

## DEVELOPMENT OF A COLLABORATIVE PLATFORM FOR INTELLIGENT TERRITORIAL MAPPING OF THE CITY OF ORAN

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### ABSTRACT:

In developing countries, sustainable development and territorial intelligence are of greater interest to public authorities and citizens. In Algeria, the combination of resources with technological innovation goes in the direction of building a productive territorial intelligence. This translates into a process aiming at developing a systemic approach of the territory in order to analyse its physical, social and economic dimensions in order to exchange the different points of view of the different actors and to make the policies more coherent. In this contribution, we have focused the research on studies related to decisional computing and participatory mapping initiatives through Voluntary Geographic Information (VGI), citizen-generated content or crowdsourcing, are now being used as a new instrument for information gathering and two-way exchange between the various entities in the urban environment, ranging from ordinary citizens to leading actors. Mapping and urban planning thus becomes smarter, in particular through the updating of data, reporting information on needs in terms of public services (roads, streetlights, signs, rubbish, etc.), alerts in the event of emergencies. The objective of our work is to provide an interactive solution, ensuring the collaboration of actors for the visualization of urban geospatial data on Oran city (western Algeria), but also, for mapping and reporting street problems for fixing them by the local authorities. The 'WILAYATI' platform, under development, will allow citizens to participate in improving their environment, and will be a challenge for the government in terms of intelligent territorial mapping and smart urban governance in Algeria.

### 1. INTRODUCTION

Web mapping today is characterized by high interactivity and user-generated content based on geo-localization. Thus, connected citizens are able to act as sensors in order to contribute to data collection initiatives for the enrichment of the geographic database of their region or even their country. This direct data is a key element in all the decision-making processes leading to the achievement of urban governance modalities. Collaborative digital platforms use the concept of Volunteered Geographic Information (VGI). VGI implicates the use of tools to create, assemble and disseminate geographic data voluntarily provided by individuals, and can be generated via browsers or smartphone apps, using geo-referencing or geocoding tools and techniques. It turned out that the use of participatory web platforms, involving several actors belonging to different spheres (government, economy, social, etc.), constitutes a tool for the development of territorial intelligence thanks to the availability of data, which allows a considerable saving of time and cost. This will allow, among other things, the development of project management through the formalisation of objectives and collaborative work for the planning and optimisation of tasks. Indeed, the construction of a territorial information system makes possible the networking of different actors, to elaborate clear and reliable schemes of urban planning for a liveable environment, which led us to think about the implementation of a web mapping platform for exchanges, collections, production and dissemination of data and social animation to reach equitable consensus. Therefore, the interest

and necessity of sharing geo-located information for decision support systems is well proven nowadays.

In our project, the objective is to develop an interactive cartographic platform for the diffusion of geospatial data on the urban environment of the city of Oran (located in the west of Algeria). This paper briefly presents the design steps and methodology we followed for the development of the platform, that we called 'WILAYATI', designed to provide a quick and efficient way for citizens to report problems occurring in their urban environment while visualizing existing data on the map. These problems may be related to roads, lighting, signage, public cleanliness, green spaces and other street needs. It could, also, be used for emergency alerts (road accidents, natural disasters, etc.). This web mapping app will provide a new data source that could be easily used by government authorities to improve regular updates to the geographic database and highlight points of interest of the city, as seen by citizens.

### 2. RELATED WORK

In order to have an overview of the subject discussed in this paper, in the field of smart urban e-governance, we reviewed some previous work in the literature.

A recent study, by O. Gil et al (2019), reveals an important point, which is the relationship between e-governance and smart city initiatives. The authors review the rise of digital media platforms in e-governance, analysing application cases and

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existing e-platforms for government-to-citizen and citizens-to-government services, for example. The authors surveyed thirteen platforms, such as *Better Reikjavik* (Iceland), *Fix My Street*, *Open Street Map* and *Small Business Research* (UK), *Línea Verde* (Spain), *Madame la Maire, J'ai une idée* (France), *New Urban Mechanics* (USA), *Sharing Car* (South Korea), and *Ushahidi* (Kenya). The researchers aimed to show the representation of the use of information technologies by these e-platforms and the objective of encouraging citizen participation in decision-making processes, improving information and service provision, and strengthening transparency, accountability and credibility.

According to Derfouf et al. (2019), the contribution of Territorial Intelligence (TI) in the strategic equation of development, as a system that meets the needs of an intelligent and participatory territorial approach, demonstrates the role of TI in the new trajectory set by the Algerian government for local authorities, as a management mode in favour of areas of intelligent economic activity. In the authors' opinion, TI fully agrees with the principles of territorial governance in order to create a space of partnership between all political, economic, institutional and social actors in the perspective of a sustainable development project. They found that, in the same context, the exploitation of a territory depends largely on the capacity to collect and process information present in the environment and that will enable it to diagnose, identify and, ultimately, develop its resources. From this perspective, the researchers deduced that TI enables the creation of a learning environment conducive to endogenous territorial development by providing the possibility of disseminating knowledge essential to the development of a territory.

In another context, the evolution of the concept of City-as-a-Platform, where the role of government in the provision of services and in the definition of public policies, was defined by Repette et al. (2021) as a new form of urban governance that is more open and participatory, with the use of technology in organising and mediating the collaboration of different actors in society for the development of smarter cities.

Among a multitude of projects related to the issue of urban governance using crowdsourced data, one project in particular comes very close to our objectives. "The Urban GEOmatics for Bulk Information Generation, Data Assessment and Technology Awareness (Urban GEO BIG DATA) is a project aiming to develop innovative Geographic Information System (GIS) methodologies and tools to exploit the integration of traditional geomatics data, Earth Observations (EO) and statistics data with new user-generated contents for promoting more effective management of urban resources and infrastructures" (Brovelli et al., 2019). As mentioned by the authors, the percentage of world population living in urban areas (according to the UN-ESA reports), is expected to increase up to 66% by 2050. Therefore, geospatial data needed for the management of the alteration of the social and cultural aspects related to the worldwide urban growth has to be handled and integrated into an efficient geospatial big data system, to benefit as much as possible, much more sustainably. Their methodology was based on two main points: a data-driven decisional approach needed to turn the huge amount of data generated daily into useful information for decision-makers, and, data mining with a particular focus on the exploitation of Open Data. Their study explored three main topics: urban mobility, land cover and soil consumption and generation of ground displacement time-series. All three cases were developed and implemented using an interoperable and

distributed Free and Open Source (FOS) geospatial data infrastructure sharing on the Web the multi-source heterogeneous geo-data of the project. Data was collected by the use of spatial and spectral resolutions of optical EO data, as Sentinel-2 images, regional topographic databases, VGI and in situ data, manual photo-interpretation, Synthetic Aperture Radar (SAR) images, floating car data by GNSS receivers, etc. Brovelli et al. (2019), presented the Urban GEO BIG DATA as "a collaborative web platform consisting of several components: local data nodes for data and related service Web deploy; a visualization node for data fruition; a catalog node for data discovery; a CityGML modeler; data-rich viewers based on virtual globes; an INSPIRE metadata management system enriched with quality indicators for each dataset". The metadata editor EDI has been used in the creation of metadata compliant with several standard schema (for example, deploying the CSW through GeoNode tool and relative services through GeoServer Web GIS server). In addition, the researchers implemented the Data-as-a-Service (DaaS) concept in this project in order to manage, maintain, and update any given data source easily and securely. Their conclusion focused about "the efforts necessary for collecting, integrating and sharing spatial information through open tools, providing access to researchers and other stakeholders that can create added value to the data. The main purpose of this work was about supporting the key process of converting spatial data into spatial information, which is of paramount importance to current and future geomatics approaches to big data" (Brovelli et al., 2019).

In their project, Kurniadi et al. (2019) have developed a public service location mapping system based on geographic information system (GIS) for mapping public services locations. Indeed, one of the information that is frequently required by the public is the location of public service. Various categories of primary and secondary public services are included to the system such as government institutions, law enforcement institutions such as police stations, health institutions such as hospitals and health centers, educational institutions such as schools and universities, banking institutions, places of worship, and other public institutions. The system designed is made in the hope of that it will help the community at large in order to get quick search functionalities, geo maps for presenting data, information about where the public services are equipped with photos, the knowledge of the nearest public service location, the display of the travel itinerary between the user's location and the destination, and add data by users with social media login functionality and easy access via an Android smartphone. Two types of users are in the Geographic information system: *Administrators* (can manage data on the public service object site from data collected through a Web-based interface) and *Users* (can find the public service place to visit with an Android smartphone-based interface). Authors conclusion was that based on the results of the tests, the use of an app based on an Android platform will further maximize the functionality of the application system mapping the location of public services.

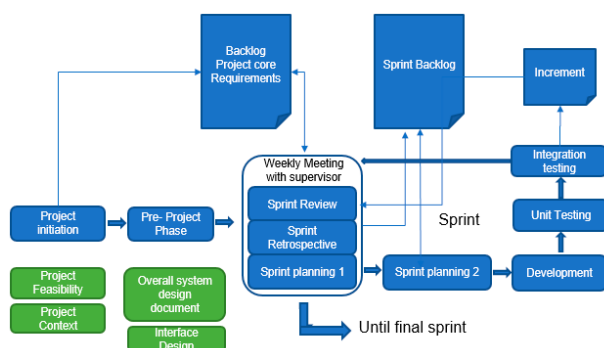
Longo et al. (2020) had the objective of developing a platform, named "Apollon" (environmentAI POLLution aNalyzer), for urban environmental monitoring and analysis (i.e. air quality, noise and UV). They managed to propose an approach for reach these four research purposes: development of a multi-parameter platform to monitor noise, air pollution and meteorological pollution; allow scientific citizens and professionals to contribute and collaborate on citizen science projects; dissemination of citizen science from the educational field;

clearing the way for Massive Online Open Laboratories (MOOLs) experiences. The “Apollon” application was described as “a solution that consists of: 1) a cloud-based platform with the following microservices: web component, discovery, edge, noise monitoring and air monitoring; 2) a dedicated mobile app (for Android devices) for enabling citizen scientists to contribute to collaborative environmental monitoring activities in smart city contexts and 3) a Web portal for distributing measurement results to community and to the interested stakeholders (e.g., policy makers, teachers, etc.)” (Longo et al., 2020). The researchers demonstrated that a supervised citizen science experience involving volunteers, schools and public administrations, is able to increase the quality of data coming from citizens and increase public awareness on environmental pollution.

### 3. METHODOLOGY

The purpose of this work is to integrate the concept of citizen participation and collaboration in the collection of data on the urban environment, through a digital platform dedicated to intelligent territorial mapping. The web platform consists of four components: the web map containing the classified data layers, the contribution application for sharing data on the urban environment, the citizen user interface for reporting street problems and, finally, the administration application with authentication for local authorities. As a study area, we chose the city of Oran, located in the west of Algeria, which is the second largest urban metropolis in the country. The methodology adopted, in our work, was the scrum incremental (or scrum agile) method of the Software development life cycle (SDLC).

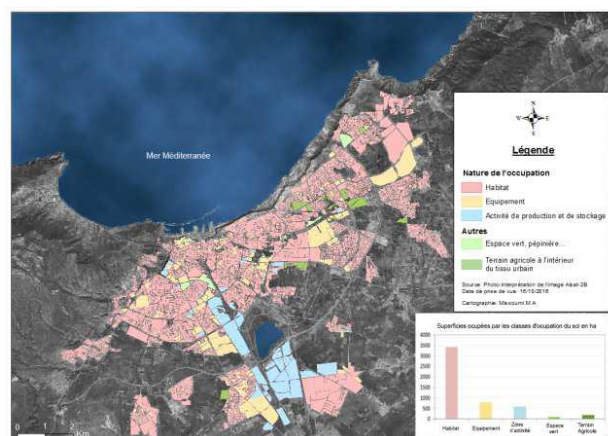
A generic SDLC consists of five phases including requirements analysis, software design, software implementation, and software testing. In brief, the requirements analysis phase is the process of capturing user requirements and producing software specifications. This method is based on an incremental delivery of software functions, i.e., the software is built step-by-step, whereby at each of the subsequent stages of the project implementation. The workflow, in scrum agile process, is divided into so called sprints, i.e., time-boxed units of work during which a specific sub-component of the project is to be delivered (Figure 1). Scrum is the most popular agile framework due to its capacity to boost the efficiency of the software development process, including the speed of delivery and the quality of the software itself. Scrum is a simple to understand and lightweight framework, defined as an empirical process, based on three pillars, such as transparency, inspection and adaptation (Saeedi et al., 2021).



**Figure 1.** Scrum agile software development process (Saeedi et al., 2021).

### 3.1 Data collection

The design process began with the collection of different types of data on the urban fabric of the city of Oran, such as land use (Figure 2), housing typology, road network, points of interest, etc. Most of the information layers were produced with remote sensing methods, such as large-scale photo-interpretation of satellite images, as part of a previous work on cartography and monitoring of urban dynamics of the city of Oran (Missoumi et al., 2019, Hadj Kaddour and Missoumi, 2021).



**Figure 2.** Land cover map of the city of Oran.

The road network datasets were obtained from OpenStreetMap (containing Highway map features). They were imported to the database after improving their intrinsic quality (as shown below in the Figure 3).



**Figure 3.** OSM data processed and rectified on the road network of the city of Oran.

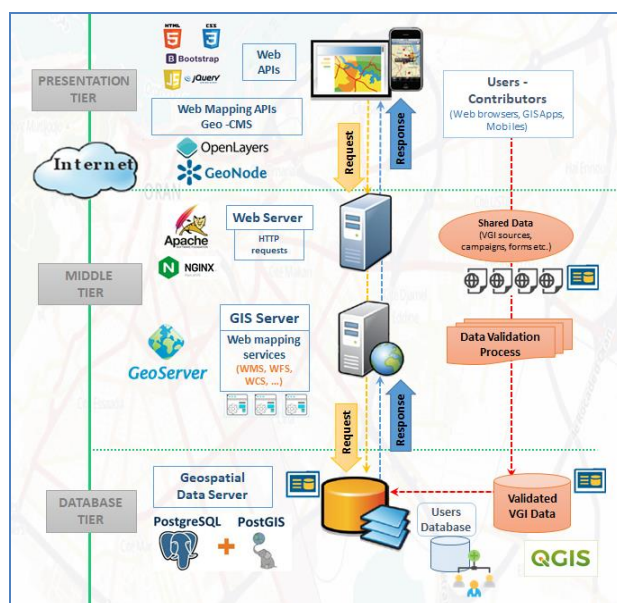
The initial modelling of the database was designed based on point of interest classes categorised by associated utility, road network classes and building classes. A data catalogue was, then, created for subsequent online publication. During this stage we used the open source GIS software QGIS for manipulation and preparation of the data layers for future online publication.

In parallel, a campaign on social networks is currently being considered, with the aim of better analysing the orientations of the public services most requested by citizens.

### 3.2 Platform system architecture

The system of the collaborative web mapping platform is based on Client-Server architecture relying on the following three main levels (see Figure 4):

- **Database tier:** for the management and security of geospatial data and user accounts. For the geo-database management server, we used PostgreSQL/PostGIS with PostGIS extension. The fundamental datasets are feature classes, raster datasets and tables.
- **Middle tier:** communication between Clients and Servers (management of users, monitoring of changes made to the platform with the processing of collected data), GeoServer is used for web mapping services. For HTTP web services, we used Apache Tomcat Web Serve and NGINX.
- **Presentation tier:** for the visual structure and functional aspects of the GUI. We used JavaScript libraries such as OpenLayers for the development of the cartographic interface and the customization of the visual and functional options of the web map. The front-end is designed to allow the visualisation of various types of spatial data formats (e.g. GeoJSON, Web Map Service, Web Feature Service, ESRI Shapefile, and GeoTIFF).



**Figure 4.** Architecture adopted for the collaborative web mapping platform system.

The development and implementation of the platform are based on Free and Open-Source Software for Geospatial (FOSS4G). First, the preparation of the data layers to be published online is handled by the open source GIS system QGIS.

The following is the data storage phase, as a spatial database management server, we used PostgreSQL with its spatial extension PostGIS, which is classified as one of the most powerful open source DBMS, through its performance and the handling of various data types and supporting the Open

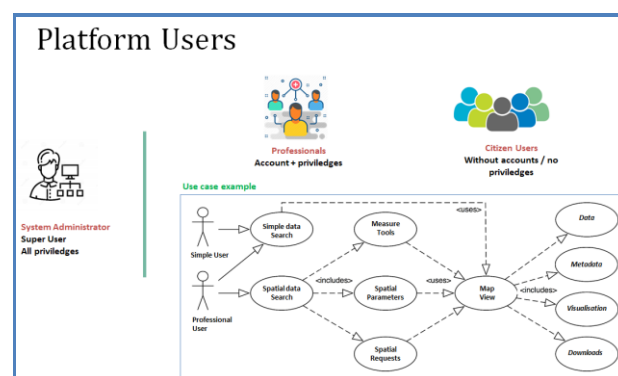
Geospatial Consortium (OGC) standard. PostGIS spatially enables PostgreSQL to be used as a backend spatial database where all geospatial data is configured, transformed and loaded.

The GIS server used in our application is GeoServer, which guarantees to satisfy a maximum of required web mapping services by exploiting OGC standards such as WMS (Web Map Service), WMTS (Web Map Tiles Service), WFS (Web Feature Service), WCS (Web Coverage Service) and WCPS (Web Coverage Processing Service), CSW (Catalogue Service for the Web), the OGC best practice for implementing WMS with time support (WMS-T). GeoServer is capable of managing the data stored in the spatial database and providing the final map images visualized by the platform users.

The web-mapping interface must offer two main components: on the one hand, an interactive citizen UI with the web map and the contribution app forms for sharing data and reporting street problems and, on the other hand, a specific authentication and management app for decision makers who will be able to consult, verify and validate the data sent in order to proceed with the action.

Among the development options for this type of web mapping interface intended to various user categories with specific privileges, for security purposes, (system super administrator, user administrators filtered by government public service type, analyst users, data collectors), we are interested in GeoNode, an open source framework based on mature and robust tools and software like Django, OpenLayers, PostGIS, GeoServer and pycsw.

In our case, the GUI developed using the OpenLayers API with web programming tools (HTML/CSS and JavaScript) will allow the integration of a multitude of geospatial functionalities for citizen-users on the web mapping platform (such as visualising data, searching locations of public utilities and reporting street problems), and for administrator users of the local authorities, the second main part of the platform will be developed using GeoNode framework enabling authenticated users to manipulate and validate collected data and to respond to any type of request on the web map. The figure 5 shows an example of use case of the two main types of potential users of the platform.



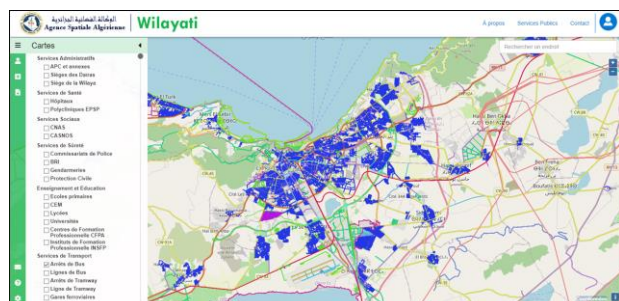
**Figure 5.** Example of a use case diagram of the web application.

## 4. PRELIMINARY RESULTS

The main parts of the platform 'WILAYATI' have already been accomplished and successfully tested on a LAN network. The



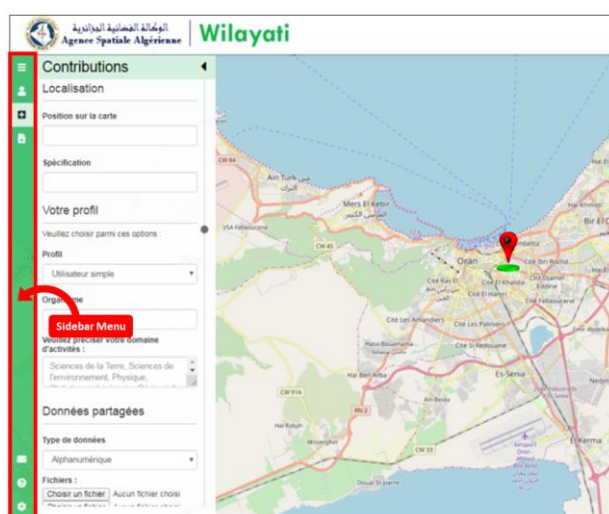
most important part is the web map allowing citizens of all categories to visualize and search for information about public services and other data available on the platform within the territory of the city of Oran. As shown in figure 6, a 'Data Catalogue' is provided to users in the left sidebar menu. As an example (on Figure 6), the road network of the city of Oran with the OpenStreetMap base map.



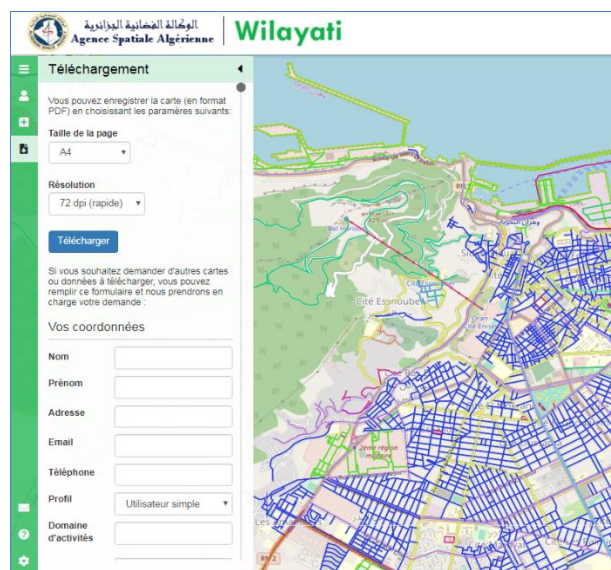
**Figure 6.** View on the platform 'WILAYATI' GUI for data visualisation. Example: Map of the OSM road network of the city of Oran.

Other features of the platform are accessible on the same left sidebar menu such as:

- **Login panel:** for professional users categorised by sector of activity.
- **Contribution form:** for any citizen-user who intends to add information on a specific location (correction or new information). A citizen-user may choose to add content according to the mouse selection (point, line or polygon). The contents on the given calculated coordinates will be imported into the geo-database (Figure 7).
- **Downloading panel:** download an image of the web map with the selected data layers and their legend (in PDF format using the jsPDF library), (Figure 8).
- **Interaction tools:** for example, to select, draw, measure, rotate and modify features).



**Figure 7.** Contribution form based on the selected location on the map.



**Figure 8.** Download form based on the map view.

We are currently working on the development of the other participatory component which is the Reporting section. This part will be inserted into the GUI as a multi-step form for entering all details about the incident (exact localisation, nature of the problem, description, photos, etc.). Authentication and administration apps are under development with the GeoNode framework. We note that the installation and configuration of the GeoNode framework, on the server station on an Ubuntu 20.04 LTS 64-bit environment, has been successful and that the modification of the Administrator interface components is in progress.

Finally, the integration phase of the different components of the platform, with the accomplished OpenLayers web map, will be carried out afterwards in order to finalise the realisation of the 'WILAYATI' collaborative web mapping platform dedicated to the public services of the city of Oran for citizens.

## 5. CONCLUSION AND FUTURE WORK

In this contribution, we introduce the collaborative web mapping platform called 'WILAYATI', currently under development, for support in intelligent territorial management. The region of the city of Oran was chosen because it constitutes a very important urban pole in Algeria. For this reason, Oran is a booming city with a constantly growing population. These parameters help to have considerable databases for the platform. At the present time, the geospatial-data visualisation interface already provides access to the database published on the server and the execution of the selection queries for searching data. As further work, on the one hand, the processing of new datasets collected is in progress and, on the other hand, the other components and functionalities of the platform are under development such as the creation of a validation process for contributions shared by citizens for the updating of the geodatabase, the authentication interface, the reporting tools and the administration platform.

This project will provide a practical instrument for territorial mapping professionals while taking advantage of the concepts of collaborative information and VGI-based system and, also, highlight the important and priority points of the city as seen by the citizens. This process will be of fundamental interest for a

statistical and data quality analysis from both the perspectives of territorial management for urban governance and citizen participation in the field of smart cities in Algeria subsequently.

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