The open source GIS, an ideal framework for the development of an integrated modelling platform devoted to sustainable urban planning: first steps with OrbisGIS and CartoPolis

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Sustainable urban planning : an interdisciplinary and systemic approach

Cities provide one of the major challenges to global sustainability. Over half the world's population is now urban and it is growing rapidly. Growth is driven by globalisation making a significant contribution to global environmental change. Cities affect social, economic, cultural and environmental sustainability. In this context, new and large-scale research is vital, to study not only cities, but also regions and their environments at all spatial scales, and over a range of timescales. Such research is challenging and complex, and will need an interdisciplinary approach. It needs to bring together the humanities and social sciences with the other major disciplines, and involve researchers, users and stakeholders in the process. It will embrace research that is quantitative and qualitative, and it may involve anything ranging from the setting up of urban observatories, to sophisticated modelling of urban systems.

In this context, sustainable urban planning needs the development of a systemic approach involving environmental, social and economic dimensions where the evaluation of public policies is of paramount importance for decision making. This approach requires setting up an integrated modelling platform for the

computation of indicators and spatial analysis tools at different spatial and time scales. A Spatial Data Infrastructure (SDI) integrating a Geographic Information System (GIS) enables the use of spatial data in an efficient and flexible way and remains an ideal framework to fulfill this objective.

This idea is emerging since the 2000s where GIS are more and more used for interdisciplinary and multisectoral contexts. The development of standards for data description and data exchange (interoperability) and the arrival of the concept of SDI, facilitate the interconnection of systems and the carrying out of systemic approaches [1][2]. Such integrated platforms can be developed by the actors of geographic information to manage the whole knowledge about a territory and to observe its dynamics (observatory). SDI are being multiplied at all levels of decision (European, national, regional, local) and in different institutional groups (public services, laboratories, etc.). In this way, at IRSTV (Institute for Research on Urban Sciences and Techniques) which is a research federation gathering 20 laboratories and leading an interdisciplinary research devoted to the development of knowledge, models, tools, methodologies for urban design and management, and to the evaluation of sustainable city policies, we have developed such an approach around an open source SDI, CartoPOLIS , and an open source GIS, OrbisGIS.

Urban data representation and management: need of an SDI

The understanding of natural and anthropogenic phenomena at work on a territory is essential to monitor, control and manage urban systems and their dynamics. Data are the key. Their massive acquisition and treatments go through the design and implementation of new methodologies and technologies adapted to different spatial and time scales. These new techniques should produce reliable data, making them easily accessible, allowing the crossing of various kinds of data to perform multi-criteria analysis. A Spatial Data Infrastructure (SDI) based on ISO and OGC standards, is suitable for the acquisition, processing, capitalization, sharing and preservation of urban spatial data and metadata. But to face systemic issues and interdisciplinary applications, several technical and scientific locks must be removed:

- Description and storage of multi-source and multi-scale data and metadata

- Querying of such data: What kind of language for users?
- Utilization of such data by models or other tools: How to enable the integration?
- Provision of data and tools: Is the set of data standards sufficient to manage the data flows? How do we manage the data processing flows and the storage of the spatial analysis tools? How to visualize the spatial data according to specific mapping rules?

Cartopolis attempts to answer these questions [3]. This open source SDI consists of 5 modules:

- A single database aggregating all data collected or produced
- A server of data flow (Geoservice): this application provides geographic data via the Internet using the standard WMS (Web Map Services)
- A tool for cataloging data (Geocatalog): it consists of a set of metadata sheets structured according to ISO 19115. It contains information such as the temporal extent of the dataset, its spatial extent, its origin, its semantic features, etc
- A mapping Internet gate with graphical interfaces for querying the Geocatalog. The user can enter a word for retrieving a data or search for given data by specifying a bounding box or a temporal scope
- An open source Geographic Information System (GIS) called OrbisGIS [3]

Diagnosis and evaluation of sustainable urban policies: need of an open source integrated platform including a GIS

Sustainable urban planning relies on the understanding of complex systems and underlying phenomena. Modeling as a tool for understanding, diagnosing and forecasting becomes essential to the development and comparison of planning scenarios (evaluations) and to clarifying decision making. Therefore, we need a platform integrating a lot of urban models exploiting, sharing and producing spatial data (SDI).

A GIS linked to the appropriate SDI remains the ideal framework where data processing involves the cooperation between urban models (computation of indicators for instance) and where the spatial analysis of the results can be achieved. OrbisGIS has been defined and carried out to fulfil these goals [3].
The open source paradigm and the use of standards are essential to facing the integration of multidisciplinary packages and its use for very different professional applications:

- The exchange of data between urban models, applications, visualization tools, etc., requires interoperability and the use of standardized data. In our platform we use OGC standards (WMS, WFS, etc.) and ISO standards (19115, 19139, etc.)

- Integrating new models as plugins in a GIS must be facilitated and transferable from one GIS platform to another one. This necessitates a modular approach to development: the developer should opt for the model-view-controller software design pattern

- The language for data query and data processing must be comprehensible to different users and must be easily completed when adding additional features like new evaluation tools or models. For this reason, OrbisGIS integrates an extended spatial language (which includes the management of both vector and raster data) based on the Simple Feature SQL (SFS) standard [4][5]. This language offers a unique way to describe spatial processing. Coupled with the Web Processing Service it permits to share in a common plateform all geospatial processing available on-demand via internet. This would enhance the current uses of the SDI by pooling all the processes built by IRSTV researchers and engineers (noise mapping, flooding modeling, atmospheric pollutant dispersion, etc.) and by creating a geospatial knowledge repository to study cities [6]

- The visualization of spatial data must cope with static, dynamic and multi-scale data, must be comprehensible by all stakeholders (good representation of the semantic and use of standards), and must be easily edited and disseminated on different supports. Symbology encoding standards have to be consistent with the purposes of research and new applications. IRSTV is

working in this direction at OGC in cooperation with the IICT laboratory [7]. As a proof of concept, a first evaluation of cartographic publications with the Geospatial PDF format has been performed in the framework of OrbisGIS [8]

Collaborative development of the open source platform

At IRSTV, our goal was to build a common platform where each member of the Institute would be an active contributor, a common tool adopted by all the different users, a single platform able to integrate and capitalize all the methods and tools necessary to describe, model and manage the city. The development of such a platform needs a specific collaborative methodology to manage the understanding and the interaction between the various stakeholders (developers, users) and to preserve the quality of code.

Co-operate software engineering

To develop a common open source plate-form a collaborative approach for the specification of new features and new tools, a project management for the integration of new packages and the preservation of the quality of the delivered code (validation process) are essential. To achieve these goals in our platform, the quality of developments in the core, but also additional developments made by the community in the form of plugins, are controlled by the open source tool Jenkins to ensure a continuous integration without regression. The application source code is managed using the platform GitHub and the GIT tool, a tool for the sharing and the distributed control of codes.

Pedagogy and student training: from software engineering to participating in coding

Besides the development of this platform, IRSTV is engaged in academic (MSc on Sciences and techniques for urban planning) and professional training providing full courses to learn how to use and develop these tools. In 2001, we introduced a semester of 128 hours based on the use of open source software (GIS, SDI, relational database …) and on the use of information from open data, plus a 160 hour training project dedicated to the engineering of geographic information. These training periods are conducted in cooperation with other existing communities like GvSIG and OpenStreetMap.

A research platform for proof and benchmarking

For a researcher, especially in the sciences of geographic information, the development of one's research proposals in an open source platform is a complementary means to prove to the scientific community the quality of its implementation and its usage, its computation performances according to the amount of data, and its ability to adapt to other datasets. It is also a way to compare its performances to other approaches on the same datasets. Finally, it is a way to demonstrate its relevance for the professional community.

Conclusion

As demonstrated in this paper, the open source paradigm addresses perfectly the needs and development methodology of an integrated modelling platform dedicated to sustainable urban planning. Participants coming from different scientific fields need to share the same urban data: open data and open source SDIs are an obvious choice. To address the systemic issue of urbanism, collaborators must integrate their various modelling packages in a single platform. These packages should be able to interact via a common language. New functionalities should be implemented to cross-examine newly generated data, and common symbology encoding will help standardize the visualization and communication of results. Research on sustainable urban development is a really great opportunity for innovation and progress in the open source community.

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