A CIS Framework for Libyan District

Amal O. Abdulghader
College of Computer Technology
Zawia, Libya
amal_osaad2003@yahoo.com

Khari A. Armih
College of Computer Technology
Zawia, Libya
khari.armih@gmail.com

Rabia Omer A. Saad
Libyan Center For Remote Sensing & Space

Abstract

In the last decades, the proliferation of digital data and the availability of digital map, and the use of geographic information system (GIS) has become the best technique to develop the cadastral information system (CIS). The digital cadastral database (DCDB) that shows real coordinates for cadastral maps is hampered by many land laws in the country. We present a new Framework for developing CIS applications to assist real estate registration. The new framework can be used as a guide to developers helping them in creating a plan of development and defining the system requirements. A cadastral web mapping solution for a Libyan district (CWMSLD) is developed using the proposed framework. CW-MSLD System based on a pilot case study in the capital city of Libya. The prototype is developed using modern GIS techniques (Web Mapping). Web Mapping techniques make maps and geo-information available to groups of end users through a web page. The prototype tool triggers the map server software which integrates the map data stored in DCDB with the land register data stored in the database. The information derived from the

system can be used to register or transfer ownership for the cadastral map and further issue a cadastral certificate for the registered cadastral (real estate).

General Terms: Algorithms, Design
Keywords: GIS, Cadastral, Digital Mapping, Framework, Land Registration

1. Introduction

A GIS is a computerised system for storage, retrieval, manipulation, analysis, and display of geographically referenced data [2].

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. As an information system (IS), GIS is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for spatially-referenced data, as well as a set of operations for working with the data [10]. The development of GIS is older than you may think. It started from 1960s in Canada [11]. GIS developed layers, overlay calculations, data structure, scanning as data entry and so on for land resources. Furthermore during the same year, U.S. Census developed digital enumeration districts and geo-coding for address matching in commercial area, and ESRI created in 1969 as one of the most successes software company in the world. As seen by today, the use of GIS grew strongly and fast in different applications like business, government, and academic.

Cadastral system is one of the GIS applications that can be successfully developed by using GIS techniques. Cadastral refers to a map or survey showing administrative boundaries and property lines [9]. Cadastral information system (CIS) is a system that consists of two sub-system i.e cadastral map system and land register system. A cadaster administration is very important for the owners to register and get a certificate for their own specific property or cadastral. The government would use this information and use the outputs from

cadastral and land registry system as input for other projects like water supply and highway projects.

The possibility of using geographic information system (GIS) techniques have generated wide interest in cadastral system, and many countries have developed digital cadastral maps by using GIS techniques known as digital cadastral databases (DCDB). However, this DCDB needs application software to add, update, delete, and search query in this database. This mean the application software will enable the map modification work to be carried out in more easily and efficient manner using DCDB.

Current cadastral work in Libya is carried out manually and this has led to a number of serious problems resulting in legal battles for ownership of land titles. Title/deeds reported as being lost have been re-created resulting in having duplicate files for a signal cadastral (real estate). Furthermore, the current manual system does not support and track updates.

In this paper, we propose a new framework for Cadastral information system. We also present a practical and functional prototype e-tools based on a Cadastral Web-Mapping Solution for a Libyan district (CW-MSLD) to assist real estate ownership registration.

2. Related Work

Several frameworks and techniques have been proposed to develop CIS systems and applications. Here we compare and describe a number of existing CIS projects.

2.1 LR&CIS

Turkey has developed the Turkish cadastral automation system [5]. The most important goal for developing Land Registry and Cadaster Information System (LR&CIS) was to improve the services by computerizing the system and make land information system (LIS) to be multipurpose in order to help other organizations by given accurate

and reliable data and information. Turkish Cadastral Automation System had been developed by using ArcIMS 2 public web services from ESRI. That system was used by the General Directorate, Ankara Regional Directorate in Turkey. In conclusion, Turkey has a complete LR&CIS integrated system. This system was bought with high cost but gives a lot of services and saves time in different organization in the country. ESRI technology has been used very successfully in cadastre side, ArcSDE for managing the cadastre data at the center of system, and ArcEditor 5 for all cadastre activities in harmony with the land registry side. ArcIMS is used for serving data via Internet for external user. Thereby, the most important LR&CIS benefits are having a central database have a backup for data, easy and faster to access data via the Internet and no damages for original documents in the digital archives. External users can access the system and get services like zoom in, and zoom out the map, pan and access and display data. LR&CIS system is one of most important part of Turkey's e-government structure. This system is not complete yet for covering all Turkey's parcels.

2.2 ECIM

The Egyptians had been well known for their maps in ancient times. They had drawn maps on parchment to show the gold mines at Coptes during the period of 1292 B.C. - 1225 B.C [3]. Egypt is one of the first countries which tried to manage cadastral by enforcing rules and regulations for that. The Egyptian Survey Authority (ESA) had started in 2002 to develop The Egyptian Cadastral Information Management (ECIM) project supported by the Ministry for Foreign Affairs of Finland [6]. The most important aim for ESA/ ECIM was to have a complete computerized system which included digital LIS based on cadastral data. The ECIM project developed a system which integrated the existing ESA, Real Estate Publicity Department (REPD), and Real Estate Taxation Department (RETD). ECIM project is an automated system which enabled the monitoring of various day-to-day activities

between various offices. The ArcSDE technology incorporated into ArcGIS 6 server is used to access multi-user geographic databases. The area was chosen Damanhour district in Beheira province, and it is a rural area which is approximately 160 km2. Oracle, ArcSDE, ArcCadastre 7, and MapObjects 8 and Visual Basic were used to develop the system. After the pilot study was successfully implemented, the ESA continued to develop the system that it could be applied nationwide. However, the cadastral and land registration system is in fact more complex and has unclear procedures. The ECIM project had highlighted a number of problems in the existing systems during the long analysis phase. ECIM project has worked hard to understand cadastral procedures, land registration legalities, and how to calculate tax for parcels or other objects. The biggest problem was how to integrate and connect four organizational levels and how data is transferred between them. The most important ECIM project output is the Unified Cadastral Database (UCD), which combines the map data with the attributes. UCD is designed based on user requirements. There are many functions that had been included in the system like continuous and automatic updating cadastral work, monitoring and printing out different map outputs, reports and statistics, converting data from analogue to digital, de-centralizing the system and achieving synchronization which co-ordinates between four organizational levels. In conclusion, ESA has developed a web application which handles the publishing of geographic and tabular information via the Internet using ArcIMS (Internet Mapping Server) from ESRI and published information could be accessed by ESA's regional offices or other stakeholders. This project brought many benefits, not only for ESA but also for the society and government. It had been tried to solve informal registration problems in Egypt. ECIM project will increase the social security by using a digital database and it is possible to standardize products in a more efficient way with lower cost. This could attract more customers and hence increase the income, and provide faster delivery services to customers. Other

benefits of the ECIM project is the improved office environment, the digital storing media takes less space than the analogue environment of storing.

2.3 GIS-Sofia

GIS-Sofia Ltd [4] in Bulgaria had developed a new cadastre and property register for Sofia Municipality. The development of an Information System of the Cadastre (ISC) was used for the territory of the Sofia capital city. This project had integrated the registry and cadastre offices. A prototype of the ISC project had been developed by using ArcView 9, AutoCAD Map R 4.0, and SQL Server. In order to develop any system, we first need to understand the laws and regulations in the system environment. Bulgaria had updated the rules and data exchange between registry and cadaster offices in April 2000. Bulgaria started working on developing the ISC from 1987, with digitization cadastral maps. Gradually the integration between attribute database and geographic data was initiated. Sofia completed its digitization by using Arc/Info 10 3.5 and established its attribute database in 1996. Cadastral mapping in Sofia is maintained in two scales: 1: 1 000 for urban area, and 1: 500 for the compact city only. In 1998, GIS-Sofia started updating its digital map base starting from nationwide Sofia city and finished the task in the summer of 2001 by giving the unique identifier for each cadastre object. The project team started work on a pilot study first where property was identified. The property verification work was identified and some techniques and procedures were developed to solve these problems. Finally, the GIS-Sofia completed digitizing about 133000 properties and 242000 buildings. The next step was to link cadastral data (graphic data) to relevant data from ownership (attribute data). Input correction and carrying out information searches was done by using registration software. GIS-Sofia developed the ISC web-based system and the ISC prototype consists of three parts namely ISC center, Library of function and User Interface. SQL Server at ISC center integrated and

managed the different parts. GIS-Sofia created an efficient environment to protect information which is not only important to cadaster and registry office but useful to a lot of customers. The digital information was used to develop and build the city. The digital cadaster used in design works for underground project, water supply and sewerage project, and the Bulgarian telecommunication company. However, GIS-Sofia had been updating urban cadastral information system by adding 3D Visualization using remote sensing and GIS. GIS-Sofia used ArcView software for collecting data needed to obtain 3D buildings. They used specific tools to represent 3D buildings to reach the most geometrically correct and real looking three dimensional objects. The geometrical accuracy is very important in cadastral application. The use of aerial- photo provides higher completeness of information, but is considerably more expensive [1]. In conclusion, the information and outcomes from this project is very important to a lot of organization in Sofia city. GIS-Sofia did not stop at this point but they are trying to design technology and applications for furnishing information from the database via Internet and thereby increase the quality of their services.

2.4 DSMM

The department of survey and mapping Malaysia (DSMM) has been looking for other countries experience and experimentation in developing cadastral system. DSMM started strong with cadastral reform and coordinate cadastre [8]. In 1986, the first pilot project was done in Johor state and it created for the DCDB at a scale of 1:4,000 and the first pilot project was successful. The next project was implemented in Penang State in 1993. Based on both these projects, cadastral reform had been done for Peninsular Malaysia in 1995 where a connection network was implemented. A survey accurate DCDB and coordinated cadastre should not be created without fully understanding the place it holds and the effects it has on the operation of the cadastral system [12]. All reforms to introduce a survey

accurate DCDB and an improved cadastral surveying system (collectively a coordinated cadastral system /coordinated cadastre) go hand in hand with reforms to the wider cadastral system including reforms to the title registration system. The model proposed for coordinated cadastre is based on a complete DCDB. The accuracy of data acquisition is very important for cadastral survey. Many devices helped the surveyor in their work like Digital Theodolite, Total Station, Digital Level, Global Positioning System (GPS) and Digital Photogrammetric. Nowadays, the District Survey offices are using GPS and it increases survey accuracy, productivity, and reduces costs. The DSMM is collaboration with University of Technology Malaysia (UTM) to determine the feasibility of introducing a Coordinated Cadastral System for Malaysia, and find best techniques for integrating cadastral data with attribute data. In conclusion, it can be deduced that acquisitions, collection, and conversion of analog data into digital format are though very important, it is a time consuming job in building a computerized information system, DSMM has been restructured in 1994 to face new challenges more effectively by using new technology in the field of survey and mapping. It will have a strong base to develop cadastral information system by using GIS technology. To look more closely, DSMM is now better set to meet the challenges of the nation's Vision 2020 which is in the process of establishing an "Electronic Government".

2.5 Summary of the Cadastral Projects Reviewed

Table 1 shows the main properties for four projects which the author has investigated.

Table1: Summaries of the Cadastral Projects Reviewed

Country / properties	Turkey	Egypt	Bulgaria	Malaysia
Land registration	Deeds	Registration of deeds until 1975 Registration of title since 1976 (80% has been done)	Deeds	Title
Projects services	Regional Directorates land registry offices cadastre offices	Egyptian landowners and relevant authorities	Registry Office Cadastre Office	Department of Survey and Mapping (DSMM)
Survey coverage Completeness	cadastral survey of 97 % of urban areas and 77 % of rural areas end of 2005	Governorate of Beheira, Egypt 54 village	Complete digitizing about 133000 properties & 242000 buildings for Sofia city	two cities were surveyed: Johor, Penang
Technology used & Tools	ESRI technology (ArcEdit, ArcSDE ArcIMS, and ArcCatalog) SQL server VB,C++ and Delphi	Oracle, ArcSDE, ArcCadastre, and MapObjects	Visual Studio environment , Avenue language ArcSDE ,Arc/Info AutoCAD MAP SQL Server Windows NT 4.0 environment Linux Red Hat 7.1 Environment	Global Positioning System (GPS)
Method or approach	"Cadastre 2014" approach	object-relational data model	Object-relational data model	"Cadastre 2014 " approach
Significant improvement	Website design	Full integrated project, Multipurpose Connected 3 applications	Website design	Land reform & established DCDB Coordinated cadastre GPS control network
Other comments	Not complete yet	Completed in August 2006 with Project financing :1 million euros	3D Cadastre under study	The project still under development

3. Proposed Framework

The first step in investigating trends and proposing framework, we looked at the existing four cadastral systems project and attempts to define and organize the system requirements for developing a cadastral system. A general framework diagram is shown in Figure 1. It is proposed by defining the eight elements that all cadastral system shares and it further defines the recent management tools and techniques used for design and development of cadastral information system. Basically, the framework identifies the relationships between the eight elements of the framework with one another.

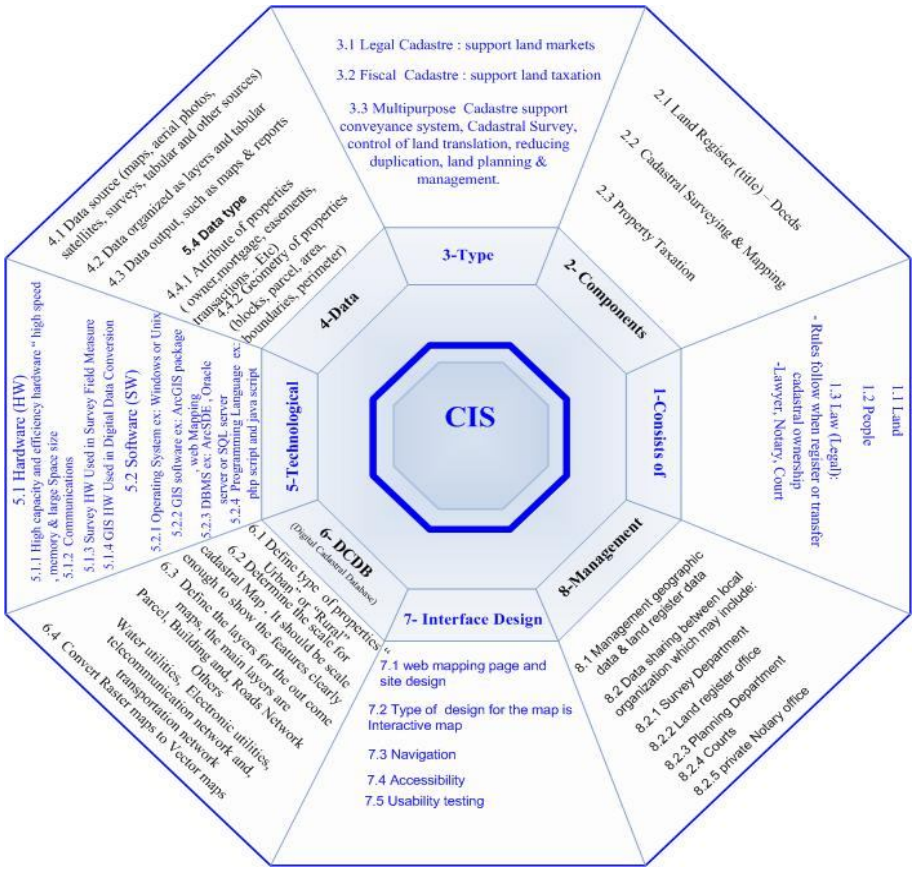

Figure 1: Cadastral Information System (CIS) Framework

First, the developer needs to define the type of CIS based on user requirements and feasibility study for the project where each cadastral system mostly consists of land, people, and legal procedures that need to be followed.
Second, the developer needs to select the components based on the type of CIS. For example, if the developer wants to develop the legal cadastral system, then the land register, cadastral surveying and mapping components ought to be selected.
Third, the developer needs to capture the necessary data and subsequently select the appropriate software to create the DCDB by digitizing the maps data. For interface design element, the developer needs to use web mapping to fulfill sound GUI requirement. Next, management element needs to organized and next you need to establish the land register, cadastral surveying and mapping data between different departments inside the cadastral office and outside the organization.

3.1 Elements of proposed CIS Framework

The eight elements for the proposed GIS framework as listed below:

- *CIS Consists of*: CIS consists of land (location), people (landowner) and law (rules to register and certify the ownership for owner). Landowners users are key components in providing data for CIS. Lawyers and notary users are responsible for certifying the ownership and survey users support the cadastral system with cadastral survey data.
- *Components of CIS*: CIS components are land register (title/deeds), cadastral surveying and mapping, and property tax-ation. Each component is a subsystem in CIS and it provides the CIS with specific data. The combination between the three components is used to carry out all registration operations and contracts on land rights.

- *Type of CIS*: There are three types of CIS namely legal cadastre, fiscal cadastre and multipurpose cadastre. The type of CIS used in the early stage of development defines the system domain and services.
- *Data*: Data requirements must be defined - thinking ahead to future policy developments. CIS includes two types of data which are land register data and survey cadastral data (spatial data). The spatial data can be captured from different resources (i.e. field survey, remote sensing, GPS, aerial photos). The output data for CIS can be maps, tables and reports.
- *Technology*: CIS require high capacity hardware and network infrastructure (ICT) to enable CIS to be accessed by different users on related organizations. The required development software for CIS is GIS software (i.e ArcGIS,Web Mapping, ArcIMS ..etc). The GIS software can be integrated with some programming language such as PHP and Java and the database used includes SQL Server and MySQL. This integration between GIS software and programming language helps to develop all user requirements. The technology should support:
  - Security, reliability, continuity of service.
  - Distribution, publication of data.
  - Use of remote access (public or private).
  - Data convergence issues.
- *Digital Cadastral Database (DCDB)*: Analogue cadastral data is computerized and store as DCDB. DCDB can be created by digitizing the cadastral map (convert raster maps to vector maps). The map scale should be defined based on the features required for digital map. DCDB allows to store the maps in different layers (i.e. parcel layer, building layer ... etc).
- *Interface Design*: GIS techniques support great interface design to CIS. The users can interact with cadastral map to get cadastral information. Web mapping is a new technique that

supports web map design. System accessibility and usability is tested interface design for the CIS.

- *Management*: Management data is most important issue for CIS. DCDB would improve the management capabilities of cadastral data. The data can be shared between survey departments, land register offices and others organization based on type of CIS that is developed.

3.2 Methodology

The CW-MSLD System prototype is actually a legal cadastre system and the component for this system includes land register (title/deeds), cadastral surveying and mapping. The GIS technology will be used to develop this system and the interface design where web mapping occurs by using open source software. In addition to these is Arc/Info software that is used for creating DCDB. There are two important benefits for using CIS framework. First, it is considered as a guide to developers helping them in creating a plan of development and defining the system requirements. This can be seen on design of the CIS framework as eight elements with specific properties. The developer can implement the eight element sequence to reach the desired goal. The second benefit is the ability to define data types. As mentioned before, the cadastral system integrates between attribute data (owner data, mortgage... etc) and spatial data (parcel, area ...etc). The CIS framework defines in shortly data type, data source, and data organized in data element (Element 4) and also points the steps for creating DCDB for the spatial data in DCDB element (Element 6).

3.2.1 Prototype Development Tools

Tool is a computer-based application which supports the use of a modeling technique. Tool-supported modeling functionality includes abstraction of the object system into models, checking that models are consistent, converting results from one form of model and representation to another, and providing specifications for review.

- **Arc/Info** is the complete GIS product to build a comprehensive desktop GIS. As a de facto standard for GIS professionals, ArcInfo provides tools for data integration and management, visualization, spatial modeling and analysis, and high-end cartography. It supports single-user and multi-user editing and automates complex workflows. This software is from ESRI and it used to gather, build, manage data, and analyze geographic relationships, discover new information, and produce publication quality maps for cadastral office which can be used as cadastral index map.
- **MapServer** is a CGI program that sits inactive on your web server [7]. When a request is sent to the MapServer, it uses information passed in the request URL and the map file to create an image of the requested map. The request may also return images for legends, scale bars, reference maps, and values passed as CGI variables. It is open source software. It can be greatly extended and customized, and it can be built to support many different input data formats and output types.

3. CW-MSLD implementation

System implementation describes the development tools that have been used in developing this system. The guidelines for using the CW-MSLD System will be given. The system developed as web mapping page makes use of the map server and PHP as the core programming language techniques. Besides that, the JavaScript and Rosa Applet have been used to help the system interfaces become more interesting and easy to use. For example the Rosa Applet tools used image button tools that help the user interact with the map in easy ways such as ZOOM IN, ZOOM OUT etc. The RDBMS used to build attribute data for this system is MySQL and for the map data (geographic data) are stored in three types of files that relate with each other to produce the vector map such as parcel layer. The merge between the attribute data

and map data is done by using map server techniques. Table 2 shows all available features in CWMSLD.

Table 2: CW-MSLD System Features.

No	Statement	Available
1	Administrator able to add new user to login to the system	√
2	Access control for authorized user to login to the system	√
3	Administrator able to monitor the login users to system	√
4	Working with real coordinates map	√
5	Use the map to get requested parcel	√
6	The system able to register the parcel not included on the map	
7	Updating certificate information before issuing certificate	√
8	The system able to register a whole cadastral (parcel/building)	√
9	The system able to register subdivides cadastral (parcel/building)	
10	The system able to transfer ownership for registered real estate	√

4.1 System Security

The system security is very essential to this system especially when the system is running on the internet environment network. Users are grouped into three groups. At the highest level is the system administrator and second level or group is the manager and the last group members are the registered staff users. Valid user ID and password are required whenever a user access the system. This is to prevent unauthorized users from using the system.

4.2 CW-MSLD System Implementation

The system actually has three types of users which are manager, staff and administrator. The Figure 2 shows the system modules tree based on users type.

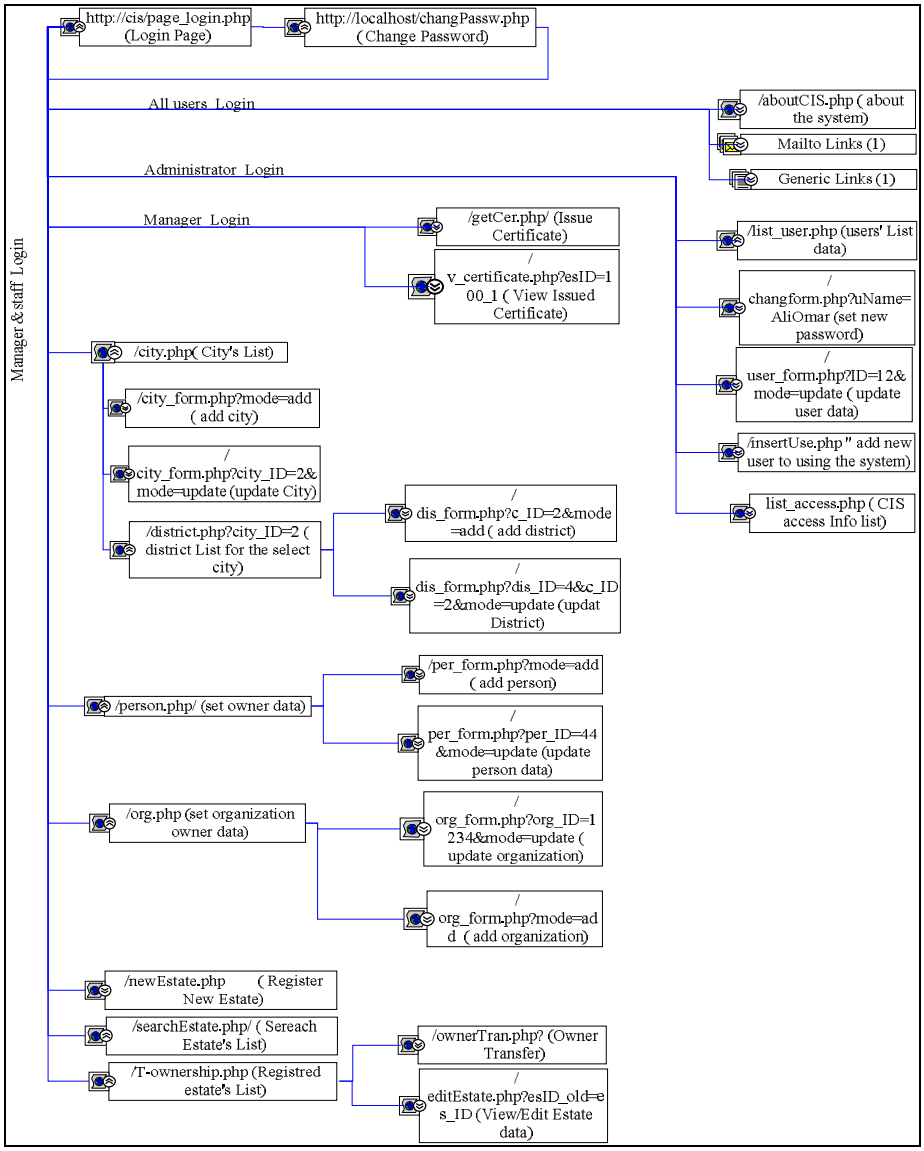

Figure 2: System Modules Tree

4. CW-MSLD Evaluation

Here we illustrate the system testing and implementation phases. The testing phase involves some modification to the pervious design phase and system testing has been done to minimize the programming and system error. At the implementation phase, system requirements such as hardware and software will be defined. Besides that, the system prototype interfaces and functionalities (module) will be fully demonstrated to users.

5.1 System Testing

Testing the system is a very important stage to ensure that all system requirements have been developed without errors. System testing can be done through some stages. The first stage is called unit testing or component testing and this testing done during the development of the system. Each component, script or module test isolates from other component or unit by checking the input and output for it. The second stage is called integration testing. The integration between components will be tested and in case there are any errors the components will be tested again. The third stage is called user acceptance testing and this testing done by users who request to develop the system. The third stage is called security testing. The final stage is called user acceptance testing and this testing done by users who request to develop the system.

5.1.1 Unit Testing

Unit testing focuses on testing module, script or component that has been designed by PHP, JavaScript, or Rosa Applet. For example, the developer tested the map tools button functionality such as Zoom in on a map or obtain information when clicking on the map by using Identify button that is designed by using Rosa Applet.

5.1.2 Integration Testing

After the unit testing has been done with satisfaction for each component or script, the integration testing is started to ensure the CW-MSLD System components worked together smoothly. The functional and non-functional requirements were tested in this stage. One example for integration testing is to search the parcel model by entering the parcel ID and if the GIS database has the parcel requested, the system will display it and it can use the data given to register new real estate.

5.2 Analysis of User Interface Evaluation

Working with user interface any system is dependent on users computer background and understanding of the system environment. Based on the evaluation, the system was found to be easy to use. The highest rating mean of 4.2 indicates that searching on the map to get information is easy. The results were converted into a bar chart in Figure 3 to show more clearly.

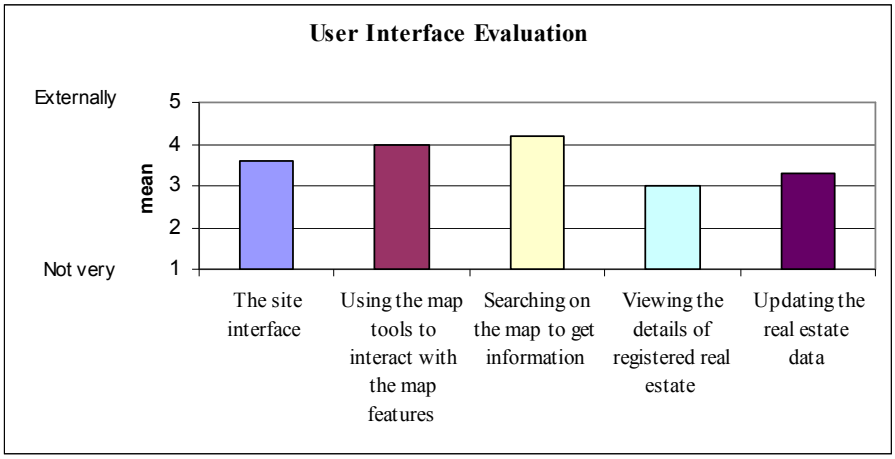

Figure 3: User interface evaluation bar chart

The bar chart in Figure 4 shows the evaluation for user interface satisfaction. The bar chart clearly indicates that the users are satisfied by with using the help tools.

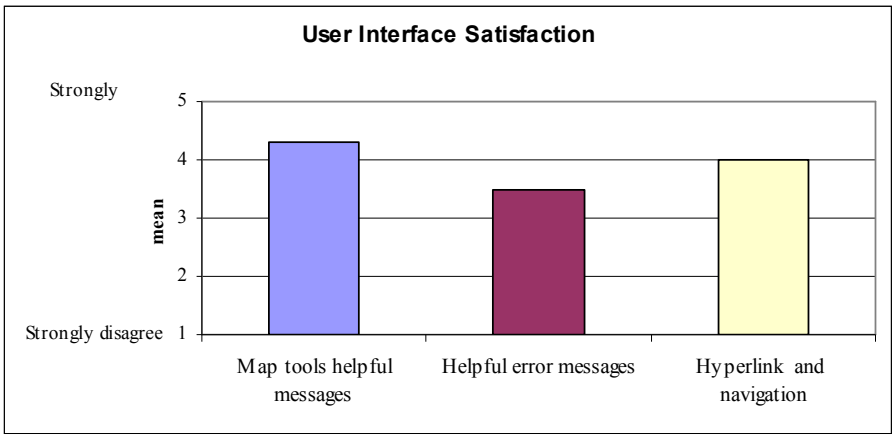

Figure 4: User interface satisfaction bar chart

5.3 Analysis of Evaluation Pertaining to Features

Figure 5 shows the evaluation of testing the accuracy of geographic data (map) as the data accuracy is the most important part of a successful GIS application. The bar chart indicates a good frequency for testing the accuracy for the parcels area, boundary, and location.

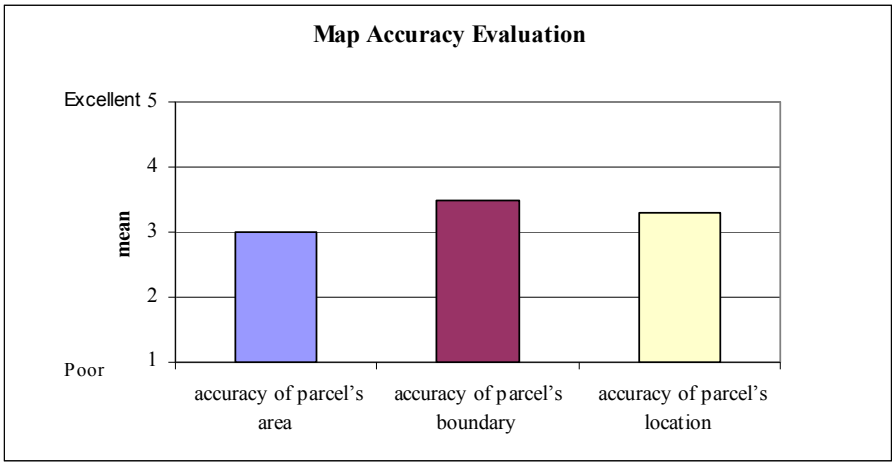

Figure 5: Map accuracy evaluation bar chart

5. Conclusions and Future Work

In this paper, we have presented a new framework for cadastral information system (CIS). The purpose of the new framework is to develop a cadastral web-mapping system, which assist real estate ownership registration. The proposed framework is obtained by studying the cadastral features, cadastral reform and cadastre 2014 vision which gives a general framework for cadastral. The proposed framework provides many options to computerize the day to day cadastral work at cadastral office and it further provides a secure way of keeping the database up-to-date. CW-MSLD System prototype was developed to increase the efficiency and effectiveness of the daily work on Tripoli Cadastral Office by using the modern GIS techniques (Web Mapping).

In future research we hope to link our system with other GIS software such as ESRI package like Arc/Info for editing the cadastral map.

References

1. Alexandrov A et al. Application of quickbird satellite imagery for updating cadastral information. In The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 2004.
2. Joseph L. Awange and John B. Kyalo Kiema. Fundamentals of GIS, pages 191–200. Springer Berlin Heidelberg, Berlin, Heidelberg, 2013.
3. T. Bernhardsen. Geographic Information Systems: An Introduction. Wiley, 2002.
4. Lazarov A Dechev, H. Cadastral information system of sofia. In Proceeding of FIG XXII International Congress Washington, D.C. USA, 2002.
5. Dr. Orhan Ercan and Dr. Emin Bank. Turkish cadastre automation system with esri technology, 2004.

6. Samir Elrouby Harju, K. Developing an automated cadastral information system in egypt. In Proceeding of Pharaohs to Geoinformatics FIG Working Week, Cairo, Egypt, 2005.
7. Bill Kropla. Beginning MapServer: Open Source GIS Development (Expert's Voice in Open Source). Apress, Berkely, CA, USA, 2005.
8. Abdul Majid Bin Mohamed. Cadastral reforms in malaysia. In Proceeding of FIG, Commision7 meeting in Penang, Penang, Malaysia, 2007.
9. International Federation of Surveyors. The FIG Statement on the Cadastre. Publication (International Federation of Surveyors). International Federation of Surveyors (FIG), 1995.
10. J. Star and J.E. Estes. Geographic Information Systems: An Introduction. Prentice Hall series in geographic information science. Prentice Hall, 1990.
11. R. F. Tomlinson, Duane F. Marble, and H.W. Calkins. Computer Handling of Geographical Data: An Examination of Selected Geographic Information Systems. Bernan Associates, 1979.
12. I.P. Williamson. "why cadastral reform?" In proceedings of National Conference on Cadastral Reform 1990, Melbourne, Australia, 1990.