESRI by the client in the form of a spreadsheet. These addresses were geo-coded using the street Address locator 9.2, which was developed exclusively for this project to find the X and Y coordinates, and then the Spatial Data Engine (SDE) data were fed into the respective database tables. “SDE data is GIS data stored in a relational database by the spatial data engine” SDE also manages the data in the tables inside the database and also handles data input and retrieval. The X and Y co-ordinates of the truck show the movement of it on the Graphical User Interface.

I was also involved in testing the Dynamic Dispatch Graphical User Interface. As part of my testing job, I developed the Software Test Plan that served as a testing guide for ESRI as well as Sunstate Equipment & co. During testing, as a Quality Analyst (QA), I focused on the requirement changes. In the process of testing, test cases were developed according to the requirement, which in turn were used in preparing the testing document that stated what error occurred during the process of testing and also provided resolutions for the errors that occurred. Once the documentation was done, the GUI was deployed to see if necessary changes were made and how those changes affected or modified the application further. Graphical User Interface was tested based on the functional requirement specification as well
as the use cases developed for every specification in the process. The testing was carried out based on the functional requirements specification of the project.

In early years, the applications of GIS in the Transportation department always supported project-level engineering. After having worked with the Transportation team and seeing the advancement in GIS technologies and the development of a dispatch application, it is clearly understood that in the future GIS will support transportation projects that are one step higher than the project level engineering and one of the example to it is the dispatch applications developed by ESRI.
CHAPTER 2
SEMPRA GAS COMPANY

Southern California Gas Company is a subsidiary of Sempra Energy headquartered in Los Angeles, California. It delivers clean, safe and reliable natural gas to its customers. “It is recognized as the nation’s largest natural gas distribution utility, serving a population of 20.1 million consumers”.

2.1 DATA PROCESSING

Sempra Energy receives periodic street data updates from Tele Atlas. “TA is the trusted source and company that supplies digital maps and dynamic contents for navigation and location based services.” Sempra Energy wanted ESRI to perform the street data processing steps for preparing this data for future applications. Sempra also wanted ESRI to document the process so that Sempra can perform the processing in the future without ESRI’s help.

The Sempra Gas Company is one of the oldest clients of ESRI. Sempra requested ESRI to upgrade their existing application (Graphical User Interface). The data processing involved making changes to the data extraction program that was developed in 2001 by ESRI for the Sempra Gas Company using ArcGIS 8.3 to one that would support the latest version of ArcGIS 9.2 and creating model builder processing routines to perform various tasks. To perform the data processing, the process was divided into three parts:

a) Model Builder
b) Graphical User Interface
c) Network Builder
2.1.1 MODEL BUILDER

“Model Builder technology provides both beginning and advanced users with a set of easy-to-use tools for building various types of spatial models within ArcGIS Spatial Analyst”. The flow diagrams created with Model Builder are a convenient way to construct and modify spatial models. They are also an excellent way to document and present one’s models to others.

The Model Builder in Fig 5 for this project was developed to perform the Geographic Data Technology (GDT) data processing using a data management function, the project, to set the projection of the street dataset from its original projection ‘Lat Lon WGS84’ to ‘NAD_1983_StatePlane_California_V_FIPS_0405_Feet’. GDT data is Street/Road network data from Tele Atlas. The Model Builder was also used to perform the geoprocessing tasks such as the select, buffer and clip.

Model Builder for GDT Data Processing

Figure 4 showing the model builder (Source: ESRI)
2.1.1.1 PROJECTION
This module is used to set the projection of the Southern California Street dataset from initially set default projection:
‘GCS_1984’ to ‘NAD_1983_StatePlane_California_FIPS_0405’. The change in projection is required to avoid incorrect alignment and accuracy in the map projections.

2.1.1.2 SELECT, BUFFER, CLIP
The select function selects five (5) individual regions from the southern Californian street dataset. Each individual region is buffered by 10 miles using the buffer function and further the Street datasets are clipped by the buffered regions using the clip function.

2.2 GDT DATA PROCESSING
The Graphical User Interface in Fig 6 was developed by ESRI exclusively for the data processing task for Sempra. It is used for processing the southern California street dataset by performing the delete redundant data and update speed functions. These functions basically delete the redundant GDT speed data records from the input dataset and update the dataset with the recent GDT speed data received by Sempra from Tele Atlas.

Graphical User Interface for GDT Data Processing:

Figure 5 showing the graphical user interface for the GDT process (Source: ESRI)
2.2.1 DELETE REDUNDANT DATA

This module is used to delete the redundant records from the input dataset using the GDT speed sheet. The request sheet is the GDT speed sheet with updated speeds from Tele Atlas. The speed data consists of the speed limit of the road network of different regions in southern California by which the gas will be supplied. It is also used to delete those records that are not available in the GDT speed sheet. The Delete Data function deletes those redundant data records from the input dataset and also those records that are not available in the request sheet.

2.2.2 UPDATE SPEED IN DATA

This module updates the speed attribute in the input dataset using the Request sheet (GDT Speed), Base speed and the Support File. This speed attribute helps Sempra to transport gas to the streets of different regions at the assigned speed. The request sheet is the GDT Speed sheet from Tele Atlas, the Base speed is a Microsoft Access Database file that has the minimum standard speed for all the streets in Southern California and the Support file is the base polygon of each Region. The Update Speed function updates the output with the recent GDT speed data and the Base speed received from Tele Atlas.

2.3 NETWORK BUILDER

Graphical User Interface for GDT Network Builder

Figure 6 showing the graphical user interface for GDT network builder (Source: ESRI)
The Network builder in Fig 7 is used to build a network of similar types of streets based on the updated speed dataset. The network builder built seven individual network streets for five individual regions. The seven street networks are: All Street, Major Street, Highway Street, One-way Street, Cmajor Street, Major Street and Added One-way Street from Southern California street dataset updated with new speeds. It also built two directories called the AllSt.nws and MajorSt.nws that give more information on the All Street and Major Street shape files.

The thing I liked the most about this project was that I got to work as a alone on the whole project. The last 3 months was very challenging and it completely prepared me for a full time job opportunity. It increased my questioning skills and paved the way to trouble-shoot a problem from different perspectives. Working on this project individually, I learned to pay attention to the minute details and gained an understanding of every phase of the project in complete depth.

**LESSONS LEARNED**

I have always been interested in Environmental Science and also posses a technical background in Computer Science. The best way of merging these two areas is through GIS. In this internship, I learnt a lot about the ArcGIS tools and specialized techniques that can be applied to get more information to perform analysis. When working as an intern, I came across different aspects of ArcObjects, which I was never introduced to previously and this gave me the opportunity to learn more about ArcObjects which is a framework that lets one create domain-specific components from other components and how it can be used in different phases of the project.

ESRI's user conference is the largest GIS conference in the world and more than 12,000 attendees from all over the world participate every year. Being an employee of ESRI I had the benefit to attend the User Conference, 2007 in San Diego. It was a wonderful experience to meet people from all over the world with similar and various interests. ESRI also sponsors
assistantships for students to attend the annual international conference. ESRI believes that
the purpose of an internship is to learn and so it encourages their interns to attend the User
Conference. I have always known ESRI as a research and development organization but after
having attended the user conference, I see ESRI not just as an R&D organization but as an
institute that enlightens professionals and students across the globe with GIS education.

This experience has also given me the opportunity to improve my programming skills and
have learned to develop programs that were previously challenging to me. Being in the
development team has helped me see GIS from a developer’s perspective. One thing I like
the most with ESRI is its organizational structure. If I need to discuss anything to my
manager or colleagues related to the project, I can approach them any time. I interact with
people who have been in the industry for a very long time now, and that way I learn more
from their experience. This internship paved way for me to analyze what I am truly interested
in.

When I was in graduate school and took classes in GIS, I thought I enjoyed more being an
end user of the software but after having done this internship; I understand that my interest
lies in also being a developer and part of the organization that develops the important tool
that shapes our world. I thank IES for including the internship program as part of the
curriculum I consider this opportunity to have been a very rewarding experience and a very
successful journey.
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## APPENDIX A: GLOSSARY OF TERMS

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<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td>Area</td>
<td>A collection of Territories that is used by Dispatchers to quickly determines where a given location is.</td>
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</table>
| Branch        | A physical location from which trucks are dispatched. The following types of branches exist in the Sunstate network:  
  - Metro – Hub in a major metro area (central dispatch or command central)  
  - Satellite – Work within a metro region.  
  - Standalone – Run independently and do their own dispatching |
| Contract      | Term may be used interchangeably with Invoices. Is generated when specific equipment number is assigned to a given customer.               |
| HATS          | WebSphere Host Access Transformation Services. With HATS, you can create Web and rich client applications that provide an easy-to-use  
  graphical user interface (GUI) for your character-based 3270 and 5250 host applications. For more info visit:  
| COTS          | Commercial, off-the-shelf is computer products, that are ready-made and available for sale, lease, or license to the general public. They are often used as alternatives to in-house developments. |
| Counter Sales | Sales person at the branch who takes in orders from customers.                                                                           |
| Dispatcher    | Primary user of the system. Responsible for assigning transaction to drivers as efficiently as possible.                               |
| WBI           | WebSphere Business Integration Server helps you to create and deploy new business processes, synchronize business information in multiple business  
  applications on diverse platforms and transform message formats en-route between applications. For more info visit:  
| WBI JDBC Adapter | WebSphere Business Integration Server Java Database Connectivity Adapter. The JDBC API is the industry standard for database-independent  
  connectivity between the Java programming language and a wide range of databases. The JDBC API provides a call-level API for SQL-based database access. For more info visit:  
| Job           | Refers to a specific location that a customer rents equipment to. A single job may have multiple locations associate with it.             |
| Region        | The entire geographic area serviced by a Metro terminal.                                                                                |
| Territory     | Regions are divided into smaller area units known as Territories. In Phoenix the Thomas Bros. Gridlines are used. In the LA market 5-digit zip  
  code are used.                                                        |