European Journal of Computer Science and Information System
Vol.3, No.2, pp.13-23, May 2015
Published by European Centre for Research Training and Development UK (www.eajournals.org)

MINERAL RESOURCES MANAGEMENT INFORMATION SYSTEM

Onuiri Ernest E., Ogbonna Akachi E., Alli-Shehu Balogun and Maduakolam Collins
Department of Computer Science, Babcock University, Ilishan-Remo, P.M.B 21244 Ikeja-Lagos Ogun State; Nigeria.

ABSTRACT: *Proper utilization of mineral resources are essential for the economy of a nation to prosper. However, a promising economy like that of Nigeria with all its potentials has continued to struggle due to mismanagement and overdependence on crude oil and perennial neglect of other mineral resources. Regrettably, it seems that some Nigerian citizens are oblivious of the wealth of their nation, in terms of mineral resources coupled with the fact that Nigeria does not have a known viable and comprehensive database for existing mineral resources, which has led to poor foreign and private investment in this sector. The aim of this research is centred on providing awareness, as well as an avenue for efficient management of mineral resources. In view of the foregoing, the guiding principles of the Rational Unified Process software methodology was adopted whereas implemented was achieved with the use of tools like Bootstrap, PHP, MySQL and HTML. Consequently, the system upon completion, created a first-step solution to the problem of mismanagement, by providing a relatively comprehensive database and an avenue for the management of these resources.*

KEYWORDS: *Resources, Management Information System, Nigeria, Mines, Solid Minerals*

INTRODUCTION

Resources can be defined as a reserve of wealth and staff that can be obtained by an individual or an organization in order to function effectively. Natural resources are those supplied to us by nature and they are of three kinds namely; land, mineral and renewable resources.

Natural resources are very essential for the functioning of modern economies, and for attaining and sustaining high standards of living in all countries. The way a nation manages its natural resources will go a long way towards determining the sustainability of its economy (1).

Mineral resources are non-living naturally occurring matters which comprises of solid inorganic matter or petrified organic substance including industrial mineral, valuable metals, which can be discovered both in and on the earth's crust in such form and quantity and of such a grade or quality that it has realistic expectations for cost-effective extraction. The term "Mineral Resource" is also used to refer to any category of naturally occurring solid inanimate elements with a distinctive crystalline form (having the nature of a solid formed by the hardening or solidification of chemicals) and a homogeneous chemical composition. Geological instruments like aerial magnetometer, scintillation counter, bearing plate, rock hammer, blasting cap, auger, Geiger counter, compass and x-ray fluorescence spectrometer are used to generate geological evidences that help determine the location, quality, geological characteristics and their abundance in nature (2).

There are over 40 different types of minerals in Nigeria. Every state in Nigeria has at least one mineral resource and some mineral resources can been found in more than one state. For instance, lead/zinc can be found in Abia, Abuja, Imo, Enugu, Ebonyi, Cross-River, Benue, Bayelsa, Anambra, Akwa-Ibom, Niger, Taraba and Plateau. Minerals like coal, iron ore, limestone, columbite, lignite, gypsum, kaolin, manganese, barite, uranium, salt, gold, bauxite, bismuth, barytes, wolfram, gemstone, emerald, aquamarine, amethyst, sapphire, ruby and crystal exist in the country (3).

A management system is an outline of procedures utilized to ensure that an organization can accomplish all tasks mandatory to achieve its objectives and goals through process optimization. Furthermore, a computerized management system is a software program that is intended to sustain a computer database for the maintenance of an organization's operation in order to ensure optimum efficiency (4). Moreover, a mineral resource management system though not popular, is designed for the exploitation of mineral resources in an intelligent and resourceful manner. Likewise, a mineral resource management system is designed based on the technologies of database, software engineering principles and geographic information (Cheng, Feng & Yu, 2011).

The Nigerian mining sector is underdeveloped and it presently contributes less than one percent to the country's GDP (Gross Domestic Product) (5). Due to the discovery of petroleum, the exploitation of solid minerals has been negatively affected. It has also been noted that foreign investors' assessment of Nigeria's mining sector is not inspiring. For instance, Mr. Adam Kendall, a South African mining expert said that Nigeria was not a significant player in many of the core global mining commodities and that Nigeria was rated very low on coal reserve base because of its poor geosciences data available in the country compared to the U.S, China, Australia, Ghana, South Africa and India. He also stressed that the government should have correct geosciences data which include availability and quality of minerals in the country, in order to attract foreign investors (6). Nigeria does not have any known comprehensive and accurate database on its mineral resources and its reserves. The Nigerian citizens are unaware of the wealth of their nation in terms of natural resources thereby leading to poor investment of the private sector in this area. The aim of this project is to provide an accurate and comprehensive system that contains information about the mineral resources in Nigeria and to help shift the weight of the economy on the already over exploited black gold (oil).

REVIEW OF CLOSELY RELATED WORKS

In the course of this research, systems with some similarities with the proposed system were evaluated. These systems are MineRP mineral resource management, the USGS mineral resources Program and Mines and Mineral Deposit (MINEDEX).

Mine RP RESOURCE MANAGEMENT

MineRP is a specially designed mineral management system software, which was created by MineRP Company to provide an incorporated commercial solution in managing mineral resources, this software allows scheming, optimization and control of mining activities. It has different modules like Common Components, Ore Reserve, Ore Flow, Pegs and Sampling which perform different functions which help with the management of resources. Its benefits include Availability, Product Actuals, Improved communication, Quick feedback and Histogram evaluation.

USGS MINERAL RESOURCE PROGRAM

The United States is one of the largest users of mineral resources and the USGS (United States Geological Survey) Mineral Resource Program (MRP) provides data on research conducted on non-fuel mineral resources, mineral consumption, production and the effects of all these minerals to the environment. They also provide geophysical, geochemical and deposits of mineral data, that could be used to understand environmental concerns on exploration and extraction of minerals as well as the basis upon which to consider how these mineral resources (vis-à-vis exploration activities) interact with their ecosystem that is; how they affect plants, water and other organisms, which is important to keep the ecosystem in a healthy balance. The USGS-MRP also supports how these mineral resources form and how they can be detected. The USGS is not into the mining of mineral resource, The Mineral Resource Program funds research to address two major program functions namely research and assessment and data collection, analysis and dissemination

MINES AND MINERAL DEPOSIT (MINDEX)

MINEDEX is an online system managed by Department of Mines and Petroleum under the government of Western Australia. MINEDEX is database containing up to date and comprehensive information on mines, mineral deposits and prospects in Western Australia. The MINEDEX contains every information including mine sites and deposits, operational status, the location and compilation of mineral resource estimates. The system contains both open files and confidential files. Information on projects and project ownership, mine sites, location data, mineral resource estimates, mineral production, mineralization attributes, commodities and commodity groups, inventory of abandoned mine sites, mine operators and contact addresses and mining proposals for development can be found on the website. The system has the ability to generate mineral production statistics, calculate and store pre-mining resources and the system also provides streamlined searching of information. (7)

METHODOLOGY

The system development methodology that will be used is the RUP (Rational Unified Process). It is a software engineering process that provides controlled methods to allocation of responsibilities. Its target is to provide high-quality software within time and budget constraints. The RUP enhances team productivity ensuring that every member of the team has access to the same knowledge base and that everyone is carried along during the course of software development even though everyone has clearly defined roles. The RUP also encourages the use of UML's (Unified Modelling Language) for clearer definitions of user requirements, architectures and design. Furthermore, it is flexible and configurable and can be used by both small and large development teams (8).

The Rational Unified Process also provides rules, models and tools essential for the team to gain from the following best practices:

i. Develop software iteratively and incrementally: it is not viable to serially express a problem completely, model the solution completely, develop the software and try-out the product after. To create a sophisticated and effective solution, an approach that allows comprehension of the problem and incrementally grow a solution over multiple iterations is required for this project.
ii. Manage requirements using use cases: the concept of use cases specified by RUP makes it easier to describe functional requirements which in turn compel design and implementation, ensuring that the final system fulfils the needs of end users. This research project captures the requirements of end users through the use of use case diagrams.
iii. Verify software quality: poor application performance, lack of consistency and stability are mutual problems with software applications today. RUP has quality assessment inbuilt in every phase of software development. This best practice has also been applied in this research project.
iv. Control changes to software: the RUP embraces the incremental and iterative approach to software development; therefore changes will always be made till the perfection of the software. Change control helps to manage and track changes of the whole development process.

ENTITY RELATIONSHIP DIAGRAM

An entity relationship diagram abets the discernment of an organization's data requirements and can also serve as a schema diagram for the required system's database. It is the graphical representation of the organization of data in a database or the logical structure of a database (See Figure 1).

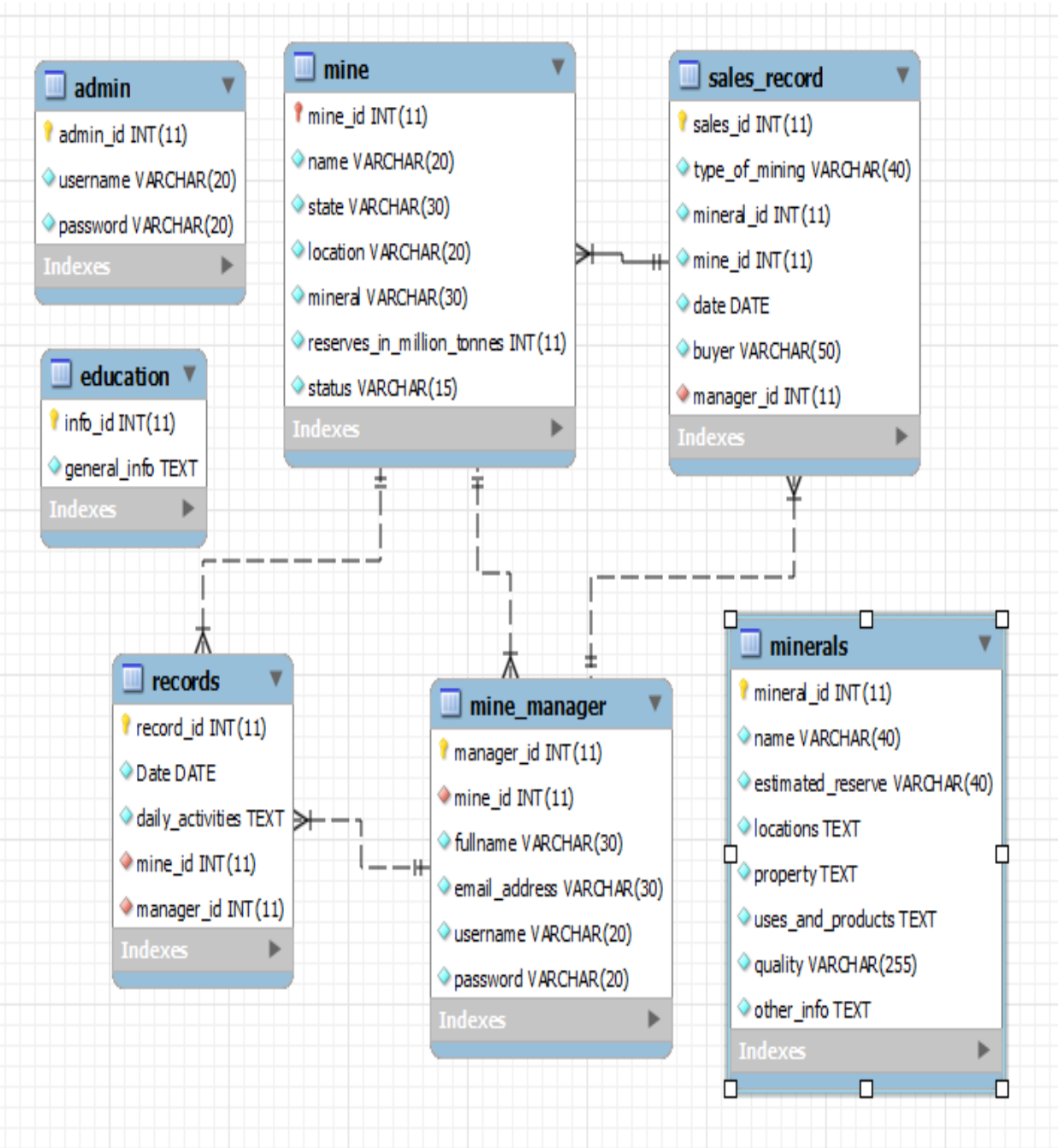

Figure 1: Entity Relationship Diagram for the proposed system

HARDWARE AND SOFTWARE REQUIREMENTS

Hardware and software requirement are the specifications that a hardware or software must meet or have to be able to run the proposed system or application.

HARDWARE REQUIREMENTS

The hardware requirements are:

i. 4GB RAM
ii. 2.20GHz processor
iii. Internet connection

SOFTWARE REQUIREMENTS

The software requirements are:

i. An operating system
ii. A web browser
iii. Database server

SYSTEM IMPLEMENTATION AND TESTING

System implementation is simply the building of a new system that uses the construct formed and results derived from system design and analysis to create systems that meet the user and system requirements elicited in the requirement gathering phase of the SDLC (9)

DATABASE TESTING

A database can be defined as a set of organized data or records which could contain one or more fields that describe an entity (10). Our database consists of 7 tables and each table has its respective fields and constraints that describe each table.

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	admin_id	int(11)			No	None	AUTO_INCREMENT	Change Drop Primary
2	username	varchar(20)	latin1_swedish_ci		No	None		Change Drop Primary
3	password	varchar(20)	latin1_swedish_ci		No	None		Change Drop Primary

Figure 2 Admin table

Figure 2 shows the admin table which contains the login details for the admin users. The table holds information such as the admin_id, username and password for every administrative user. This is the table that is checked when an administrative user attempts to login.

#	Name	Type	Collation	Attributes	Null	Default	Extra
1	info_id	int(11)			No	None	AUTO_INCREMENT
2	general_info	text	latin1_swedish_ci		No	None	

Figure 3 Education table

Figure 3 represents the education table holds extra information asides from the mineral information that the admin users would like to share with the public users. It comprises of the info_id and the general_info fields.

#	Name	Type	Collation	Attributes	Null	Default	Extra
1	mine_id	int(11)			No	None	AUTO_INCREMENT
2	name	varchar(20)	latin1_swedish_ci		No	None	
3	state	varchar(30)	latin1_swedish_ci		No	None	
4	location	varchar(20)	latin1_swedish_ci		No	None	
5	mineral	varchar(30)	latin1_swedish_ci		No	None	
6	reserves_in_million_tonnes	int(11)			No	None	
7	status	varchar(15)	latin1_swedish_ci		No	None	

Figure 4 Mine table

Figure 4 shows the mine table which holds details of each mine. It includes of fields like mine_id, name to represent the name of the mine, state to represent the state where it is found, location to represent exact location of the mine, mineral to represent the mineral found in the mine, reserves_in_million_tonnes to represent the amount of reserves found in the mine and the status of the mine representing if the mine is active or inactive.

1	mineral_id	int(11)			No	None	AUTO_INCREMENT
2	name	varchar(40)	latin1_swedish_ci		No	None	
3	estimated_reserve	varchar(40)	latin1_swedish_ci		No	None	
4	locations	text	latin1_swedish_ci		No	None	
5	property	text	latin1_swedish_ci		No	None	
6	uses_and_products	text	latin1_swedish_ci		No	None	
7	quality	varchar(255)	latin1_swedish_ci		No	None	
8	other_info	text	latin1_swedish_ci		No	None	

Figure 5 Mineral table

Figure 5 shows the mine table which contains fields that describes each mineral resource.

1	manager_id	int(11)	No	None	AUTO_INCREMENT
2	mine_id	int(11)	No	None	
3	fullname	varchar(30) latin1_swedish_ci	No	None	
4	email_address	varchar(30) latin1_swedish_ci	No	None	
5	username	varchar(20) latin1_swedish_ci	No	None	
6	password	varchar(20) latin1_swedish_ci	No	None	

Figure 6 Mine manager table

Figure 6 shows the mine manager table which contains the login details as well as other details of the mine managers.

1	record_id	int(11)	No	None	AUTO_INCREMENT
2	Date	date	No	None	
3	daily_activities	text latin1_swedish_ci	No	None	
4	mine_id	int(11)	No	None	
5	manager_id	int(11)	No	None	

Figure 7 Record Table

Figure 7 shows the record table that keeps record of the daily activities of each mine. It has the mine_id and manager_id as foreign key constraints to trace back the mine that has this record as well as the mine manager that recorded it.

1	sales_id	int(11)	No	None	AUTO_INCREMEN
2	type_of_mining	varchar(40) latin1_swedish_ci	No	None	
3	mineral_id	int(11)	No	None	
4	mine_id	int(11)	No	None	
5	date	date	No	None	
6	buyer	varchar(50) latin1_swedish_ci	No	None	
7	manager_id	int(11)	No	None	

Figure 8 Sales_record table

Figure 8 shows the sales_record table which is specially designated to record sales of mineral resources.

INTERFACE TESTING

Interface testing is usually carried out to determine if the various components of the system tallies with specified requirements (11). The interface testing shows that the mineral management system has passed data and control correctly that is it meets the necessary specifications outlined. It assures that all the connections between the interface and the database are accurate.

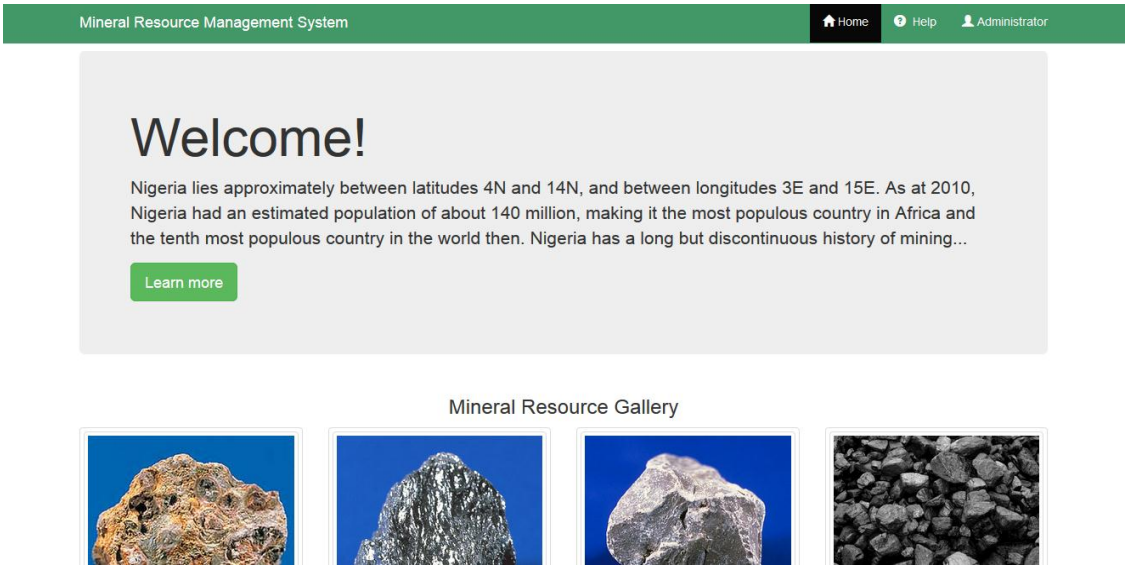

Figure 9 Home Page

Educational section

This is the part of the system that will consequently be updated by the admin user. It is used to educate the general public on what minerals are available in the country, their locations, quantities, and their qualities, it also has a section that contains links to other sites where information can be obtained.

Admin login page

The administrator login page is where the admin is validate and granted access to the administrators page, if the details are incorrect it displays an error message 'username or password incorrect' and provides the opportunity for the Admin to retry logging in multiple times until both details are correct.

Admin Home page

The administrator can view and edit what the public users can see, add and delete mine managers and change his password as well.

Mine manager login page

The mine manager login page is where the manager is validated and granted access to his page, if the details are incorrect it displays an error message 'username or password incorrect' and provides the opportunity for the manager to input it multiple times until both details are correct. The system also allows the mine managers change their login details. The managers are specifically assigned a particular mine in which they manage. They also get RSS live feeds that allows them to make decisions based on occurrences around the world, edit his daily record based on what happens on a day-to-day bases and also input and edit record sales.

DISCUSSION OF RESULTS

In the course of this research work, we realized that building a system the proper way can be a very tasking activity. Though the aim of this project was partially fulfilled, we have been able to develop a system that provides a relatively comprehensive repository of information and a system that will assist the economy if properly implemented.

The system design combines user-friendliness with a simple and beautifully designed interface. The RSS-feed incorporated into the system makes it unique when it is being compared to other mineral resource management systems. Since the system is built for the country, it uses the country colours as its theme. The system also embraces the mobile-first approach to design

FUTURE RESEARCH

This research work exposed us to different mineral resource management systems and to further augment the current systems, the following should be implemented to improve adeptness

i. Implementing a spatial database. A spatial database is special kind of database specially designed to store data that defines a geometric space. These data are frequently associated with geographic locations and features. Spatial databases store data as coordinates, points, lines, polygons and topology and some can handle more complex data like three-dimensional objects, topological coverage and linear networks (12). This kind of database will help to keep a better record of the mineral resources in the country.
ii. Improved scientific data on the mineral resources. Extensive scientific research should be carried out on the mineral resources in the country. Since information is power, having more information will assist the exploitation of these resources.

REFERENCES

1. World Trade Report. 2010, p. 70.
2. Barrick Gold Coporation. Mineral Reserves and Mineral Resources. 2012.
3. Federal ministry of Information. Nigeria Natural resources. *Federal Government of Nigeria.* [Online] 5 November 2012. [Cited: 24 March 2014.] http://www.nigeria.gov.ng/2012-10-29-11-05-46/2012-11-05-09-52-15.
4. Janssen, Cory. Enterprise: Computerized Maintenance Management System (CMMS). *Techopedia.* [Online] 2013. [Cited: 3 April 2014.] http://www.techopedia.com/definition/25281/computerized-maintenance-management-system-cmms.
5. National Bureau of Statistics. *Gross Domestic Project of Nigeria.* Abuja : Federal Government of Nigeria, 2013.
6. Sule, Fatima. NEWS ANALYSIS: Developing solid minerals sector to enhance economic growth. *News Agency of Nigeria.* [Online] 3 January 2014. [Cited: 28 March 2014.] http://www.nanngronline.com/section/features/news-analysis-developing-solid-minerals-sector-to-enhance-economic-growth.
7. SRA Information Technology. Our Customers. *SRA Information Technology Website.* [Online] 29 September 2010. [Cited: 26 June 2014.] http://www.sra.com.au/Our-Customers/Managing-WAs-Mineral-Wealth/.
8. Rational Software Corporation. *Rational Unified Process Best Practices for Software Development Teams.* 2003. p. 21.
9. SEBoK Authors. Systems Implementation. [Online] 22 April 2013. [Cited: 3 March 2015.] http://sebokwiki.org/w/index.php?title=System_implementation&oldid=48168.
10. LINFO. Database Definition. [Online] 22 June 2006. [Cited: 12 March 2015.] www.limfo.org/database.html.
11. Rouse, Margaret. Definitions: GUI(Graphical User Interface). *TechTarget Website.* [Online] February 2014. [Cited: 18 March 2015.] http://whatis.techtarget.com/definition/GUI-testing-graphical-user-interface-testing.
12. Janssen, Cory. Spatial Database. *Techopedia.* [Online] 2012. [Cited: 5 March 2015.] www.techopedia.com/defination/17287/spatial-database#.
13. TechTarget. What is use case diagram? - Definition from WhatIs.com:. *whatis.techtarget.com.* [Online] 1999. [Cited: 23 August 2014.] http://whatis.techtarget.com/definition/use-case-diagram.