Implementation of an Intermunicipal Spatial Data Infrastructure

The Intermunicipal Community – Terras de Trás-os-Montes Case Study

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The number of municipalities (9) that make part of Intermunicipal Community of Terras de Trás-os-Montes (IMC-TTM) hence the dispersed and although diachronic different geographical information systems (GIS) existing solutions, plus the responsibilities of intermunicipal communities (combined authorities) in different domains, set a compelling need for the implementation of an intermunicipal spatial data infrastructure (SDI) that allow the availability of updated and interoperable geographic information.

In this context, IMC-TTM implemented a SDI in open source software, working as a single, uniformed central repository, transversal to the municipalities, allowing a greater effectiveness and efficiency of local governments in the management and development of the territory.

If IMC-TTM SDI should facilitate access to geographic information - assure efficiency and effectiveness of territorial decisions, adopt European and national policies, industry standards (OGC standards), joint work methodologies, define and use common data models, have a unique SDI access point to all users, eliminate data duplication and allow the optimization of data maintenance tasks -, then we have adopt a solution based on geOrchestra framework and have installed it. It's an open, modular, interoperable and secure software solution that allows the registration of the different stakeholders and access through different user profiles.

The first part of this paper presents the four phases of the project implementation, coming up with some lessons for helping future efforts of IMC-TTM and other inter-municipal communities that are developing similar projects. In the second part of the paper the technical solution is described.

KEYWORDS

Intermunicipal SDI; OGC; INSPIRE; FOSS; geOrchestra.

1. INTRODUCTION AND CONTEXT

A spatial data infrastructure (SDI) can be defined as a system of systems composed of a set of very heterogeneous resources (data, software, hardware, metadata, services, standards, staff, organization, legal framework, agreements, policies, users ...), managed by a community of stakeholders, to share geographic information (GI) on the web in the most effective way possible [1]. This definition is one of several definitions of SDI that can be found in the literature. For municipalities and intermunicipal communities (combined authorities), one of the most important issue in the SDI definition is the possibility of easily overcome the traditional problems of geographic information systems (GIS) implementations in municipalities. The overcoming of these problems implies a paradigm change in the use and management of geographic information.

Considering the responsibilities of intermunicipal communities in different domains, the implementation of intermunicipal SDIs that allow the availability of updated and interoperable geographic information is a necessity to decide properly on the territory.

In this context, the Intermunicipal Community of Terras de Trás-os-Montes (IMC-TTM) has developed a SDI, in open software, working as a single, uniformed central repository, transversal to the municipalities, allowing a greater effectiveness and efficiency of local governments in the management and development of the territory.

If IMC-TTM SDI should facilitate access to geographic information, assure efficiency and effectiveness of territorial decisions, adopt European [3] and national policies [2]; industry standards (OGC standards), joint work methodologies, define and use common data models, have unique SDI access to all users, eliminate data duplication and allow the optimization of data maintenance tasks, then become obvious that a solution based on geOrchestra framework [6] was a good solution and should be installed.

The geOrchestra technology solution was chosen for IMC-TTM's SDI implementation based on the following principles: use open source software, incorporate OGC standards [4] and INSPIRE Directive [3], universal access to information, and ensure project sustainability.

The first part of this paper presents the four phases of the project implementation, coming up with some lessons for helping future efforts of IMC-TTM and other inter-municipal communities that are developing similar projects. In the second part of the paper the technical solution is described. This description includes the SDI framework overview, the software architecture, main functionalities and the data publication workflow.

2. PROJECT IMPLEMENTATION

The implementation of the IMC-TTM SDI took place in four phases, which are presented in the following points.

2.1. PHASE I

The first phase corresponded to the diagnosis of the existing information, definition of the scope and the set of layers to include in IMC-TTM SDI and includes three main tasks. This phase began with the diagnosis of the information in use by IMC-TTM and the availability assessment of existing management and storage systems. The next task was the elaboration of a technical report with a SWOT analysis to define the intermunicipal SDI implementation strategy. The report starts with the AS IS approach where the following items were analyzed: assessment of the technological infrastructure, analysis of the GIS software and existing applications, diagnosis of the existing geographic information and the diagnosis of the needs and priorities of IMC-TTM departments. The second part of the report is the TO BE approach. This part of the report includes a proposal over the following items: the support infrastructure, the information editing/maintenance matrix, the functional architecture, the application architecture, the data model, the nomenclature layers rules and the organization of metadata.

Regarding the results of the SWOT analysis, the following strengths were identified: qualified human resources with experience in FOSS; several GIS projects prepared and published on the Internet; extension of the IMC-TTM competences with implications for the management of shared geographic information; existence of a collaborative context and availability of technological infrastructure (hardware and software) for the development of the SDI. The identified weaknesses were: different realities in the management of geographical information between the municipalities; the geographical information in the municipalities is not centralized; the geographical information in the municipalities is not shared; the procedures for updating and maintaining the geographical information in IMC-TTM database by the municipalities are not explicit; the organization and systematization of geographic information in the database is not explicit; existence of duplication of themes and temporary themes or results of processing; network bandwidth with limitations to serve geographic information on the Internet; absence of domain in the LAN and existence of outdated base cartographic information. The opportunities for the development of the project are: strong motivation; scale gains associated with the number of municipalities involved; common geographical information needs arising from legal obligations; existence of a common project containing the strategic guidelines for intermunicipal SDI and financial support available on an intermunicipal scale. The threats to the project development are: budget constraints; resistance to change; effort duplication in geographic information maintenance; absence of human resources in some municipalities in GIS; absence of data dissemination and sharing policy; lack of responsibilities definition for maintaining geographic information and lack of a domain server. Considering the strengths, weaknesses, opportunities and threats identified, the following strategy (Table 1) was designed:

STRATEGY (Strengths Opportunities)	STRATEGY (Weaknesses Opportunities)
Development of a multi-year training plan focused on the management / maintenance component of the SDI geographic information Establishment of implementation priorities and linking these priorities to harmonized data models (eg tourism, heritage, etc.)	Separation of the production environment from the development environment Functional Architecture should preferably be based on a maintenance approach through browser tools Migration of existing data to a harmonized data models
STRATEGY (Strengths Threats)	STRATEGY (Weaknesses Threats)
Accountability of users in maintaining data through the publication of sectoral projects on the Internet Development of workshops by municipality focused on the management / maintenance component of the SDI geographic information Development of a regional seminar to present results (involving municipalities) Quality certification of the IMC-TTM GIS department	Implementation of open source technical and application solutions Implementation of an open data policy Definition of operational procedures that ensure the updating of geographical information and the accountability of services Provision of technical support to municipalities in sectoral projects to be developed (involving the expansion of the SDI)

Table 1: IMC-TTM SDI implementation strategy.

The last task of this phase consisted in the structuring and organization of metadata to meet the INSPIRE directive. For the structuring and organization of the IMC-TTM SDI metadata, the GeMA application (Azores Metadata Manager) was initially used, followed by its publication and availability through Geonetwork.

2.2. PHASE II

The second phase of the project was the physical implementation of spatial data infrastructure in open software and includes two tasks. The first task was the definition of SDI catalogue, storage and data sharing model. The second task was to install the software and configure the SDI components. The underlying principles were the following: the database management system should be Postgres / Postgis; the geoprocessing services should ensure data access and editing and support for WMS and WFS services with metadata developed and updated; each municipality should visualize the geographical information of the adjacent territory, but may only be allowed to edit for the information it owns; the IMC-TTM should be the system administrator holding all the permissions for configuration, database design, performance monitoring, security, troubleshooting, as well as backup and data recovery.

2.3. PHASE III

The third phase of the project was the insertion of information into the database. The information integrated in the database was mostly the information covered by the existing databases and their reuse, avoiding generating duplication and / or incoherence of information. The information initially inserted in the database was the following: vectorial cartography at 1/2000, 1/5000 and 1/10000 scales; master plans geographic information; existing infrastructures such as water supply and wastewater drainage; public transport circuits and school transport circuits; information from the forest fire plans, hazard maps, road network, water points and other geographic information on existing public facilities.

The layers provided by municipalities, when possible, were harmonized, adopting national data models associated with legal standards (eg master plans, forest fire plans and emergency plans) or INSPIRE data models (eg toponymy, infrastructures, equipment's). This harmonization process was carried out using the HALE tool.

The layer organization for the development of an intermunicipal SDI is a critical point since it establishes the easiness of access and maintenance. For the development of the IMC-TTM SDI, the following model was used to organize the layers (Fig. 1):

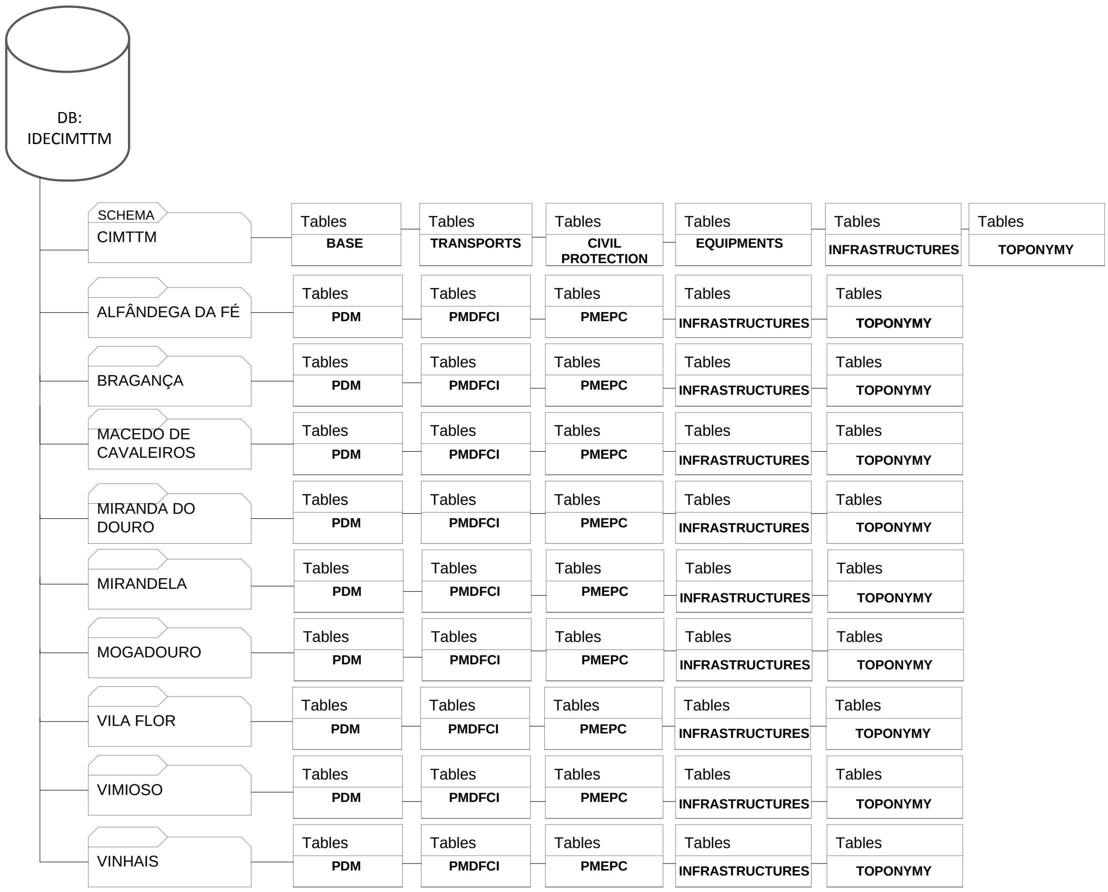

Figure 1: Layers organization.

This model is characterized by the separation of municipal management layers into different schemas in a single geographic database (IMC-TTM SDI database). The municipal and intermunicipal layers are stored in the schemas through the tables nomenclature standardization.

2.4. PHASE IV

To proceed to the transfer of knowledge to IMC-TTM technicians and municipalities, two training actions (on the functional level and in the maintenance of the solution) were carried out. The training actions were directed to IMC-TTM users, municipalities users, IMC-TTM SDI administrators and municipalities administrators. The training actions themes were: management of profiles and users; publication of data in Geoserver; visualization, querying and editing geographic information in map viewer; and management of metadata in Geonetwork.

3. INTERMUNICIPAL SDI CHARACTERISTICS

3.1. SDI FRAMEWORK OVERVIEW

Two open source technological options for implementing the framework of the IMC-TTM SDI have been evaluated. The following solutions were considered: GeoNode (http://geonode.org/) and geOrchestra (http://www.georchestra.org/). Although the software modules and the geographic database for the two solutions (GeoNetwork, GeoServer and PostgreSQL/PostGIS) are the same the option fell on geOrchestra mainly for the flexibility for implementing other modules. One of these new modules is the civil protection event management.

The SDI can be accessed through the following link: https://ide.cim-ttm.pt/mapfishapp/ (Fig. 2).

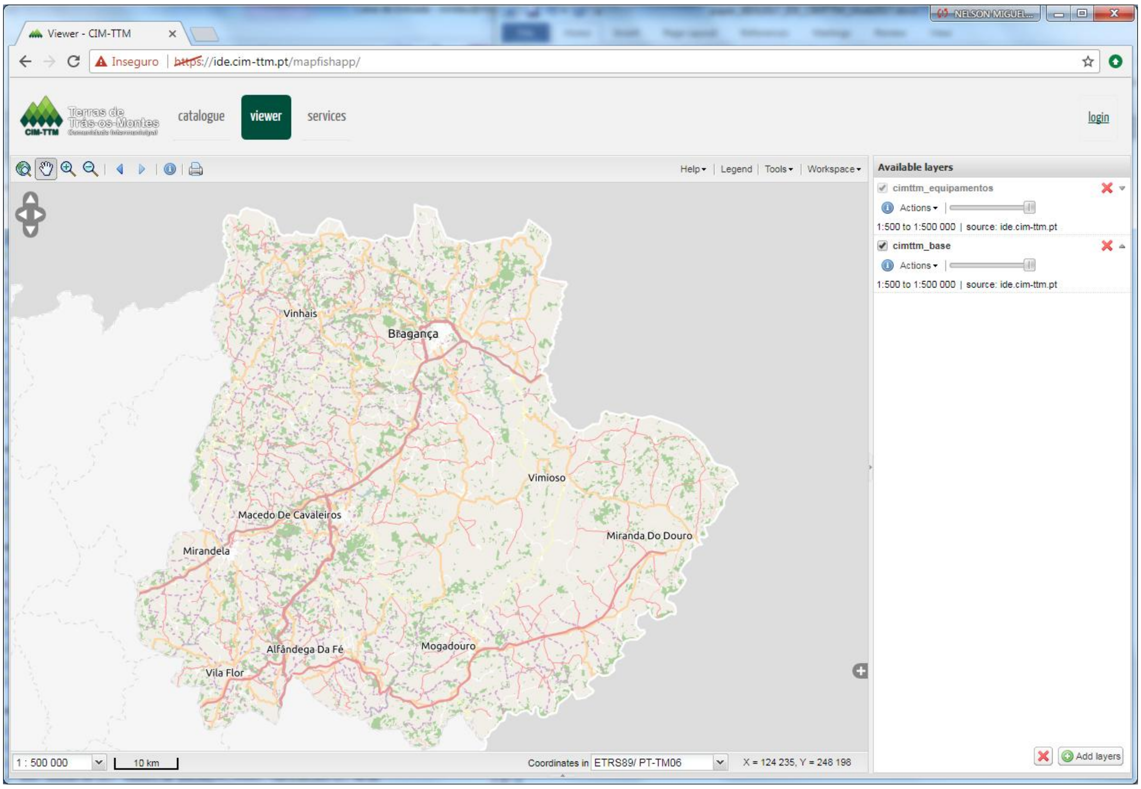

Figure 2: IMC-TTM SDI layout.

One of the main reasons associated with the geOrchestra solution is the ability to manage permissions that can be assigned to users. Given the inter-municipal character of the SDI, there's the need to include users of several entities with different levels of access. For instance each municipality visualizes the geographical information of the adjacent territory but can only have edit permissions for the information it owns. These conditional access resulted in the following user profiles:

- Super Admin - IMC-TTM;
- Admin - IMC-TTM;
- Master User - IMC-TTM;
- Basic User - IMC-TTM;
- Admin – Municipality;
- User – Municipality;
- User – Citizen.

3.2. SOFTWARE ARCHITECTURE

The software architecture (Fig. 3) is based on different open source solutions. The servers use GNU/Linux operating system (Ubuntu), Apache as a proxy and web server and Apache Tomcat as a Java applications server to deploy the geOrchestra modules.

Next to security proxy and a single-sign-on authentication system, IMC-TTM SDI geOrchestra use the following independent and interoperable modules:

- The geographic database is PostgreSQL\ PostGIS.
- A file server for storing geographic files like shapefiles, CAD files or rasters.
- A map server for sharing geospatial data (Geoserver).
- A cache server for to cache map tiles coming from Web Map Service (Geowebcache)
- A catalog application to manage spatially referenced resources (GeoNetwork).
- A map viewer to visualize, query and edit geographic objects (Mapfish).
- A central authentication system (CAS), a security proxy and a LDAP users directory, providing shared rights management between all modules.
- An analytics module for monitoring the use of web services.

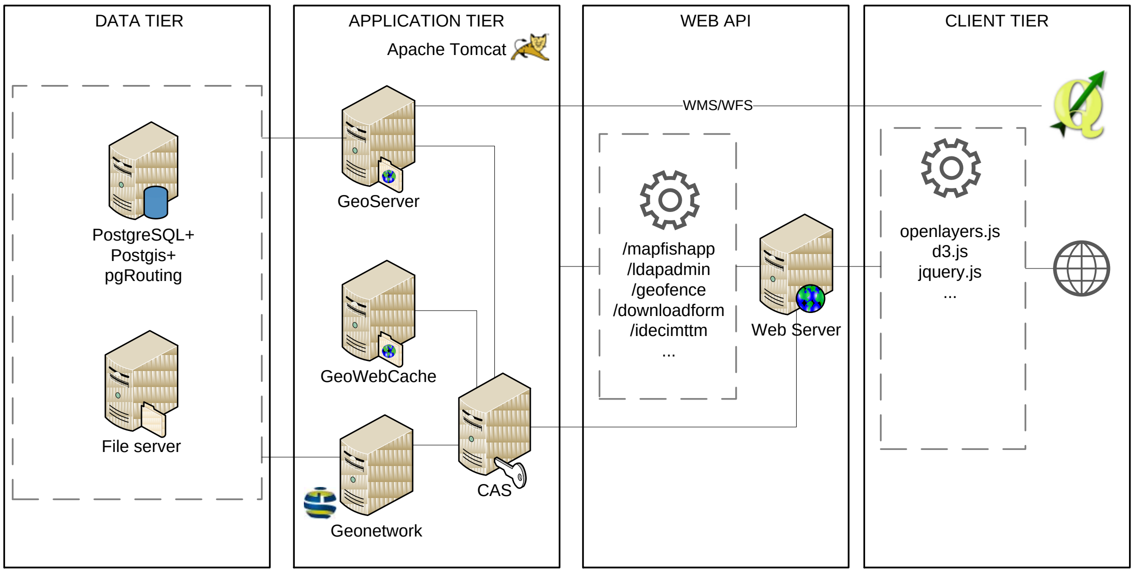

Figure 3: IMC-TTM SDI arquitecture.

A remote desktop connection is available for all the municipalities allowing a direct connection to the central database with QGIS (desktop GIS client in IMC-TTM). Some municipalities use GIS Desktop commercial software. These municipalities use the OGC services to access the GI.

3.3. FUNCTIONALITIES

The main functionalities of the IMC-TTM SDI are the following:

- **Map viewer**

- Navigation tools (zoom in, zoom out, full extend).
- Query active layers.
- Display coordinate system.

- Add new layers from the catalog or a remote WMS.
- Style editor;
- Save or restore a list of layers using Web Map Context (WMC) files.
- Print a map in PDF format.

- • **Map server**
  - – Allow several data connections.
  - - Allow layer configuration (CRS and styles).
  - – Publish layer OGC web services.
  - INSPIRE compliant OGC web services
- • **Catalog**
  - – INSPIRE compliant metadata profile.
  - – Allow to harvest metadata records on distant catalogs.
  - - INSPIRE compliant metadata.

3.4. DATA PUBLICATION WORKFLOW

One of the operational objectives of Phase I consisted in gathering the existing geographical information in the municipalities with relevance to the intermunicipal SDI. The diagnosis of the geographical information in use by the IMC-TTM and the municipalities began with a survey. After the survey, the data was formally requested to all municipalities under the premise that the information management and data sharing policy is responsibility of each municipality SDI administrator. The vectorial data was harmonized and converted to PostgreSQL using QGIS. Two base layers (orthophotomaps and street network) were made available through GeoWebCache. All the final layers were stored in the server and published using Geoserver. Those layers are organized in workspaces, using the municipality name. The last step is creating an INSPIRE metadata record in GeoNetwork and link it to the OGC services metadata (WMS, WFS). To create new layers the municipalities, access the server through a remote desktop connection. With this connection they manage their own schema in the database.

4. CONCLUSIONS

In this paper we have expressed the challenges and difficulties of a combined authority in terms of SDI implementation. Such an SDI is now serving the following purposes: centralize information in a single, uniform repository; improve the quality of information and work tools; improve the operational and business level (administrative modernization) and enable greater effectiveness and efficiency of municipalities in the management and development of the territory.

It is not yet possible to draw conclusions, since the actions designed have not yet been full implemented. However, feedback from the first year of life of the SDI by users has been positive. In IMC-TTM SDI implementation the main experience has been to understand that building a SDI is basically an organizational challenge, in which the technological implementation covers less importance than the correct comprehension of the social reality of the stakeholders [5] as verified in similar projects.

From the technical lens, geOrchestra has proved to be a flexible and robust solution for a combined authority. One of the crucial tasks in the project has been the technical training. That project task made possible the involvement of stakeholders and the participation of a great number of municipalities. On the other hand, some municipalities never adopted the SDI framework, leaving the database empty. The main challenge to solve in these stakeholders is the lack of human resources. In this on-going project, we have verified an increased efficiency in communication between the intermunicipal and municipal levels.

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