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SIGARH ARCHAEOLOGICAL AND HISTORICAL GIS: A MUTUALIZED HISTORICAL URBAN DATABASE

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ABSTRACT

Four major partners, the regional archeological service of the French Ministry of Culture, the University of Bordeaux III, the INRAP (National Institute for Research in Archaeological Preservation) and the City of Bordeaux are working together in a collective research project to study the evolution of Bordeaux (France): the *SIG Archéologique et Historique de Bordeaux* - SIGArH.

By deconstructing the spatio-temporal properties of each historical entity, the project will create a database and interfaces to manage and share sources (maps, land tenures, etc.). This information system aims to describe the city's dynamics. The SIGArH system is designed to support historians', archaeologists' and city planners' studies.

This article presents the first step of the development of SIGArH. Researchers are currently able to capture, consult, manage and share data.

1. INTRODUCTION

In the last few years several aspects of the evolution of Bordeaux (France) have been analyzed (Jean-Courret, 2006, Schoonbeart, 2007, Lavaud et al., 2009). Above all a great amount of archaeological discoveries has completed and renewed knowledge about Bordeaux's evolution. Those varied enquiries stress the need for GIS and databases to share sources and verify their complete integration. The French Ministry of Culture regional archeological service initiated a collective project in 2010 to explore these issues and to study the evolution of Bordeaux from protohistory to the present day. The involved partners are the University of Bordeaux III, the INRAP (National Institute for Research in Preventive Archaeology) and the City of Bordeaux. This project will provide a complete information system including a shared database and interfaces for users to exploit the database (visualize, consult, edit, update, share, etc.). Such a system will pave the way for new studies on the evolution of Bordeaux. With this system as a documentary resource, all researchers, archaeologists and historians will be able to work with their own definition of the problems to be analyzed and with their own methods. The first year of the project focused on formalizing and implementing the database's conceptual model and developing tools for data management. The system has to be user-friendly and as a result needed to be simple.

2. GIS AND LONG TERM TIME MANAGEMENT

2.1 Historical Data in GIS

Representing objects over time is difficult in Archaeology. Tasks such as the comparison of data from different epochs are especially time consuming for archaeologists and historians. With the development of computer science, dedicated GIS have been developed. Since 2002, the French cultural ministry has been using Patriarche. This system centralizes all geographic information and attributes derived from each Regional Archaeological Service. Geometries are locally stored. This system is single-user oriented and extremely complex to use.

Different other projects exist in France or abroad. They deal with spatial analysis (Rodier, 2000), data hierarchy (Lorho, 2008) or integration of existing vector data into a modern referential (Noizet et al., 2008). Some of these projects are research programs, some are more focused on data representation, others aim at establishing inventories.

2.2 Time, Function and Space

(Peuquet, 1977) proposed the "What, Where, When theory" in which people need to answer three basic kinds of questions to study an object. The approach suggests a separate analysis of the three different aspects of an object: time, function and space.

Based on Peuquet's researches, (Rodier, 2000) proposes the OH_FET model (historical object space-time function). This model is a way to study relations between each aspect. It integrates them in three different features. The definition of a feature in a GIS is usually based on its localisation, which forms a spatial feature (SF). These SF depend on the construction and deconstruction of historical objects and their position in time. Time features (TF) express temporal information on the evolution of historical objects and functional features (FF) express their social aspects. Their assemblage makes the historical entity.

Every evolution in one of these three features leads to a new historical entity. For a better spatial precision, (Galinié, et al. 2004) uses the smallest spatial denominator.

This model can be used to completely explore each historical entity. From function (F), time (T) and space (S), analyses can combine several aspects: F x T, F x S, T x S or F x S x T. However, this method leads to the subdivision of objects in each dimension, which makes storing, managing, and updating the database complex.

The OH_FET model shows a way to study historical entities. The model proposed in this paper adapts this model to the database structure of the SIGArH project and extends it using chronological uncertainty, with fuzzy set theory.

2.3 Data Hierarchy

These three aspects of the historical entity are important for analysis. Nevertheless, archaeologists also need the context of an entity. This is why (Lorho 2008) introduces the context in his SIGUR system, a GIS applied to Urban Archaeology. This system aims at drawing archaeological city maps of the city of Rennes, France.

(Lorho 2008) shows the importance of two parameters: data sources and data hierarchies. To represent and study entities, archaeologists need to know their level of uncertainty, especially insofar as sources are concerned. Lorho divides that level of uncertainty into two categories: reliable data for archaeological structures and the others considered as fortuitously discovered data or miscellaneous findings. He makes the division depending on whether or not the data is georeferenced adequately and represented correctly. He also makes a comparison between referential and thematic data.

For the interaction between entities, he divides them into three hierarchical levels: e.g. walls, first level; rooms, second; buildings, third. This division into three levels helps to show only structural elements or buildings. It can also help to study a building through these three levels.

The hierarchical expression of entities is an important process for urban structure analysis. However, the expression in three classes is too strict for the purposes of our project. The data hierarchy proposed in our approach is based on a composite pattern.

In Patriarche and Mérimée (a architectural inventory, by the French Ministry of Culture); the hierarchy exists but is limited to two levels: container and content. The expression of hierarchy, for every aspect, is important to explain and show interactions between historical entities.

3. MUTUALIZED HISTORICAL URBAN DATABASE: "SIGArH"

3.1 Data sources

Bordeaux is an old French city and many different documents were produced to record the city's structure. These documents include: iconographic data, cartographic data (from maps or the cadastral registry), excavated objects and bibliographic documents. Some are easily integrated on modern referentials, some are not.

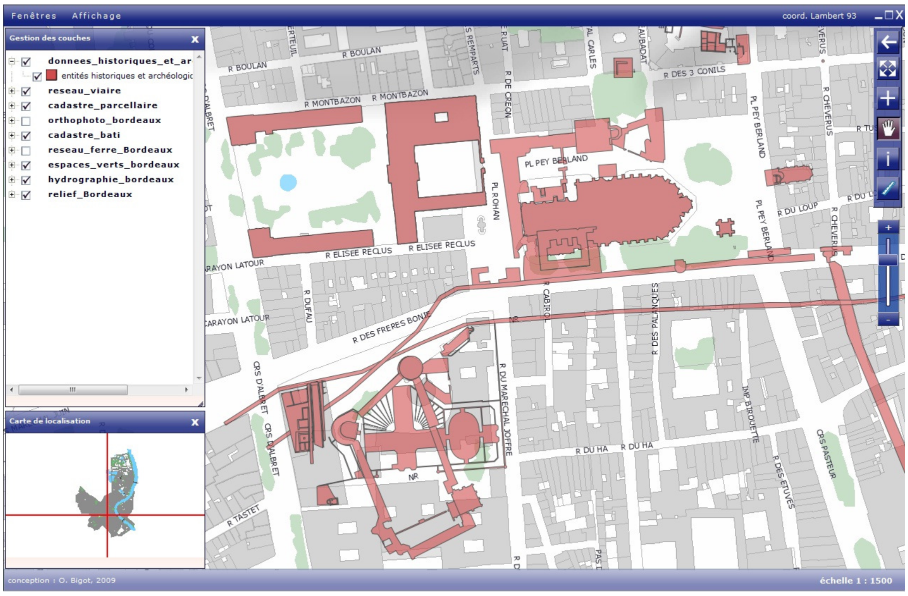

Fig. 1: Data integration on the cadastral registry (Web interface)

(Jean-Couret, 2006) tries to rebuild the city by analysis of Bordeaux fiscal acts, from 1224 to 1586. The acts describe the parcels, grouped into land tenures, by owner, nature, taxes, neighbors (front, back, left and right). As a puzzle; they wish to understand the evolution of each parcel.

The problem of uncertainty is emphasized with the different types of sources and periods.. As Lorho explained, there is sufficient or unsufficient representation, and good or bad georeferencing. But the spatial uncertainty is just a part of the problem: there is also an uncertainty in terms of time or function. For each uncertainty, the further back we look in time, the more the sources are uncertain. Tenures are the perfect example of the most uncertain sources. That's why tenures are just a sub-layer in the system information layer. The integration of road networks will complete the structural information. They will be stored in lines or polygons, depending on scale, so that network analysis can be achieved.

In order to evaluate and improve our GIS, we chose a specific archaeological and historical area on the border of the Peugue, an old river turned into a sewer, from Saint André's Cathedral to the Garonne river.

3.2 SIGArH's Structure

Users of the SIGArH are located in different offices because of the multi-institutional character of this project. That is why the system needed to be completely mutualized (Fig. 1). First, a PostGreSQL/PostGIS (http://www.postgres.com / http://www.postgis.org) database was chosen for the server. Second, the system needed important software to manage data, do spatial analysis and other statements. The choice was an ArcGIS, in the ArcInfo version, for fat clients. To complete that software, a simple cartographic web viewer had to be developed for the browsers. It was built around WMS/WFS services. (It will not be presented in this article).

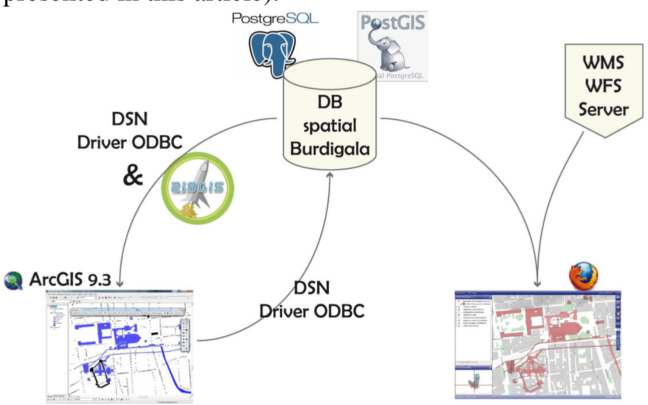

Fig. 2: SIGArH's Structures

3.3 Database Modelling

With the experiences of other researchers, we chose to implement our own database model. It is divided into two parts: geometries and entities, as an M-N link. Each entity can be linked with one or more geometry, and geometries can be linked with one or more entity. (Fig. 2) It offers the possibility to keep the same geometry for the same building, even if its occupation changes, and to follow the structural evolution of an entity such as expansion or destruction. The distinction between entities and geometries prevents the data from overflowing. With M-N links, time management is problematic. We need to know a building's construction/destruction and an entity's lifespan. But this link is temporal too. The system stores the three different chronologies. Due to the important time scale, the year is used for dating references.

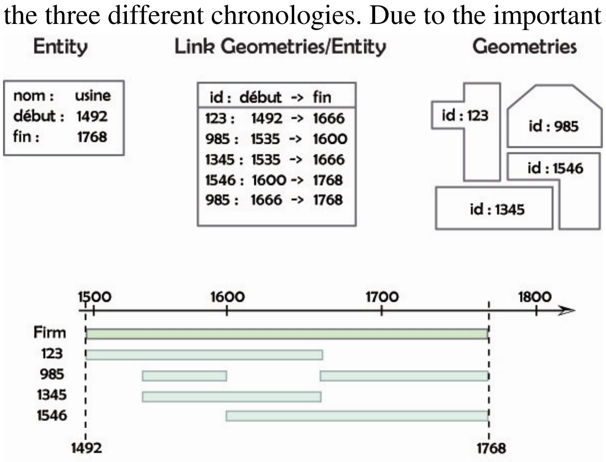

Fig. 3: Different step of entity building (or reconstruction)

This example shows the temporal links between an entity and its geometries: an entity's beginning, construction, destruction, re-use and end of life.

Functional attributes are separately stored in a different table to be integrated into a flowchart. Such hierarchies are also based on composite patterns. This flowchart (Fig. 3) has been inspired by those of the National Center of Urban Archaeology (CNAU), Patriarche and Mérimée.

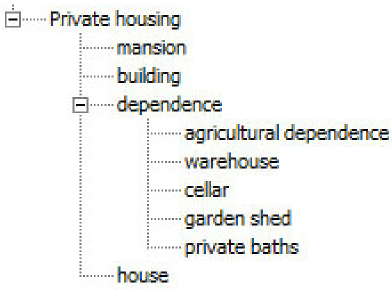

Fig. 4: Functional Thesaurus

This model is adapted from OH_FET's model. In order to easily use the database, a chronological link has been added between entity and geometry (Fig. 4). To complete that, every chronology is expressed by a fuzzy set.

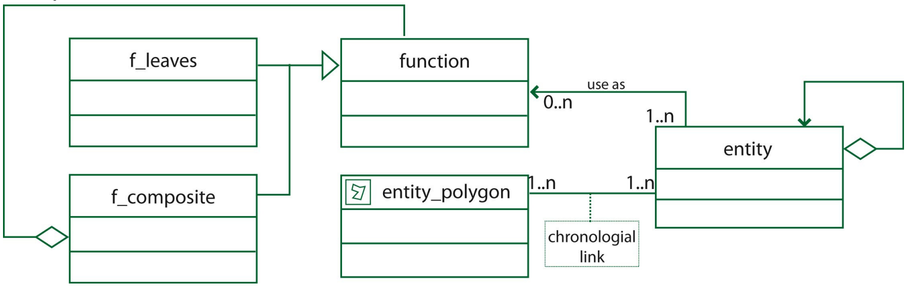

Fig. 5: SIGArH's Model

To order data, the system is organized around four referentials: Cadastral land registries (1830, 1850 and current) and IGN's Address DB (BDAdresse®) / IGN's Topographic DB (BDTopo®). They will facilitate exchanges with other institutions, and integration into other referentials.

4. IMPLEMENTATION AND RESULTS

4.1 Management tools

One of the biggest difficulties in this project was the development of a powerful system for historians, archaeologists and city-planners, knowing that these users are not familiar with complex software such as GIS. This consideration was taken into account in the development of a simple and intuitive interface.

Each user has a login and password to access the system. This entry method identifies, grants or revokes rights, and then follows modifications. Each entity's attributes can only be modified by its owner (manager). An administrator session manages all data from the server side and fat clients.

With the PostGIS database, the work is mutualized and updates are fast and secure. Between fat clients and server side, two solutions are used for updating management: ZigGIS (http://www.paolocorti.net / http://abegillespie.blogspot.com) for geometry and Driver ODBC for attributes.

4.2 Data integration

Database fields have been reduced to essential attributes to address the complex database modeling, and the necessity of being simple. Some free text fields exist to help summarize complementary information. Users are not lost between each interface and can easily evolve inside, independently.

After training, each user is able to view data, find it by geographic selection or attribute research. The owner of an entity summary can also modify all attributes and geometry. Creating a new entity or new geometry is possible.

A special space is present on the server to store digital files or folders to complete the database.

But the principal problem of data integration is "how to manage uncertainty". Three types of uncertainties were identified: spatial, chronological and functional.

To take functional uncertainty into account, the user can choose one or two entity's functions and add uncertainty.

Spatial doubt deals with quality of data source. Representation and georeferencing could not be precise in every case. Geometries have a location precision: sure, supposed or possible.

The chronology is based on approximate dates. Archaeologists and historians can only give a confidence interval for the beginning and the end of an entity's life. That's why we chose to store chronological markers (by year): confirmed start and stop limits, and unconfirmed start and stop limits. In a fuzzy set, unconfirmed ones are the support, and confirmed ones are the heart. The gap between confirmed and unconfirmed limits represents the chronological uncertainty. If confirmed and unconfirmed start dates are identical, there is no uncertainty; if they are different, uncertainty is expressed by the amplitude between the two limits.

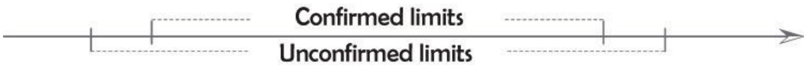

Fig. 6: Uncertainty in chronology

But the database also works with triggers. These sub-programs are designed to manage database records automatically. With triggers, some fields are completed and compared, and the centers of objects are computed and intersected with the cadastre. Triggers are important for the automation process.

4.3 Analysis methods

The system has been developed to provide a powerful tool to study the evolution of the city.

The current database allows evolution analyzes of a geographic position, a building or a square selection. It can evolve for other types of analysis.

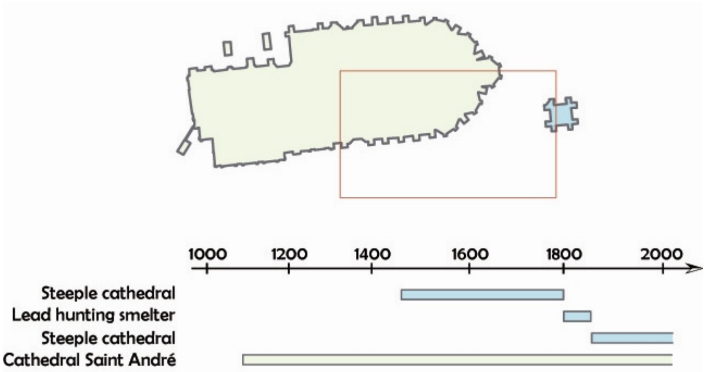

Fig. 7: Exploration of the entities present in an area through time

The GANTT diagram presents the entities through time in a rectangular selection (Fig. 6).

Users can easily study the influences of other buildings during a time period with this diagram (Fig. 7).

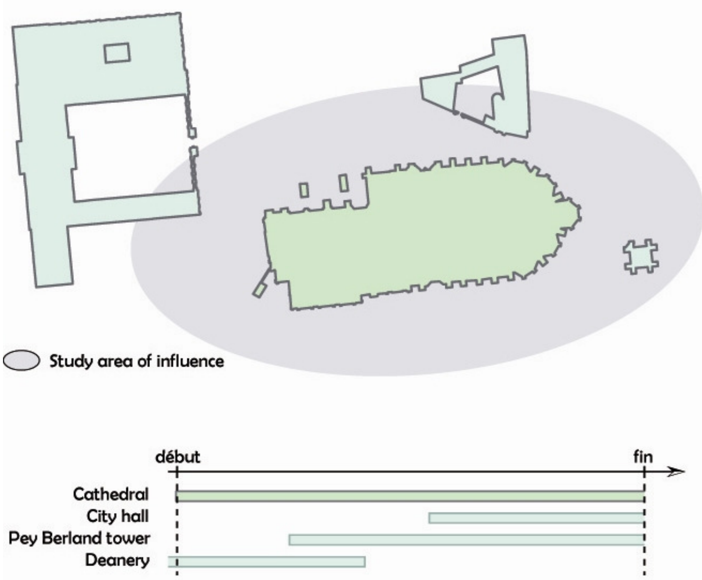

Fig. 8: GANTT of building's existence which affect on the Cathedral (for a specify chronological period)

Genealogical analyses are an integral part of the system, as well as structural hierarchical analyses.

The time is divided into periods to facilitate user work and research (Fig. 8). Those time periods can also be viewed in a flowchart. It is directly extracted from a CNAU/Patriarche chronological division.

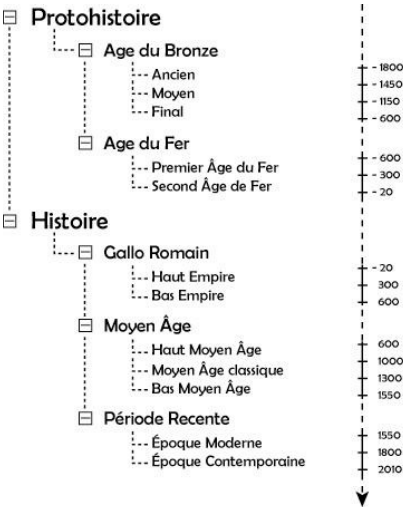

Fig. 9: Chronological periods

5. DISCUSSION AND CONCLUSION

In this paper, we proposed SIGArH, a Historical and Archeological GIS to store, manage and study the evolution of the city of Bordeaux. The storage is based on a PostGreSQL/PostGIS database in order to obtain a complete mutualized, fast and secure system.

The main contributions of our work are the extension of the OH_FET model to handle chronological uncertainty using fuzzy set theory and the integration of data hierarchies on every aspect of historical entities (function, space, and time).

Faced with a limited budget for computers, servers, software and staff, the system is built with free or none expensive solutions. ZigGis and ODBC are not the easiest way to link ArcInfo and PostGIS (compared to solutions such as ArcSDE). ZigGIS can display and update geometry features; an ODBC Driver such as DSN (data source name) is used to edit data attributes and geometries.

A second difficulty comes from the French Ministry of Culture’s network service: some connecting ports are closed to secure its network. Nevertheless, connecting a PostGreSQL database to a computer required one of these ports.

Having solved these problems, this project has in fact just begun. Researchers are waiting to complete the database before beginning the analysis process and developing more capabilities. With the cooperation and experience of other researchers community involved in similar projects, different types of analysis will certainly be implemented in the future.

The entity’s manager is responsible for database updating. With the administrator, the manager is the only one who can change attributes. A comment/chat system will enable every user to propose modifications. The discussion begins and people usually find the most appropriate solution. As OpenStreetMap, we aim at developing a collaborative edition tool, which would keep moderator’s rules.

No symbolization has yet been formalized. More attention to cartography should be given in the future in order to specify the symbology of the different historical entities. Moreover, users will need to be able to extract the data corresponding to the complete life of an entity in order to compare them to one another, use it in the field (during excavation) or create reports.

REFERENCES

Rodier, Xavier, « Le système d'information géographique TOTOPI : Topographie de TOurs Pré-Industriel ». *Les petits cahiers d'Anatole*, 4, 2000.

Barraud, D., Régaldo, P., « La façade orientale de l'enceinte antique de Bordeaux : nouvelles données et nouvelles hypothèses », *Itinéraire de Saintes à Dougga. Mélanges offerts à Louis Maurin (J.-P. Bost, J.-M. Roddaz, F. Tassaux éd.)*, Bordeaux, Ausonius, 2003.

Galinié, H., Rodier, X., Saligny, L., « Entités fonctionnelles, entités spatiales et dynamique urbaine dans la longue durée », *Histoire et Mesure*, vol .XIX, n°3/4 2004, p. 223-242

Lefebvre, B., « Construction et déconstruction de l’espace urbain : une modélisation en volume du bâti ancien », *MIA Journal*, volume 0, VII 2006, n° 2, p. 53-58.

Jean-Couret Ezéchiel, *La morphogenèse de Bordeaux des origines à la fin du Moyen Age : fabrique, paysages et représentations de l'Urbs*. Thèse d'Histoire du Moyen Age. Université Michel de Montaigne - Bordeaux III, Centre Ausonius, 2006, 3 vol., 642 p. ; 83 p. ; 397 p.

Rodier X., Saligny L., « Modélisation des objets urbains pour l'étude des dynamiques urbaines dans la longue durée ». *SAGEO*, 2007.

Schoonbaert Sylvain, *La Voirie bordelaise au XIXème siècle*. Paris, PUPS, 2007, 730 p.

Lefebvre B., Rodier X., Saligny L., Understanding Urban Fabric With the OH_FET Model Based on Social Use, Space and Time », *Archéologia e Calcolatori*, 19, 2008, pp. 195-214.

Lefebvre, B., *La formation d'un tissu urbain dans la Cité de Tours : du site de l'amphithéâtre antique au quartier canonial (5e-18e s.)*, thèse, Université François Rabelais - Tours (2008-12-02), Élisabeth Lorans (Dir.), 2 vol., 446 p. ; 460 p.

Lorho, Thierry, « SIGUR : Un SIG pour la pratique de l'archéologie en milieu urbain ». *Archéologia e Calcolatori*, 19, 2008, p. 61-72.

Noizet H., Dallo A., Blary G.-X., Costa L., Pouget F., "ALPAGE: towards the setting-up of a collaborative tool", *Archeologia e Calcolatori*, 19, 2008, p. 87-101

Lefebvre, B., « How to Describe and Show Dynamics of Urbain Fabric: Cartography and Chronometry ? », *Computer Applications to Archaeology*, Williamsburg, Virginia, USA, March 22-26, 2009.

Runz, Cyril de, Desjardin, Eric, « GISSAR, De la saisie de fouilles à l'analyse spatiotemporelle en archéologie », Spatial Analysis and GEOmatics, 2009.

Lavaud Sandrine (coord.), *Atlas historique des villes de France : Bordeaux*, Bordeaux, Ausonius Editions, 2009, 3 vol.

Barraud, D., Sireix, C., « Burdigala à la lumière des nouvelles découvertes », *Simulacra Romae II, Bull. de la Soc. Archéol. Champenoise*, Mémoires n°19, 2010, p. 161-170.

Gerber, F., « Burdigala, port d'estey, port de Garonne », *Aquitania*, Supplément n°18, Les structures portuaires de l'Arc atlantique dans l'Antiquité, 2010, p. 83-93.