❏   140

Mobile Geographic Information System Platform (MGISP): A GPS Information Collection System

Abdelilah Azyat, Naoufal Raissouni,
Nizar Ben Achhab, Mohamad Lahraoua and Asaad Chahboun

Innovation & Telecoms Engineering, Research Group. Remote Sensing & Mobile GIS Research Unit.
National School for Applied Sciences Tetouan-Tangier. University Abdelmalek Essaadi (UAE: www.uae.ma), Morocco.
Telf. +212662273285 / +212671703704
azyat2002@yahoo.fr ; nraissouni@uae.ma

Article Info	ABSTRACT
	All Goegraphic Information Sysyem (GIS) data acquisition devices can acquire ample valuable attribute information. This information will be edited and georeferenced, then stored in the spatial database. Georeferencing process is very necessary because these data will be integrated with other information from multi-sources. Field data collection is always a difficulty for cartographers, surveyors and researchers. The tools available for mapping applications have been bulky in size and weight, expensive, and difficult to learn for a long time. Fortunately, the advances of remote sensing, Global Positioning System (GPS) technology, GIS and some data edit and analysis softwares drive the field data collection. The advance refers not only precision has been improved, but also the hardware has become smaller, lighter, and cheaper. The software has become easier to learn, and more inexpensive; so the data collection task becomes easier, more economical and faster to complete. MGISP is based on GPS data with other services of map rendering used in the field for GIS projects. The Trimble Juno SC GPS receiver has been used on purpose to collecting GPS information and testing.

Corresponding Author:

Naoufal Raissouni,
National School for Applied Sciences of Tetuan, Abdelmalek Essaadi University,
Innovation & Telecoms Engineering Research Group. Remote Sensing & Mobile GIS Unit,
Mhannech II, B.P 2121 Tetuan, Morocco.
Email: nraissouni@uae.ma

1.   INTRODUCTION

Nowadays, geographic information is immensely important in our life; for the industry, government and for the society. To construct a spatial data infrastructure which is based on geodata, it requires gathering a huge amount of spatial data and organizes it in databases. To extend GIS from the desk to the field[1-4]. Mobile Geographic Information System (MGIS) technology[1-4] is used. This technology combines between GIS software [2-8], GPS, and portable computing devices [9]. MGIS is an emerging term which describes the use of connected devices [10] enabling improved workflows and productivity. It is closely related to field-force automation with which it shares many common features.

Therefore, MGIS basically changes the way information is collected [2], used in the field, and shared with the rest of an organization. It allows to fieldworkers to display information in a digital map, gather information anytime and anywhere [2;11], and interact in a direct way with the world around them; consequently, improving productivity and data accuracy. It seems that there are several factors that contribute

in the MGIS development, among them [12;13]; the enhancement in GPS technology, essentially, the precision of the positioning which arrive at sub-millimeter. This, due to the integration of new technologies, such as mobile computing [14], Mobile Databases (MDB) [15] and communication means [16;17].

Services integrating a mobile device's location [18] or position with other information can be defined by location services [13] as so as to provide added value to a user. Since the 1970s, the United States (US) Department of Defense (DoD) has been operating the GPS [19], a satellite infrastructure serving the positioning of people and objects. Initially, GPS was conceived for military purposes [20] , but the US government decided in the 1980s to make the system's positioning data freely [21] available to other industries global. Since then, many industries have taken up the opportunity to access position data through GPS and now use it to enhance their products and services. For example, the automotive industry has been integrating navigation systems into cars for some time. In traditional positioning systems, location information has typically been derived by a device and with the help of a satellite system (i.e., GPS receiver). GPS forms an important component in MGIS [16]. In our platform, we design and develop a component so as to acquiring GPS information. In the second section we are going to give an overview about GPS.

2.   GPS BASIC CONCEPTS
2.1. Geopositioning and basic facts

Positioning (i.e., the determination of stationary or moving objects) [22] can be determined as follows: in relation to a well-defined coordinate system, usually by three coordinate values and in relation to other point; taking one point as the origin of a local coordinate system. The first mode of positioning is known as point positioning [23], the second as relative positioning. If the object to be positioned is stationary, we term it as static positioning [24]. When the object is moving, we call it kinematic positioning [24;25]. Usually, the static positioning is used in surveying, and the kinematic position in navigation. The GPS is based on satellites and computers [19;24] to compute positions anywhere on the Earth. It is also founded on satellite ranging. That means the position on the Earth is determined by measuring the distance from a group of satellites in space. In order to understand GPS basics, the system can be categorized into the following five logical steps [19;25];

1. Triangulation from satellite is the basis of the system.
2. To triangulate, GPS measures the distance using the travel time of the radio message.
3. To measure travel time, GPS need a very accurate clock.
4. Once the distance to satellite is known, then we need to know where the satellite is in space.
5. As the GPS signal travels through the ionosphere and the Earth's atmosphere, the signal is delayed.

To calculate a position in three dimensions, we need to have four satellite measurements. The GPS uses a trigonometric approach to calculate the positions. The GPS satellites are so high up that their orbits are very predictable and each of the satellites is equipped with a very accurate atomic clock [19;25].

2.2. GPS components

The GPS is divided into three major components [25]: i) Control Segment, ii) Space Segments, iii) User Segment.

i) Control Segment

The control segment consists of five monitoring stations (Colorado Springs, Ascension Island, Diego Garcia, Hawaii, and Kwajalein Island). Three of the stations (Ascension, Diego Garcia, and Kwajalein) serve as uplink installations, capable of transmitting data to the satellites, including new ephemerides (satellite positions as a function of time), clock corrections, and other broadcast message data, while Colorado Springs serves as the master control station [25]. The Control Segment is the sole responsibility of the DoD who undertakes construction, launching, maintenance, and virtually constant performance monitoring of all GPS satellites. The DoD monitoring stations track all GPS signals for use in controlling the satellites and predicting their orbits [25]. Meteorological data also are collected at the monitoring stations, permitting the most accurate evaluation of tropospheric delays of GPS signals. Satellite tracking data from the monitoring stations are transmitted to the master control station for processing. This processing involves the computation of satellite ephemerides and satellite clock corrections. The master station controls orbital corrections, when any satellite strays too far from its assigned position, and necessary repositioning to compensate for unhealthy (i.e., not fully functioning) satellite.

ii) Space Segment

The space segment consists of the constellation of NAVASTAR Earth orbiting satellites [25]. The current Defence Department plan calls for a full constellation of 24 Block II satellites (21 operational and 3

in-orbit spares). The satellites are arrayed in 6 orbital planes, inclined 55 degrees to the equator. They orbit at altitudes of about 12000 miles each, with orbital periods of 12 sidereal hours (i.e., determined by or from the stars), or approximately one half of the Earth's periods, approximately 12 hours of 3-D position fixes. The next block of satellites is called Block IIR, and they will provide improved reliability and have a capacity of ranging between satellites, which will increase the orbital accuracy. Each satellite contains four precise atomic clocks (Rubidium and Cesium standards) and has a microprocessor on board for limited self-monitoring and data processing. The satellites are equipped with thrusters which can be used to maintain or modify their orbits [25].

iii) User Segment

The user segment is a total user and supplier community, both civilian and military [25]. The user segment consists of all Earth-based GPS receivers. Receivers vary greatly in size and complexity, though the basic design is rather simple. The typical receiver is composed of an antenna and preamplifier, radio signal microprocessor, control and display device, data recording unit, and power supply. The GPS receiver decodes the timing signals from the 'visible' satellites (four or more) and, having calculated their distances, computes its own latitude, longitude, elevation, and time [25]. This is a continuous process and generally the position is updated on a second-by-second basis, output to the receiver display device and, if the receiver display device and, if the receiver provides data capture capabilities, stored by the receiver-logging unit.

2.3. Types of GPS Positioning

2.3.1. Absolute positioning

The mode of positioning relies upon a single receiver station. It is also referred to as 'stand-alone' GPS, because, unlike differential positioning, ranging is carried out strictly between the satellite and the receiver station, not on a ground-based reference station that assists with the computation of error corrections [26]. As a result, the positions derived in absolute mode are subject to the unmitigated errors inherent in satellite positioning. Overall accuracy of absolute positioning is considered to be no greater than 50 meters at best by Ackroyd and Lorimer and to be plus 100 meter accuracy by the United Stated Army Corps of Engineers.

2.3.2. Differential positioning

Relative or Differential GPS (DGPS) carries the triangulation principles one step further, with a second receiver at a known reference point [25;27]. To further facilitate determination of a point's position, relative to the known Earth surface point, this configuration demands collection of an error-correcting message from the reference receiver. Differential-mode positioning relies upon an established control point. The reference station is placed on the control point, a triangulated position, the control point coordinate. This allows for a correction factor to be calculated and applied to other roving GPS units used in the same area and in the same time series. Inaccuracies in the control point's coordinate are directly additive to errors inherent in the satellite positioning process. Error corrections derived by the reference station vary rapidly, as the factors propagating position errors are not static over time [25].

2.3.3. Accuracy of GPS

There are four basic levels of accuracy (Table 1) - or types of solutions – that we can obtain with real-time GPS mining system:

Table 1 GPS systems accuracy

GPS system	Accuracy
Autonomous	15 – 100 meters
Differential GPS (DGPS)	0.5 – 5 meters
Real-Time Kinematic Float (RTK Float)	20 cm – 1 meter
Real-Time Kinematic Fixed (RTK Fixed)	1 cm – 5 cm

GPS satellites broadcast on three different frequencies (Table 2), and each frequency (or career wave) has some information or codes on it. It is similar to three different radio stations broadcasting several different programs. The Table 1.8 lists the signals and the contents:

Table 2 Three signals frequencies and contents

L1 Career	L2 Career	L3 Career
19 cm wavelength	24 cm wavelength	Data not available
1575.42 MHz	1227.6 MHz	
C/A Code	P Code	
Navigation	Navigation Message	

- ▪ P Code : Reserved for direct use only by the military
- ▪ C/A Code : Used for rougher positioning
- ▪ For Single frequency use only L1 career is used
- ▪ For Double frequency, L1/L2/L3 career is used
- ▪ The navigation message (usually referred to as the ephemeris) tells us where the satellites are located, in a special coordinate system called World Geodetic System 1984 (WGS84). If we know where the satellites are at any given time, then location can be computed on the Earth.

Using GPS for GIS data collection and data maintenance is essential for timely decision-making and the wise use of resources [25;28]. Any organization or agency that requires accurate location information can benefit from the efficiency and productivity provided by GPS technology. All over the world, government agencies, scientific organizations, and utility companies use GIS data collection and data maintenance systems to stay up-to-date and competitive [29]. Based on GPS information we have developed MGISP for data collection in the field.

3.   MGISP: DEVELOPMENT APROACH AND OPTIMAL ARCHITECTURE

This section starts with a close look at the software development methodologies. After that, an overview of the software development models is given. Then, a description of the object-oriented process and Object-Oriented Analysis and Design (OOAD) with Unified Modeling language (UML) is brought in [1;2]. Finally, we have followed system architecture design to realize the MGISP.

3.1. Software Development Methodologies (SDM)

In the early 1980s, academic interest in the systems development methodologies [30;31]scope appears to have pointed. A succession of conferences on ISs design methodologies were initiated. However, the concept of "methodology" used for these conferences was limited to the design stage of the System Development Life Cycle (SDLC), and many of the methodologies analyzed were derived from academic research rather than practice [30]. In order for improving the quality of a software development effort, software engineering is made-up and it means the practice of using selected process techniques. A lot of interested peoples have different sight depending SDM definition. For instance, Chapman (1997) called SDM or SDLC; the policies, processes and procedures documented collection used by a development team or organization to practice software engineering. SDMs have been developed with the reason of designing and developing effective ISs. According to Avison and Fitzgerald, ISs development methodology is a system of procedures, techniques, tools and documentation aids, usually based on some philosophical view [32], which help the system developers in their efforts to implement a new information system . The SDLC is the multistep process that starts with the initiation, analysis, design, and implementation, and continues through the maintenance and disposal of the system [30;31]. The main idea of the SDLC has been to pursue the development of ISs in a very deliberate, structured and methodical way, requiring each stage of the life cycle from inception of the idea to delivery of the final syste, to be carried out in rigidly and sequentially [33;34]. At the present time, there are a lot of methodologies for software development; we mention here some ones in the following Table 3 with date of the starting place and a bit description:

Table 3 Software development methodologies root

Year	Methodology	Description
1969	Structured Programming	Seen as a subset or subdiscipline of imperative programming, one of the major programming paradigms. It is most famous for removing or reducing reliance on the GOTO statement.
1974	Cap Gemini SDM	A software development method developed from the software company PANDATA. It was used extensively in the Netherlands for Information and Communications Technology (*ICT*) projects in the 1980s and 1990s.
From 1980 onwards	Structured Systems Analysis and Design Methodology (SSADM)	The standard structured method used for computer projects in Britain government departments. It is also being adopted as a standard by various other bodies.
During the mid-1990s	Object-Oriented Programming (OOP)	A programming paradigm that uses "objects" – data structures consisting of data fields and methods together with their interactions – to design applications and computer programs. Programming techniques may include features such as data abstraction, encapsulation, modularity, polymorphism, and inheritance.
During the mid-1990s	Team Software Process (TSP)	Provides a defined operational process framework that is designed to help teams of managers and engineers organize and produce large-scale software projects of sizes beyond several thousand lines of code.
Since 1991	Rapid Application Development (RAD)	Uses minimal planning in favor of rapid prototyping. The "planning" of software developed using RAD is interleaved with writing the software itself.
Since the late 1990s	Scrum	A type of software engineering, an iterative, incremental framework for project management often seen in agile software development.
Since 1999	Extreme Programming (XP)	Proposed to improve software quality and responsiveness to changing customer requirements.
Since 2003	Rational Unified Process (RUP)	Iterative software development process framework created by the Rational Software Corporation, a division of IBM
Since 2005	Agile Unified Process (AUP)	Simplified version of the RUP developed. It describes a simple, easy to understand approach to developing business application software using agile techniques
Since 2007	Integrated Methodology (QAIassist-IM)	Refers to a group of software development practices and deliverables that can be applied in a multitude (iterative, waterfall, spiral, agile) of software development environments, where requirements and solutions evolve through collaboration between self-organizing cross-functional teams.

3.2. Object-Oriented Methodology (OOM)

OOM focuses on the objects and classes of objects in a system [33]. At the beginning of 1990, the use of OOM for analyzing and designing systems [35] started to mature with the launch of methodologies from the three industry-leading methodologists: Ivar Jacobson, Grady Booch and James Rumbaugh [33]. There are a lot of object oriented methodologies being used to develop object-oriented systems, examples are; Fusion , Booch and the Coad and Yourdon's approach . In this work the Object Modelling Technique (OMT) is used because OMT [36] is one of the more popular object-oriented design methodologies being used world-wide . For encouraging and facilitating the re-use of software components, OOM can be applied as a new development system. Using this methodology, a computer system can be developed on a component basis which enables the effective re-use of existing components and facilitates the sharing of its components by other systems. Through the adoption of OOM, higher productivity, lower maintenance cost and better quality can be performed . In other word; object modeling is based on identifying the objects in a system and their interrelationships. Once this is done, the coding of the system is done .

3.2.1. Object-oriented process

In 1991, Rumbaugh was first introduced and described OMT [37]. This technique is mainly used by object oriented system and software developers as it provides support for full life-cycle development. OMT incorporates the best techniques of other methodologies such as Booch and Jacobsen . Figure 1 shows the main stages during OMT are: System Analysis, System Design, Object Design, Implementation and testing. OMT uses three models to describe the system being created. The three models used to describe the system are; functional model, object/static model and dynamic model.

The above models are initially developed during the analysis phase of the system and are subsequently used and added to during all stages of development. This three pronged approach to application design and development is important as each model enables the designer to view the system from different perspectives. The object model identifies and describes the objects used to build the system, the dynamic

model represents the interactions between the various objects, and the functional model identifies the data transformations of the system. While the object model is most important of all as it describes the basic element of the system, the objects, all the three models together describe the complete functional system.
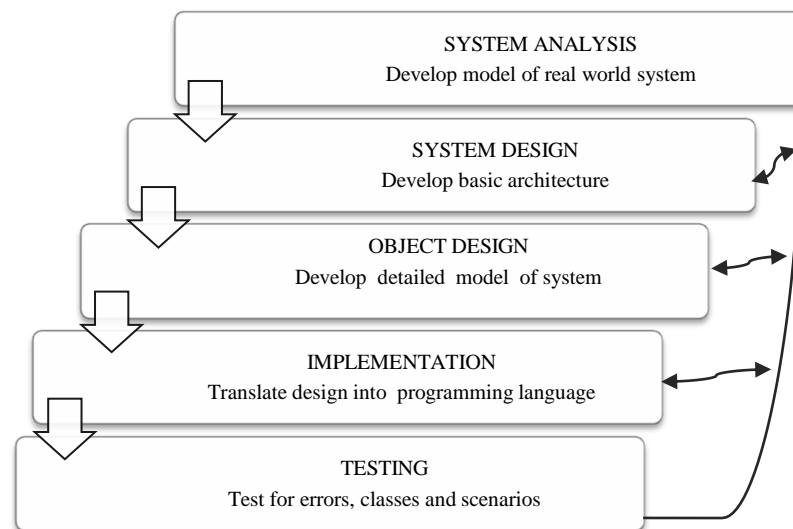

Figure 1 Object-Oriented Development process

OMT is described by as a set of activities [37] that need to be performed to construct a system. The activities can be performed in several different orders as well as simultaneously, depending on the needs of the project at hand. When the activities are performed there is a considerable amount of overlap and iteration. The first stage of the software development process is analysis.

3.2.1.1. System analysis

System analysis is the first phase of development in case of OMT as in any other system development model. In this phase, the developer interacts with the user of the system to find out the user requirements and analyses the system to understand the functioning. In software development, analysis is the process of studying and defining the problem to be resolved. The output of analysis [37;38] is a document containing a written problem statement and diagrammatic representations of the object model, the dynamic model and the functional model.

3.2.1.2. System design

It is concerned with developing an OO model of a software system to implement the identified requirements. The objects in an OO design [39] are related to the solution to the problem that is being solved. There may be close relationships between some problem objects and some solution objects but the designer inevitably has to add new objects and to transform problem objects to implement the solution. If analysis means defining the problem, then design is the process of defining the solution. It involves defining the ways in which the system satisfies each of the requirements identified during analysis.

3.2.1.3. Object design

Object design [39] is the process of defining the components, interfaces, objects, classes, attributes, and operations that will satisfy the requirements. We can typically start with the candidate objects defined during analysis [39;40], but add much more rigor to their definitions. Then we add or change objects as needed to refine a solution. In large systems, design usually occurs at two scales: architectural design, defining the components from which the system is composed; and component design, defining the classes and interfaces within a component. The important concept in the understanding OO development is based on objects that are grouped into classes.

3.2.1.4. Implementation with Object-Oriented Programming (OOP)

Throughout this phase, the class objects and the interrelationships of these classes are translated and really coded using the programming language. Several modern programming languages depend largely or exclusively on the concept of objects: a close syntactic binding of data to the operations that can be performed upon that data. In these Object-Oriented Languages (OOL)—C++, C#, Java, Eiffel, Smalltalk, Visual Basic .NET, Perl, and many others—programmers create classes, each of which defines the behavior and structure of a number of similar objects. Then, writing code which creates and manipulates objects that are instances of those classes.

4. OBJECT-ORIENTED ANALYSIS AND DESIGN (OOAD) WITH UNIFIED MODELING LANGUAGE (UML)

The perspective of OOAD [4] was to avoid the problem of the fact that systems developed with the algorithmic perspective, tend to be very hard to maintain [41], as the system grows and the requirements change. The results of the OOAD phases are captured using a formal syntax of a modeling language, producing an unambiguous model of the system to be implemented. UML [3;4] is appropriate for modeling ranging from enterprise IS to distributed web based applications and even to hard real-time embedded systems. Using UML with OOAD, there are models which consist primarily of diagrams: static diagrams that depict the structure of the system, and dynamic diagrams that put in evidence the behavior of the system. With the dynamic diagrams, we can draw through the behavior and analyze how various scenarios play out. By means of the static diagrams, we can make sure that each component or class has access to the interfaces and information that it needs to carry out its responsibilities. And it's very easy to make changes in these models: adding or moving or deleting a line takes moments; and reviewing the change in a diagram takes minutes.

5. SYSTEM ARCHITECTURE DESIGN

Software architecture is an area of growing importance to practitioners and researchers in government, industry, and academia. In addition to, the study of software architecture is in large part a study of software structure that began in 1968 when Edsger Dijkstra [42] pointed out that it pays to be concerned with how software is partitioned and structured, as opposed to simply programming so as to produce a correct result. Dijkstra was writing about an operating system, and first put forth the notion of a layered structure, in which programs were grouped into layers, and programs in one layer could only communicate with programs in adjoining layers. He pointed out the elegant conceptual integrity exhibited by such an organization, with the resulting gains in development and maintenance ease. David Parnas pressed this line of observation with his contributions concerning information-hiding modules [43], software structures [44], and program families [45]. This section will provide an overview of design features and the MGISP architecture development for spatial data management [46] [47] [48] [49], describing in a detailed discussion of the SQL Server CE database created for this study .
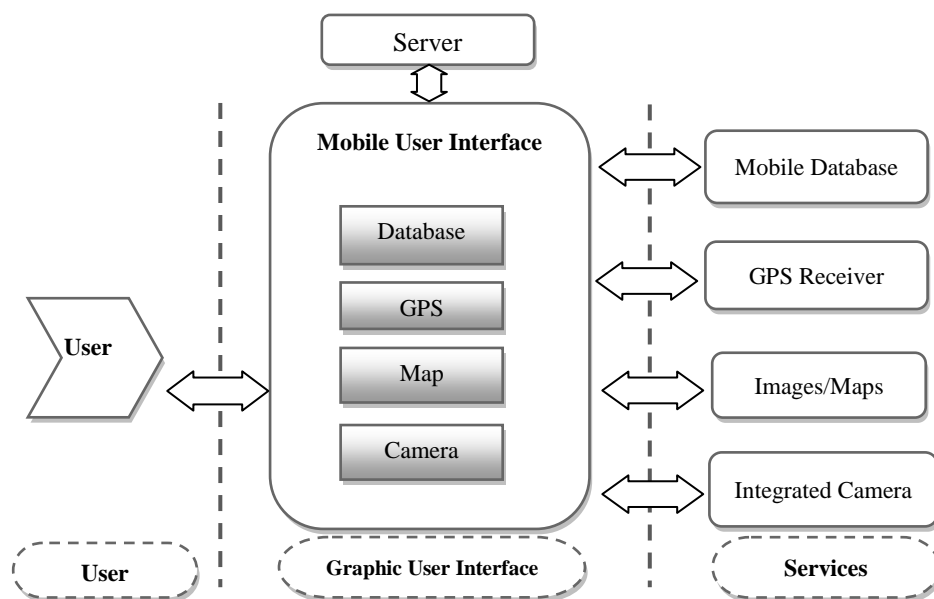
Figure 2 MGISP overall architecture

Referring to the Figure 2, the structure of the platform is organized in three components: a component for spatial data management; the server with a Relational Management Database System (RMDBS), a component for interfacing and a component for services as viewing maps and images, capturing photos through camera. the architecture is based on three levels which communicate and manage informative fluxes coming from GPS receiver and camera toward database interface and also the server. The spatial data management component corresponds to the store of local positions; the latitude, longitude and others attributes in a local database. In addition, the GPS information, camera photos and images/maps are stored in the device or in a storage card.

5.1. Analysis

According to [50], a real world system model is developed throughout analysis. The basis of the OMT specification is formed by analysis. It provides a clear illustration of what work must be done. Other than it does not specify how the builder will carry out the work. It comprises the functional view, as well as a subset of static and dynamic views, excluding the component, deployment and collaboration diagrams.

5.2. Object model

Object model forms the system main model. It will identify all the objects that will make up the system, their attributes and relationships with other objects. [51] identifies guidelines that are followed when developing an object model, they have been modified slightly to suit the scale of this project as follows.
   i) Develop a problem statement.
   ii) Identify the object classes and their attributes and associations.
   iii) Discard unnecessary and incorrect classes, attributes and associations.
   iv) Use inheritance to share common structure.

5.3. Dynamic model (DM)

The changes to objects are reflected by the DM and their relationships over time, demonstrating possible control flows through the system. [52] verifies this: "The DM shows the time independent behavior of the system and the objects in it". DM is important for interactive and real time systems. It is vital for applications that depend on collecting information from the user. The current project will not be directly involved with interactions with the end user, thus the DM is not very important, but it is important to consider the DM for the MGISP, as this will indicate the types of control flows expected from the object-relational framework.

5.4. Functional Model

The functional model/view is one of the three modeling process views [53]. It enters among the analyses level. In this model we can establish three types of diagrams model business process [54], use cases, activity diagram and sequence diagram [53].

5.5. System design

In the context of this application, architecture design is, about planning a successful mobile solution implementation. The goal of the system design is to assist in achieving a doing well implementation. As seen early, OOD is a design strategy where system designers think in terms of 'objects' instead of operations or functions [55]. An OOD process involves designing the object classes and the relationships between these classes. When the design is realized as an executing program, the required objects are created dynamically using the class definitions. Through system design high level decisions are made towards solving the issues raised within analysis. Some of the decisions made during system design include: what type of MDB, will be used and how it will be used; will the application run on multiple platforms or not and what programming language will be used to implement the design. For MGISP it was specified in the problem statement that the Microsoft Visual C# .Net language with .Net Compact Framework version 3.5 which helps in develop contents for a pocket PC or a Smartphone would be used. As a result of this the system can be easily ported to Windows Mobile platforms.

5.6. MGISP deployment

For putting the application into action, we will now describe the physical implementation of the developed application MGISP [48] with the help of two final types of diagram offered by UML: i) the component diagram, ii) the deployment diagram. Figure 3 shows the component diagram being evidence for dependencies among the software components that constitute the MGISP [49]. A component can be an executable, source code, binary code, etc. In fact, a component represents every physical and replaceable part of a system that conforms to, and provides, the realization of a set of interfaces. The main components are

deduced from all of the preceding study. Each task has its own human-computer interface. These all interfaces used by the user, are controlled from the main GUI tasks. On the other hand, the data are stored in a local mobile database created by means of database component [46]. We have represented the latter in relation with a storage source. Indeed, the GPS, Map/image view and camera components are also represented.
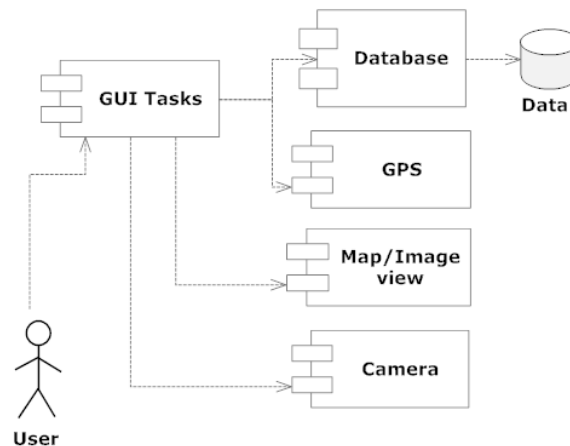

Figure 3 MGISP component diagram

The purpose of deployment view is to show each physical element of the system architecture. Showing the physical configuration of different run-time processing elements that take part in executing the system, as well as the component instances that they support. Every actor/user has his or her own mobile client that is a PDA maybe connected to the server of the organization. In particular, this mobile device contains the MGISP application [48]. As regards the SQL server CE, it hosts the data as well as the databases [49]. This entails a Windows Mobile 6 system.

6.　RESULTS AND TESTS
6.1. Developer's unit test phase
The developer test is performed by the developer to make certain the system's performance. Firstly each unit component is tested in isolation from the others using actual inputs and then the units are integrated together into the whole system and tested again. This is to ensure that the system requirements in terms of functionality are fulfilled. As it has been mentioned earlier in the general introduction, the main objective of this work is to develop a platform that can conveniently be used to acquire spatial data and be able to store, edit and update data in a local MDB with the use of GPS receiver [48]. The final product should be a simple database with possibility to disseminate a map and image, and to explore the camera as well. The various components of the platform tested comprise of the database interfaces, the GPS component, the map and image displaying and the camera component [49].

6.2. Developing and testing MGISP interfaces
The mobile user interfaces were designed using Visual Studio 2008 with .Net Compact Framework. A customized interface with this last consists of one or more forms. A form consists also of pages and panels which can also be one or more as well. A page contains control buttons and box text which accepts actions and inputs, hence execute functions. Every part of the form and page interface has titles to describe the functionality they are purported to perform. In support of this development, the mobile graphical interface that appears when MGISP is loaded is the main interface (Figure 4a), into which all the other interfaces were built. Concerning database interfaces, four main interface forms were built: the "AddData (Figure 4b) interface to create or add a database and/or table, validation of this operation is realized by the ok button, the "Reading data" interface (Figure 4c) permits reading data to database through entry fields and an ok button of confirmation, the "GPS8_Info" interface (Figure 4d) allows the reading GPS data and displaying them.

(a) Tasks Form   (b) Add Data Form   (c) Editing data form   (d) GPS information form
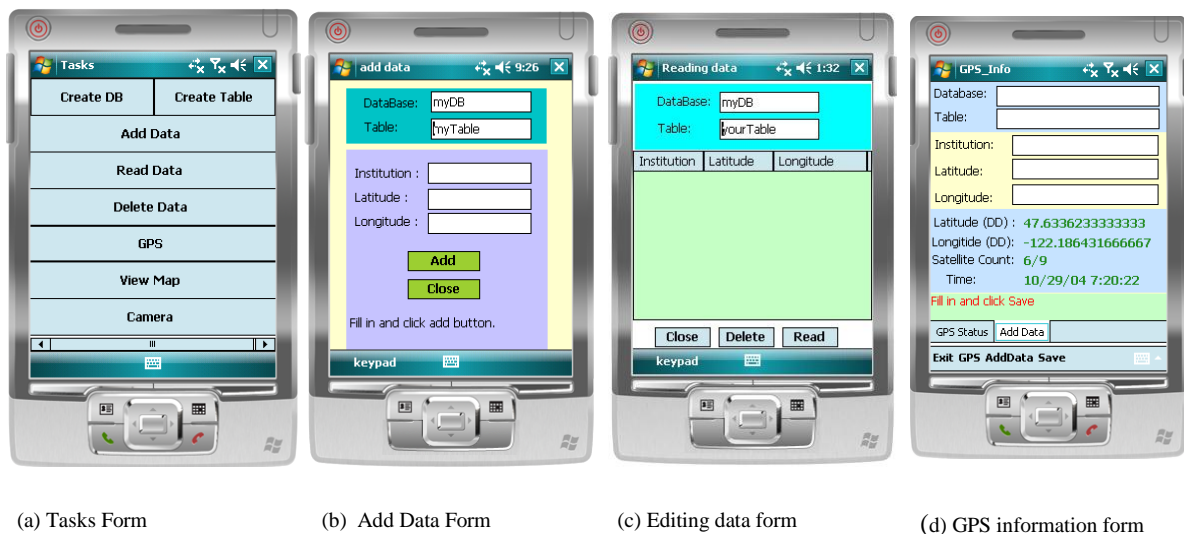
Figure 4 MGISP's main and database interfaces

The implementation and testing of the MGISP have been designed and developed. Key elements to be implemented among others in the conceptual model are: the graphical user interface for the mobile client and the different components of services; the local database, the use of GPS Intermediate Driver (GPSID) for collecting GPS information, the vector/raster map and images visualization, as well as the camera functioning. Implementing the platform, the software, the hardware and the programming languages. The preparations of the embedded database to manipulate data by way of programming, and the first platform testing are also discussed. Application results of MGISP: GIS platform, use cases: i) University Abdelmalek Essaadi (UAE) institutions spatial references, ii) capacities and weakness points study; Tangier Old Medina (Hay Bni Yeder), and iii) image georeferencing of university campus in Tangier have been presented.

7.   CONCLUSION

Even though conceived for a project dealing with the application of integration of GIS and GPS in mobile systems, MGISP is suitable for other fields. Its structure allows creating and manipulating local databases and exploring many services. MGISP has been tested in order to verify its usability with hand-held devices specifically Pocket PC (and Smartphone in process). Moreover, the application was fully tested on Windows Mobile 5 and 6 Classic Emulator and on Trimble Juno SC PDA. Spatial data acquisition and management are important assets to GIS project development. It, therefore, needs proper collection mechanism and practical system. There have already existed many products, but these do not taken in consideration the local MDB, except little commercial solutions. This work came out with user interfaces within the MGIS platform to provide this concern and to add other services.

ACKNOWLEDGEMENTS

REFERENCES

[1] A. Abdelilah and R. Naoufal, "MGISP: Integrated Framework Based on GPS for Spatial Data Acquisition, Management and Geovisualization," *International Journal of Engineering Science and Technology*, 2011;3(6):5366-80.
[2] A. Abdelilah, and R. Naoufal, "Design and Development of a Mobile Geographic Information System Platform (MGISP) Based on GPS Technology for Spatial Data Acquisition, Management and Geovisualisation: Multi-utilisation Interface", 2011.
[3] G.Jason, "UML for Managers," 114. 2005.
[4] S.L.Martin,"UML Applied: A .NET Perspective," 2004.
[5] A. Abdelilah, *et al.*, "Towards a Mobile GIS Workflow for Spatial Data Management and Geo-visualization Solutions,"Moscow - Russia: 4th International Conference "Earth from Space - the Most Effective Solutions"; 2009.

[6]   A. Abdelilah, *et al.*, "Development of a Mobile GIS Platform using Web Services Technologies: Spatial data Management and Geovisualisation," Al khobar - Saudi Arabia: 5th National GIS Symposium; 2010.

[7]   A. Abdelilah, *et al.*, "Determination of Capacities and Weaknesses Sites using GIS and Mobile GIS Platform: Tangier Old Medina (Hay Bni Yeder) Case Study," Algeciras (Cadiz) - Espain: EuroMediterranean Scientific Congress on Engineering; 2011.

[8]   A. Abdelilah, *et al.*, "Spatial Data Collection based on GPS: MGISP-Mobile GIS Platform Development," Algeciras (Cadiz) - Espain: EuroMediterranean Scientific Congress on Engineering; 2011.

[9]   M.H. Tsou and C.H.Sun, "Mobile GIServices Applications in chapter in Dynamic and Mobile GIS: Investigating Change in Space and Time," (edited by Drummond, J, Billen, R., Forrest, D. and Joao, Ed. 2006. published by Taylor & Francis. (Innovations in GIS book series), pp. 213-236". 2007.

[10]   K. Novak, "Mobile Mapping Technology for GIS Data Collection," PE&RS 1995;Vol.61(No.5):493-501.

[11]   H. K. Kang, K.J. Li, "A Framework for Dynamic Updates of Map Data in Mobile Devices. Lausanne: Springer. 2005 p. 66-77.

[12]   D. A. Grejner-Brzezinska, *et al.*, "From Mobile Mapping to Telegeoinformatics: Paradigm Shift in Geospatial Data Acquisition, Processing, and Managemen,". *Photogrammetric Engineering & Remote Sensing*, 2004;70(2):197-210.

[13]   S. Pietila and M. Williams, "Mobile location applications and enabling technologies," Portland, Oregon (Institute of Navigation, Fairfax, Virginia), 2002 p. 385-95.

[14]   M. Mallick, " Mobile and Wireless Design Essentials," Wiley Publishing, Inc.; 2003.

[15]   K. Ka-wai and S.Wen-zhong, "A study of Dynamic Database in Mobile GIS," Ottawa 2002.

[16]   P. Zhong-Ren, T. Ming-hsiang, "Internet GIS: distributed geographic information services for the Internet and wireless networks," 2003.

[17]   D .Li, *et al.*, "The Technique Integration of the Spatial Information and Mobile Communication," Geomatics and Information Science of Wuhan University 2002;27(1):1-6.

[18]   A. Brimicombe and L. Yang, "Mobile Space-Time Envelopes for Location-Based Services," Transactions in GIS 2006;10(1):5-23.

[19]   A. Leick, "GPS Satellite Surveying. Second Edition," ed. John Wiley & Sons, 1995.

[20]   E. Thompson, "Integrating PDA, GPS and GIS Technologies for Mobile Traffic Data Acquisition," Sweden: IT University of Goteborg (MSc thesis). 2002.

[21]   Y. Xue, *et al.*, "Telegeoprocessing: The integration of remote sensing, geographic information system (GIS), Global Positioning System (GPS) and telecommunication," *International Journal of Remote Sensing*, 2002; 23(9):1851-93.

[22]   F.Ackermann and H.Schade, "Application of GPS for Aerial Triangulation," PE&RS 1993;59, No.11:1625-32.

[23]   K.Jacobsen, "Correction of GPS Antenna Position for Combined Block Adjustment," 1993 p. 152-8.

[24]   D. C. Merchant, "Airborne GPS-Photogrammetry for TransportationSystems," 1994 p. 392-5.

[25]   E. Kaplan, "Understanding GPS: Principles & Applications," Boston London: Artech House Publishers; 1996.

[26]   E. Caroline, "GPS positioning guide," Natural Resources Canada; 1993. Report No.: Natural Resources Canada.

[27]   K. E, Ct A, W. W, K. M., "Integrating Differential GPS data into an Embedded GIS and its Application to Infomobility and Navigation," Germany 2001.

[28]   R. Li, *et al.*, "Integrated GPS and Related Technologies for Rapid Data Acquisition," GIS World , 41-43. 1994.

[29]   D.Ashbrook and T.Starner, "Using gps to learn significant locations and predict movement across multiple users," *Personal and Ubiquitous Computing*, 2003;7(5):275-86.

[30]   B. David, "Software Design," Reading, MA: Addison-Wesley, 1993.

[31]   G. L.Bass, *et al.*, "SAAM: A Method for Analyzing the Properties of Software Architectures," Sorrento, Italy, May 16-21, Los Alamitos, CA: IEEE Computer Society Press, 1994 p. 81-90.

[32]   J. Burge, *et al.*, "Rationale-Based Software Engineering," Springer-Verlag; 2008.

[33]   H.E. Amnon, "A Theory of Object-Oriented Design," Information Systems Frontiers 4:4, 2002;379-91.

[34]   D. Garlan and M. Shaw, "An Introduction to Software Architecture.Advances in Software Engineering and Knowledge Engineering," River Edge, NJ: World Scientific Publishing Company, 1993.

[35]   D. Coleman, *et al.,* "Object-oriented Development : The Fusion Method," Upper Saddle River, NJ, USA: Englewood Cliffs; 1994.

[36]   M. Chonoles and T. Quatrani, "Succeeding with the Booch and OMT Methods a Practical Approach," Lockeed Martin Advanced Concepts Centre, Rational Software Corporation; 1996.

[37]   K.W.Derr, "Applying OMT: A Practical Step-by-Step Guide to Using the Object Modeling Technique," New York: SIGS Books; 1995.

[38]   A. Carmichael, "Object Development Methods, Advances in object Technology," Southampton, UK, Object UK Ltd. 1994.

[39]   G. Booch, "Object Oriented Design," Redwood City, CA: Benjamin Cummings; 1991.

[40]   E. Gamma, *et al.*, "Design Patterns, Elements of Object-Oriented Software," 108. 1995.

[41]   I. Bracken and C.Webster, "Information Technology in Geography and Planning, including principles of GIS," London: Routledge: 1990.

[42]   T. Hassan, *et al.*, "Bridging Land-based Mobile Mapping Using Photogrammetric Adjustments," Marne-la-Vallée, France. 2006.

[43]   P. Gordon, "An Introduction to the Technology Mobile Mapping Systems," Geoinformatics, 32-43. 2010

[44]   L. Robert, "The global market for GPS/GNSS in GIS mapping 2009-2013," Position One Consulting 2010.
[45]   Colorado Department of Transportation, "GPS/GNSS Survey," 2008.
[46]   J. Holliday, *et al.*, , "Planned disconnections for mobile databases," A.E 2000 p. 165-72.
[47]   P. Héroux and J.Kouba, "GPS Precise Point Positioning with a Difference," Ottawa, Ontario, Canada, 1995.
[48]   M. Jack and M. Mike, "The Role of GPS and Mobile GIS Technology in Geospatial Infrastructure Creation for National Ownership Mapping Programs in Developing Countries," San Antonio, Texas 2006.
[49]   D. Barbara, "Mobile Computing and Databases-A Survey," *IEEE TKDE* 1999;11(1):108-17.
[50]   B.Y.T. James, " Fundamentals of Global Positioning System Receivers: A Software Approach," John Wiley & Sons, Inc; 2000.
[51]   Trimble, "How GPS works?," http://ww2.trimble.com/gps_tutorial/howgps.aspx. 2011.
[52]   J. Rumbaugh, *et al.*, "Object-Oriented Modeling and Design," Englewood Cliffs, NJ: Prentice-Hall; 1991.
[53]   ESRI, "ArcPad: Mobile GIS," http://www.esri.com/library/whitepapers/pdfs/arcpad.pdf. 2004.
[54]   S. Shimano, *et al.*, "Application of mobile mapping technology and real time GIS for ubiquitous society," Padua, Italy 2007.
[55]   G. Retscher, "Ubiquitous positioning solutions for pedestrian navigation," Padua, Italy 2007.

BIOGRAPHY OF AUTHORS

Abdelilah Azyat received the degree in Informatics, Electronics, Electrotechnics, and Automatics (IEEA) and M.S. degree in Bioinformatics from University Abdelmalek Essaadi (UAE), Tetuan, Morocco, in 1995 and 2004 respectively. Currently, he is a member of Remote-Sensing & Mobile-GIS Unit/Telecoms Innovation & Engineering Research group. His research interests include remote sensing, spatiotemporal studies of thermal infrared satellite imagery of the earth's surface and the development of remote sensing methods for land cove dynamic monitoring, GIS and Mobile GIS.

Naoufal Raissouni received the M.S., and Ph.D. degrees in physics from the University of Valencia, Spain, in 1997, and 1999, respectively. He has been a Professor of physics and remote sensing at the National Engineering School for Applied Sciences of the University Abdelmalek Essaadi (UAE) of Tetuan, since 2003. He is also heading the Innovation & Telecoms Engineering research group at the UAE, responsible of the Remote Sensing & Mobile GIS unit. His research in terests include atmospheric correction in visible and infrared domains, the retrieval of emissivity and su rface temperature from satellite image, huge remote sensing computations, Mobile GIS, Adhoc networks and the development of remote sensing methods for land cover dynamic monitoring.

Nizar Ben Achhab received the degree in Informatics, El ectronics, Electrotechnics, and Automatics (IEEA) and M.S. degree in Bioinforma tics from University Abdelmalek Essaadi (UAE), Tetuan, Morocco, in 1995 and 2004 respectively. Currently, he is a member of Remote-Sensing & Mobile-GIS Unit/Telecoms Innovation & Engineering Research group. His present research include remote sensing multitemporal and spatiotemporal studies of thermal infrared satellite imagery of the earth's surface, the in-situ LST measurements and the development of remote sensing methods for land cove dynamic monitoring. It includes also, Grid computing, Multithreading, GPGPU, hardware and software methods for time computing optimizations.

Mohamad Lahraoua received the degree in Chemistry and M.S. degree in Bioinformatics from University Abdelmalek Essaadi (UAE), Tetuan, Morocco, in 1992 and 2004 respectively. Currently, he is a member of Remote-Sensing & Mobile-GIS Unit/Telecoms Innova tion & Engineering Research group. His present investigations include remote sensing algorithms, thermal infrared satellite imagery of the earth's surface and the development of remote sensing methods for land cove dynamic monitoring and Grid computing.

Asaad Chahboun obtained his degree from Central School of Arts and Businesses in Brussels Belgium, M.S. in Telecommunication Systems from University Abdelmalek Essaadi in 2006. He was Maintenance responsible engineer of radiology and medical imaging materials, at FREELANCE SERVICE enterprise Rabat-Morocco, from 1995 to 2003. Currently, he is a member of Remote-Sensing & Mobile-GIS Unit/Telecoms Innovation & Engineering Research group. His current areas of research are Wireless Sensor Networks, Routing in Ad hoc Network, Network Security, remote sensing, the development of remote sensing methods for land cove dynamic monitoring and Grid computing.