

A GEOGRAPHIC INFORMATION SYSTEM
APPLICATION TO VISUALIZE AND MANAGE DATA

by

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Abstract

A geographic information system(GIS) allows an individual to map, model, query, and analyze large quantities of data from a database according to their spatial locations. This project uses the ArcGis Java software Development Kit (SDK) to visualize, manipulate, and comprehend large amounts of publicly available information relevant to a spatial location.

The application developed uses a graphical user interface to examine the public data of Riley County, Kansas. The user is able to load shapefiles through the interface and then examine the many spatial locations. By examining a spatial location the user is able to view the associated attribute information, manipulate it, and add additional attributes. Beyond viewing information at selected geometric locations, a user can also query the layer(s) to return the spatial locations that fit the query. These abilities can allow a user to understand and visualize patterns that they would not have been able to easily see from looking at the raw data. Increasing users' understanding of the environment they are working with improves their likelihood of success in their desired objectives.

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List of Abbreviations

- **Geographic Information System (GIS)**
- **Environmental Systems Research Institute (ESRI)**
- **Software Development Kit (SDK)**
- **Application Program Interface (API)**

Acknowledgments

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I would like to acknowledge and the staff in the Computing and Information Sciences and Graduate School for working with me to get all the required paperwork in. Special thanks goes to Sherie Taylor, a GIS Analyst in the Riley County Information Technology department for providing me with the Riley County GIS data.

Dedication

I dedicate my report work to my family and many friends. A special feeling of gratitude to my loving parents, Mark and MaryJo Wurtz whose words of encouragement and push serve as reminder for all I do in my life. My sisters Rachel & Sarah who have never left my side. Cassie Kuker for her love, support, and reminder to stay on task. Most of all my daughters Kaylee and Mackenzie whose pride and excitement of their dad gives boosts to my spirits

I also dedicate this dissertation to my many friends who have supported me throughout the process. I will always appreciate all their encouragement and support.

Chapter 1

Geographic Information System

A geographic information system (GIS) is a system containing spatial, geographic, and/or temporal data. The information system collects, stores, modifies, interprets, manages, and shows the geographic data. GIS is applied across most industries, throughout government at local levels up to the top levels, in the military, in politics, academia, and the list likely extends to touch most areas where humans are present and beyond. If you have used Google Maps, a navigation application, or used a location based service then you have personally used a GIS application. The power of a GIS is that by mapping information to a location we can better understand that data, how it relates to other mapped data, and understand how the data associated at location changes with time with use of temporal data.

GIS continues a rapid integration into our lives as the internet allows more data to be shared and connected to other data. "GIS technology has been used in recent elections to view voter turnout and determine where politicians should focus their efforts (Hanewicz, 2012)." The candidates' political teams, in reality one candidate better than the other, were able to leverage the power of GIS to efficiently allocate the candidates' time to areas where it would have the most benefit to the success of their campaign. Collection of satellite and weather station data across the world leads to more accurately predicting weather events and finding weather patterns. This understanding of weather has led to decrease in lives lost, monetary savings, and a better scientific understanding of how the world works. This weather data is leveraged by farmers to plan crop planting, by engineers working on water control systems, and by weather reporters to give us a better sense of mind. The GIS application developed for this paper visualizes a large data set of Riley County Kansas. From it we can see address clustering within Manhattan, how bodies of water have directed land development, and many

others patterns by just visually observing the data layers.

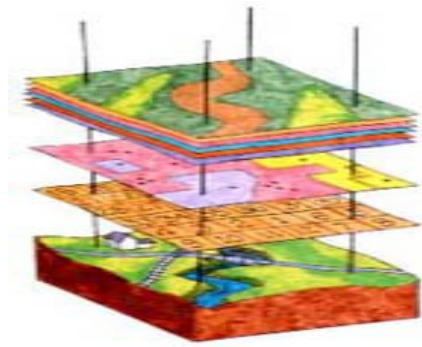


Figure 1. GIS Layers. This figure illustrates a base map and layers. (EPA)

If we look at Figure 1 we can see that the geographic data is made up of layers that are mapped to a coordinate. At the base layer is a map that may be a topographic map that shows contours of elevation, a climate map, a political map, a resource map, or one of many kinds of maps. As we add layers on top of this base map we can start to visualize relationships between each of the individual layers and the base map. We don't need a base map to visualize data as is seen in the GIS application presented in this paper but it is helpful in understanding many situations. If we added a climate layer on top of a topographic map containing contour lines we could likely see how elevation effects climate at various areas, such as a rain shadow. The various layer locations can be thought of as roads, addresses, city boundaries, country boundaries, political regions, etc.

The coordinate system is an important part of a GIS. A terrestrial coordinate system may be a set of of latitude and longitude, geographical coordinates, as seen in Figure 3 or an x, y, and z for three-dimensional Cartesian coordinates. The coordinate system as a set of (x,y), where x y may be (c,r) for Raster grid or (E,N) for a map grid system as seen in Figure 2. A definition of either Cartesian or polar coordinates is used when projecting a map (Maling, 1991).

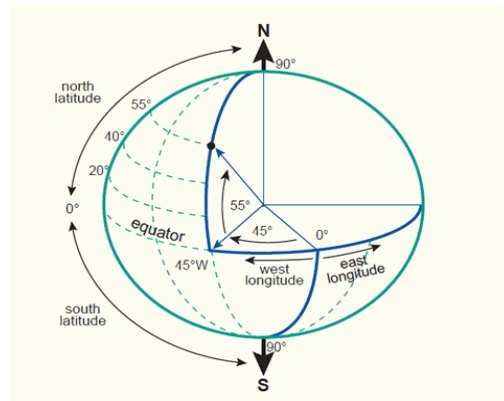


Figure 2. Coordinate Systems. This figure illustrates terrestrial mapping. (Knippers, 2015)

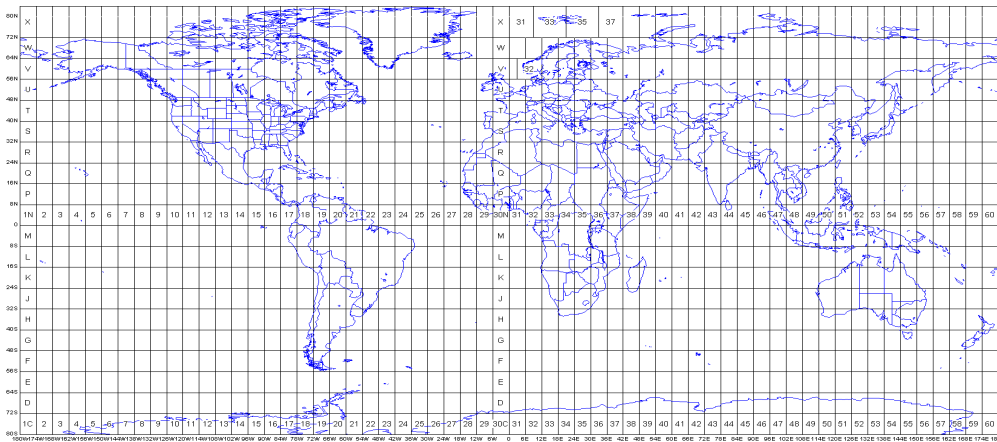


Figure 3. Projections and Coordinate Systems. This figure illustrates a flat map. (Washington.edu)

The projection is important because of storage capacity needed to hold terrestrial coordinates for a large area or trying to approximate a plane grid.

Raster and the vector are two main file format categories used in a GIS. Within those categories there are too numerous of file formats to cover in the paper appropriately. The raster data model consists of single square cells with a single value attached to it. This type of model is useful for representing continuous data or performing map mathematics.

Vector data model is often used for representing geographical features as it is well suited to express geometric shapes. The point, line, or polygon are the three main geometries for the vector model where any other geometry can be expressed by use of these. This model produces better looking and more accurate maps because of the use of various geometries to

represent non-continuous data. The GIS application explained in this paper uses data in a shapefile format which is one of the formats within the vector model. Associated with the geometry features is non-spatial data called attributes. These attributes for instance in the address points shapefile contain the address, the site type, name for non-housing, municipality, and so on. Not only can a layer have a specific geometry at that location but a wealth of information attached to it. As you add more layers a clearer picture begins to develop of all the interrelating data in one small area.

Dr. Roger Tomlinson (1933 -2014) “can be thought of as the father of GIS for persuading the Canadian Government to build the Canada GIS in 1966 (Coppoc, 1991).” Companies and government agencies started to look at the digitization of maps, relating information to addresses, and other small steps in the 1960's and 70's as the processing power of computers increased. As more data became digitized there was a greater focus of relating it spatially. This growth continued to and past to where in “the late 1980's, more than 2000 systems of GIS software... were being sold each year (Coppoc, 1991).” That growth continues to this day as seen in Table 1 and more so as the internet has created a framework to easily share data.

A GIS is more than just a map. It stores data about spatial features, analyzes it, manipulates, and visualizes it together in a one map of many layers. We are already seeing first person perspective GIS's. I believe this data visualization trend in GIS will continue to grow as virtual reality becomes further integrated into our society.

**GIS/Geospatial Industry Growth 2004-2011
Growth Analysis - Software, Services, and Data
Worldwide Revenue Estimates and Forecast**

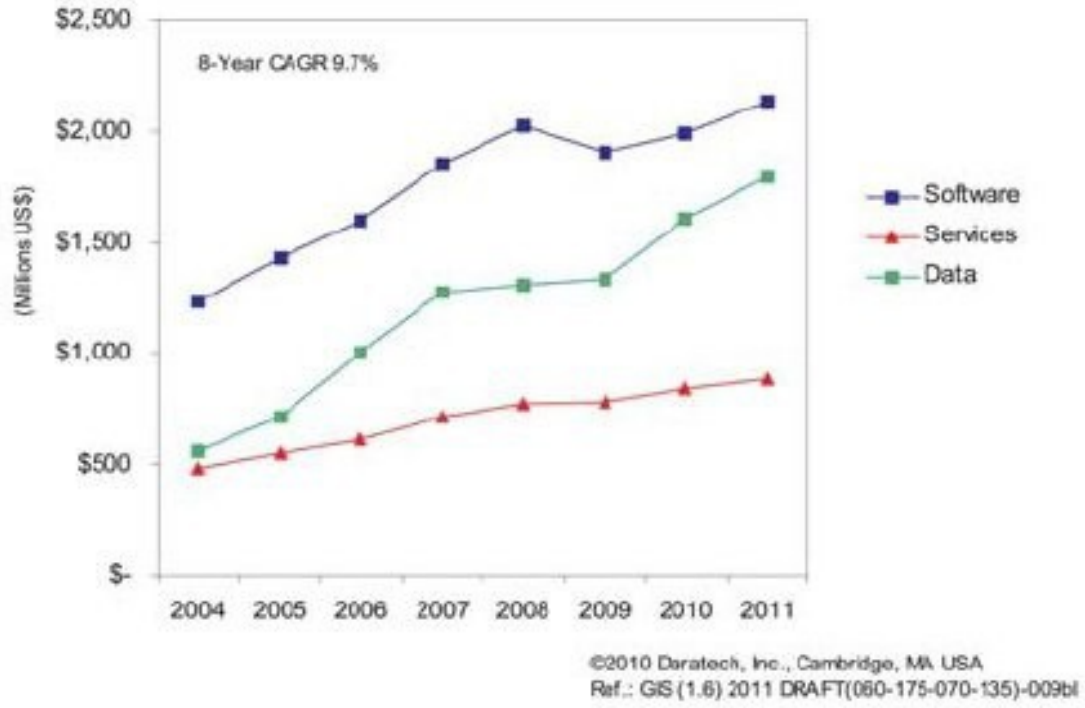


Table 1. GIS/Geospatial Industry Growth 2004-2011. This table illustrates GIS industry growth.

(geospatialworld.net, 2010)

Chapter 2

Data Visualization & Public Data

Data visualization goes back thousands of years “defined as information which has been abstracted in some schematic form, including attributes or variables for the units of information (Friendly, 2009).” “human-computer interaction have created new paradigms for exploring graphical information in a dynamic way, with flexible user control (Friendly, 2009).” As mentioned earlier, mapping information to certain locations helps us to see geographic points, spatial distributions as was used for the candidates campaign, and to find patterns. Viewers of visualized data are able to more effectively understand and use it by abstracting away the more complex parts.

As the internet continues to mature we have a growing access to publicly available data. A large subset of this data is made up of collections of spatial data with attached attributes, which is known as GIS data sets. Many levels of government keep files or databases containing GIS ready data that individuals can then retrieve. A large collection of data was retrieved from the Riley County government for the GIS application described in this paper. That data was in a shapefile format ready to load into the GIS application for viewing.

Chapter 3

Shapefile Geographic Information System Implementation

The GIS application developed for this paper was written using the Java language and the ArcGIS Runtime Java SDK. ArcGIS Runtime is a framework developed by ESRI for developers to develop their own GIS applications. ESRI was founded in 1969 and is the largest GIS software provider in the world. There are many tools you can use within this SDK to perform geocoding, geoprocessing, find driving directions, table relationships, and many other useful GIS tasks. Unfortunately many of these tasks can not be used with the shapefile format.

The shapefile format is developed and regulated by ESRI as a near open specification. It consists of a single fixed length header followed by variable length record(s). Those records have a fixed length header and a variable length content field. The content field is made shape type of the vector and content. The main header has fields for X_min, X_max, Y_min, Y_max coordinates, a z coordinate for elevation, and a m coordinate for temporal state (*ESRI Shapefile Technical Description, 1998*).

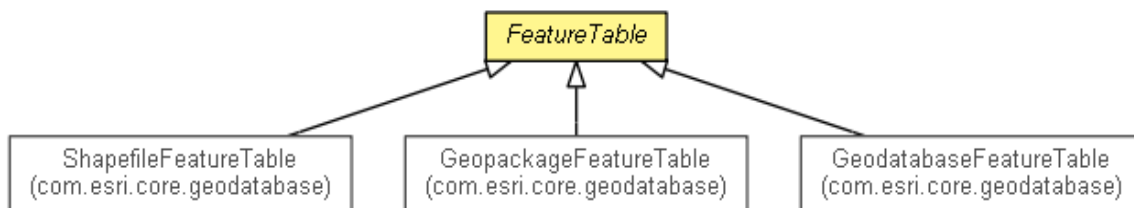


Figure 4. FeatureTable UML Diagram. FeatureTable relationship. (ESRI)

A shapefile file location is passed to the ShapeFileFeatureTable constructor. Looking at Figure 4 we can see the relationships between FeatureTable Classes. This object can only get Features or query Features. The API has listings to add and remove features that are inoperable. They may add this functionality in the future. This ShapeFileFeatureTable is

passed to the FeatureLayer constructor to make the layer that is added to map which allows selection and display of Features. Figure 5 shows the relationships between the Layer Classes. Obtaining a Feature from a layer then allows to get attribute information, stored as hash-map, connected to that Feature. For the application developed in this paper we used ShapeFile Feature's. Figure 6 shows the relationships between the Feature Classes. The user interface provides ability to toggle features, query feature layers, adjust layer ordering, and display the attributes mapped to that feature.

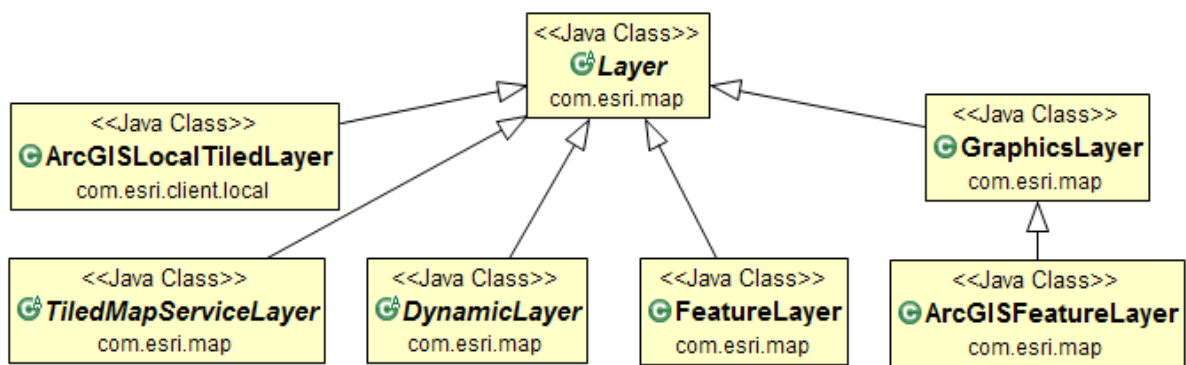


Figure 5. Layer UML Diagram. Layer relationship. (ESRI)

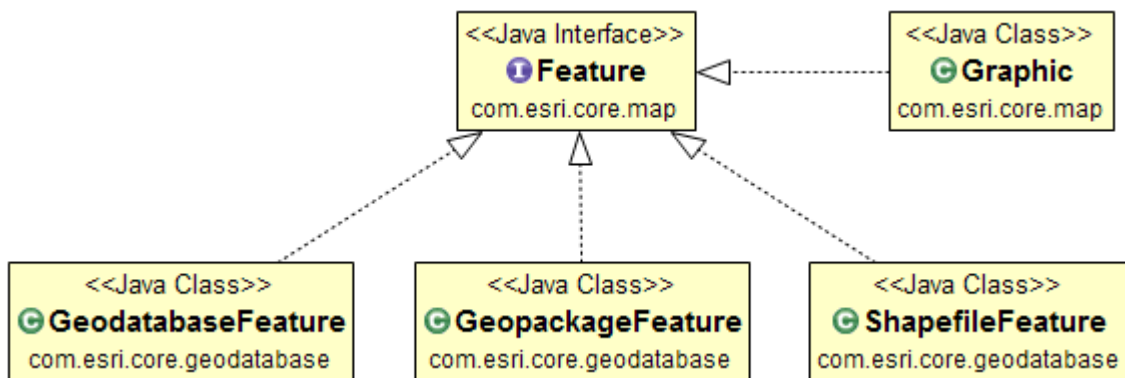


Figure 6. Feature UML Diagram. Feature relationship. (ESRI)

Chapter 4

Conclusion

A GIS application is a powerful tool visualize, manage, and ultimately comprehend how large collections of data layers interact. By contacting various levels of government, searching on the world wide web, or purchasing data sets we can visualize large volumes of GIS-ready data. This visualized data allows a better understanding of the world, can help to discover patterns, provide the information to succeed in endeavors. Unfortunately the ArcGIS Runtime SDK does not provide some of the higher level functionality that you see when using file formats or data streams other than the shapefile format.

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