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# Geospatial Database Template for Urban Management in Fez (Morocco)

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## ABSTRACT

In order to develop an urban GIS of Fez, we began with the scoping and feasibility study of the system. This strategic review has identified the characteristics of the urban areas, their problems, needs and existing potential, both in terms of data, equipment or personnel. This contribution focuses on a conceptual modeling of the geospatial database, the proposed template for the system and the quality assurance plan for the project. According to the feasibility study conducted during the first phase, the system must have an architecture respecting the intervention of actors in the city. Therefore, the implementation of the system requires an adequate hardware and software platform for optimum operation of the proposed urban GIS. After identifying technical choices, the financing plan of this scenario has been proposed. This arrangement is structured in three parts: Hardware, Software and Development/Training.

## 1. Introduction

The advances in information technology and opportunities for management and analysis, lead to the generalization of GIS at all levels of the territory. However the implementation of GIS remains an important human and financial investment. Indeed, the implementation of a GIS project is not limited to the choice of an appropriate system and its installation, but requires the existence and interaction of many complex technical and human elements [1,2]. Among the critical factors of the success of an urban GIS project there are the strong political commitment of local decision makers, effective contribution of each actor involved in the process, realistic stages planning for the transition from the existing system to the new system and finally a good communication between stakeholders [3-5]. Thus, GIS is an essential tool for optimizing the services provided by urban municipalities of Fez. The objective of this study is the implementation of the guidelines that were highlighted during the first phase of the urban GIS project of Fez. It will be focused on modeling of the geospatial database and proposition of the implementation scenario of the system.

## 2. Material and Methods

### 2.1. Study Area

This work concerns the historic city of Fez located in the

center-northern Morocco (**Figure 1**). It is 200 km far from Rabat. The region of this study refers to the urbanized area of the prefecture of Fez 105 km$^2$. According to the new administrative division, described by the new communal charter, the prefecture of Fez has two urban municipalities (commune of Fez and commune of Fez Jdid Mechouar). The current population of the city is over 1 million inhabitants [6]. Fez is characterized by a relatively high population density. This density reaches significant values at the old Medina of Fez. The outskirts of town to the south are characterized in recent years by a constantly increasing process of urbanization. Fez is the third largest city in Morocco.

### 2.2. Conceptual Modeling of the Geospatial Database

The diagnosis of the existing and needs analysis showed that urban information is much localized data. Its management thus requires adequate analytical tools that can properly manage the problems of data location, their links and cartographic presentation of the phenomena. Thus, the GIS is considered in a framework where the location information is a fundamental component [7,8]. The geospatial database modeling is one of the most important tasks in the process of developing a GIS. Step devoted to the analysis can be considered more strategic than those devoted to the design and implementation themselves. It

**Figure 1. Location of study area.**

must represent, understand and identify the system requirements to design and implement a stable and efficient application [9,10].

In object-oriented approach, systems are composed of entities called objects. It provides a range of assets to an adequate modeling. The solutions obtained are indeed independent of the hardware changes and therefore more adaptable to any changes in the system [11,12]. It will be possible to extend the treatment options for adding software to existing patterns of new items updating the overall functionality of the model [13].

### 2.2.1. Functional Specification
The case of using a GIS is an essential element of the modeling system. They should allow to design and build a system tailored to the needs of the user during the design phase, implementation and testing. The use diagram describes the system behavior in terms of user in the form of actions and reactions.

The actors identified for the urban GIS of Fez are:
- Data provider: that provides geographic information in the urban area. It produces data in its own area of work. (Cadastre, REDEF, ADER, Urban Agency, etc.).
- Data user: this actor is likely to use the system in place. (Citizen, Administration, etc.).
- Project manager: who controls the urban GIS project and also the actor responsible for the technical administration of the system.
- GIS software: which is the technical solution and its physical implementation through a geospatial database.

### 2.2.2. Geographic Data Dictionary
The data dictionary is the result of analysis phase of existing needs in terms of geospatial data. This data is available either in analog form (maps) or digital (computer support). A data dictionary is a collection of meta-

data and necessary reference data for designing a geographic database. It describes data definition, data type, coordinate system, feature class field properties, relationship diagram and reference table. This is the main referential of the project, relied on by the system developers. It is often represented by table containing the name, code, data type and comments, etc. (**Table 1**).

### 2.2.3. Conceptual Data Model (CDM)
The development of a conceptual data model allows the database by defining objects (object classes), their attributes and their relationships. This class diagram is a very important part of modeling. It allows defining what the components of the final system are. It allows the organization of the work very effectively in the case of work done in groups (which is almost always the case in industrial settings), to separate the components so as to divide the work between members group. The package approach allows defining sub-systems. A subsystem consists of a set of classes each having a certain logical relationship. Often, a package is subject to achieving a largely independent and can be entrusted to a group, or individual not having close contact with leaders of other packages [14,15].

For the urban GIS of Fez, we classified data as the following packages (Features dataset) (Equipment, Urban land, Road network, Cadastre, Activity and point of interest, Raster maps, Vector maps, Administrative boundaries, etc.) (**Figure 2**).

## 2.3. Implementation Template

The development of a GIS project is a multi-dimensional device whose conduct must be based on an appropriate methodology that can be drawn as follows:
- Favorable environment and organization of the institutional and organizational details that can guarantee the establishment of procedures for system operation.
- Availability of basic data (graphic and descriptive) to manage over time in view of ensuring the sustainability of the system.
- Availability of necessary hardware.
- Availability of geographical analysis software with capabilities for creation, management and treatment of localized information.
- Availability of proper functional architecture.

### 2.3.1. Organizational Framework
The implementation of a GIS often involves an adaptation of the institution and the establishment of new operating rules as well as internally related partners. For a long term project, it is clear that we must define an adequate working environment and institutional organization. Given the analysis of the expressed needs and means

**Table 1. Geographic data dictionary of the urban GIS.**

|   | Data designation | Data type | Category | Data provider[1] |
|---|---|---|---|---|
| 1 | City map | Raster | Base plan | ANCFCC |
| 2 | Aerial photography | Raster | Base plan | ANCFCC, AUSF |
| 3 | Satellite image | Raster | Base plan | CRTS |
| 4 | MNT | Raster—TIN | Topography | AUSF, CRTS |
| 5 | Prefecture | Vector polygon | Administrative | AUSF, ANCFCC |
| 6 | District | Vector polygon | Administrative | AUSF, ANCFCC |
| 7 | Neighborhood | Vector polygon | Administrative | AUSF, RADEEF |
| 8 | Plot | Vector polygon | Land | ANCFCC, AUSF |
| 9 | Building | Vector polygon | Base plan | AUSF, ANCFCC |
| 10 | Road | Vector, polyline | Network | AUSF |
| 11 | Hydography | Vector, polyline | Network | AUSF, ANCFCC |
| 12 | Drinking water | Vector, polyline | Network | RADEEF |
| 13 | Sewerage | Vector, polyline | Network | RADEEF |
| 14 | Electricity | Vector, polyline | Network | RADEEF |
| 15 | Hydraulic structure | Vector, point | Network | RADEEF |
| 16 | Electrical structure | Vector, point | Network | RADEEF |
| 17 | Urban area | Vector, polygon | Development plan | AUSF |
| 18 | Under development | Vector, polygon | Development plan | AUSF |
| 19 | Land use | Vector, polygon | Development plan | AUSF |
| 20 | Land information | Alphanumeric | Land | AUSF |
| 21 | Equipment | Vector, polygon | Point of interest | AUSF |
| 22 | Monument | Vector, point | Point of interest | ADER |
| 23 | Point of interest | Vector, point | Point of interest | ADER |

[1]**ANCFCC** (Agence Nationale de la Conservation Foncière du Cadastre et de la Cartographie), **AUSF** (Agence Urbaine et de Sauvegarde de Fès), **CRTS** (Centre Royal de la Télédétection Spatiale), **RADEEF** (Régie Autonome de Distribution d'Eau et Electricité de Fès), **ADER** (Agence pour la Dédensification et la Réhabilitation de la médina de Fès).

required for GIS installation, it was suggested that a progressive development incorporates two complementary implementation scenarios. It will have the advantage of not commit major investments while enabling operational results at limited cost to demonstrate the benefits of such system.

### 2.3.2. Functional Architecture

The proposed geospatial database template is based on n-tier functional architecture. This architecture allows:

- Consolidation and storage of multi-source geographic data interoperable in an urban geospatial database. This database is hosted at the Department of GIS project.
- Administration of geospatial database to provide access to the various participants according to their profiles.
- Update of the database from different data sources from the actors in the urban environment.
- Processing, analysis and display results through features offered by the developed system.
- Dissemination of information stored at the geospatial database for users and stakeholders.

### 2.3.3. Hardware Architecture

The proposed functional architecture requires a hardware platform suitable for optimum operation of the Urban GIS. It requires skills in administration of computer network and Internet access facilitating consultation or viewing data. The n-tier architecture proposed is located
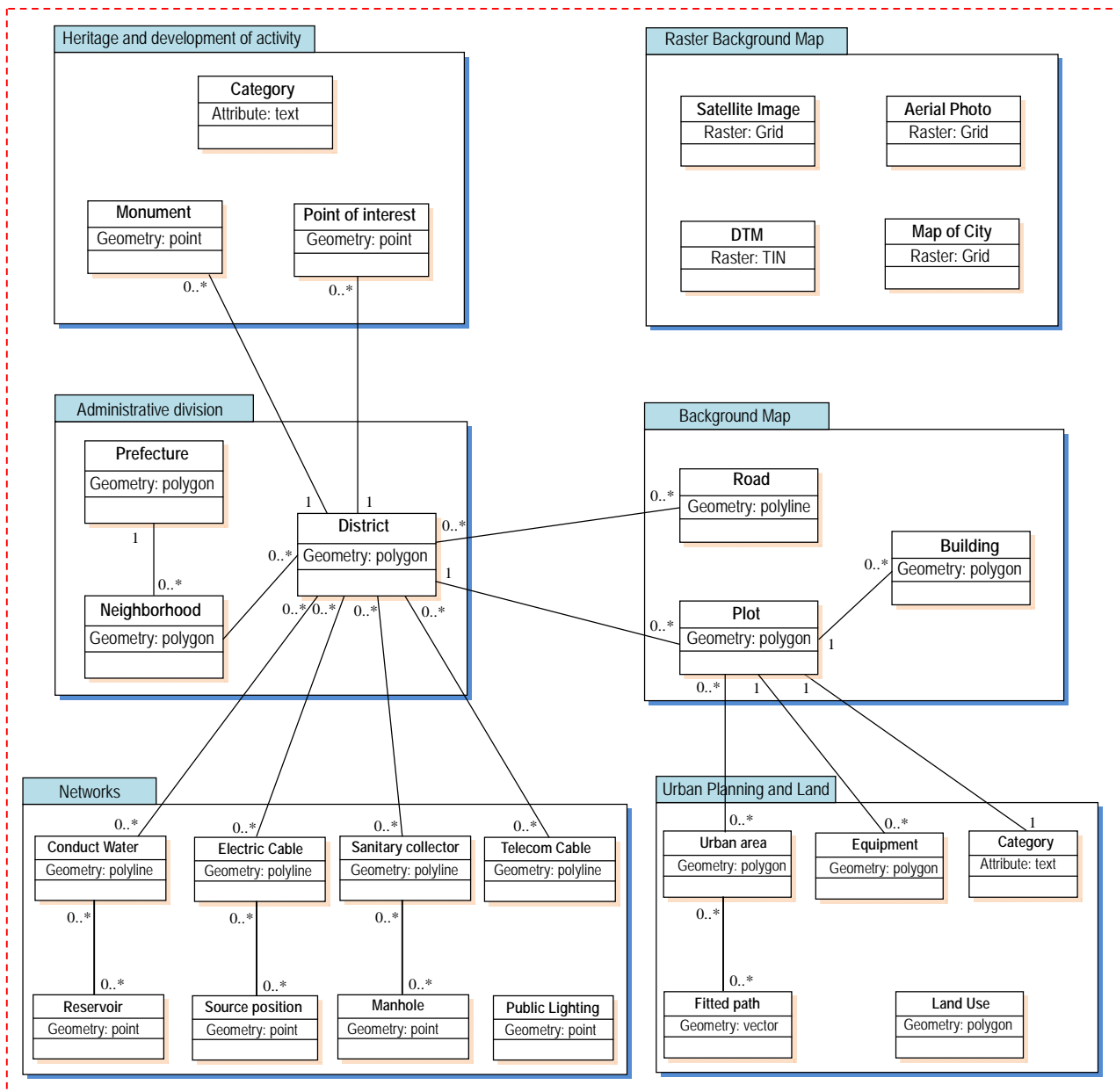
**Figure 2. Conceptual data model of urban GIS.**

on the following material (**Figure 3**):

- Geodatabase server. It ensures the consolidation and storage of the urban database.
- Server machine. It allows the administration, updating and processing of geospatial database.
- Client-machines for consultation.
- GPS and scanner for acquisition and integration of new data into the GIS.
- A0 plotter and A3 color print jet that will print maps and documents from the system.

### 2.3.4. Software Architecture

As for hardware, software selection has been a thorough

analysis so that its functionality and/or business applications derived meet the expectations of key users. The compatibility problem between GIS software, is now solved. Indeed, virtually all GIS software market can integrate and read data from competing software. The criterion of compatibility with the used tools by partners is no longer decisive. However, the criterion for pooling resources and expertise is important in choosing the same software structures to work together regularly. The software architecture adopted is based on two software layers. First, the functional software layer that includes software applications specifically linked to urban GIS solution and operating these modules. Second, the software layer
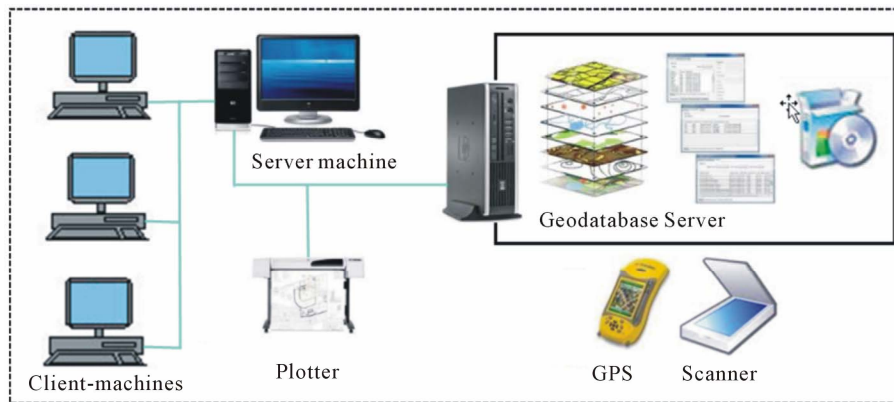
**Figure 3. Hardware architecture of the Fez urban GIS.**

that includes the support software for the operation of the hardware (client or server workstation).

### 2.3.4.1. Server Side

The server contains the following software platforms: the DataBase Management System (DBMS), a cartographic server and web services (**Figure 4**).

The choice of a DBMS is based on a comparison and classification of a set of capabilities offered by four DBMS (Oracle Spatial, SQL Servers, My SQL and PostgreSQL). Oracle Spatial tops the rankings followed by PostgreSQL/PostGIS. However, attention is on the second choice because it is open source, and is almost as powerful as Oracle Spatial.

The map server is the tool used to display maps on a computer workstation. It is controlled by scripting languages such as PHP, JavaScript, Python or Perl that allow it to dynamically generate a map in response to a

prepared statement by a user interface. GeoServer offers nearly the same features and same performance as Arc-IMS, ESRI licensed product.

For the web services, we opted for the choice of Apache Tomcat, not only because of its free status, but also for its vast popularity.

### 2.3.4.2. Client Side

For specific users in the department where the system is hosted, the solution involves GIS platform software. This solution is the core of GIS that handles update, processing and analysis of geographic database. We believe that ArcGIS is the software that allows more functionality while maintaining ease of use. This is valid only on condition of having extensions such as Network Analyst for network analysis and Spatial Analyst for raster analysis. Also to ensure more geo-processing tool, we adopted the ArcGIS ArcEditor.

The system configuration allows also a wide distribution of the geographic data for various stakeholders and other users in the urban areas of Fez. The position of the user requires no technique installation. It takes only a web browser and an Internet connection.
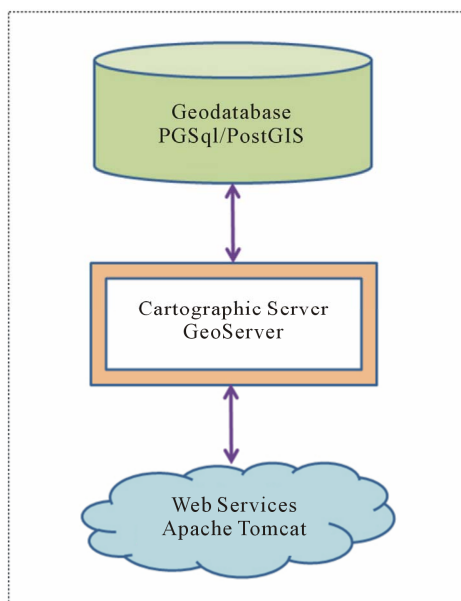
## 3. Quality Assurance Plan for the Urban GIS Project

The Quality Assurance Plan is a document that describes the specific agreements between the client and the contractor to meet the quality requirements needed for the project. These agreements are established early in the project and may be revised and modified, if necessary, throughout the project. Planning involves setting quality standards and quality rules relevant to the project (contractual rules and requirements established by the quality policy) and the determination of conditions of the products satisfaction and activities that make up the project. The expected goals of quality assurance plan are:

- Definition of the quality requirements of urban GIS



**Figure 4. Platform software at the server side.**

*JGIS*

and criteria to check and track.

- Ensuring compliance with the commitments acquired in each phase of the project, the requirements of each step, as prerequisites to move from one phase to the next.
- Definition of the necessary resources and activities to ensure the project completion.

To reach these goals, a contract is signed between the financial organism (the Ministry) and the research organism (University). This contract includes details of how to perform the following tasks:

- Project monitoring (project plan, deliverables, etc.).
- Annual checks to be carried out during all stages of implementation.
- Treatment of nonconformities and corrective actions.
- Audits to be carried throughout the project.

## 4. Conclusion

This paper described the development of a geospatial database for urban management of Fez. For this project, we have identified the characteristics of urban areas, its problems and needs, whether in terms of data, equipment or personnel. For the successful implementation of this system there are several challenges, it includes a good initial design of a plan of development according to the appropriate methods and practices to each particular user. In this stage of the project, we conducted the conceptual modeling of geospatial database (functional specification, geographic data dictionary and conceptual data model) and the proposed implementation scenarios of the system that concerns, organizational framework, functional architecture, hardware architecture and software architecture. The GIS is based on a transversal architecture respecting the intervention of actors in the urban areas of Fez, and allowing mutual access to the various actors according to their profiles. After identifying the technical choices, the financing of this scenario has been proposed. To ensure compliance with quality standards for the project and determining the conditions of satisfaction of products and activities of the project, a quality assurance plan was necessary.

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