Towards a spatiotemporel model for the interworking of the GIS

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Abstract: The designers of GIS application (Geographical Information system) are confronted with the problems of integration of the multiple layers of geographical data. Ontology plays a significant role in the new generation of the GIS. It is also a keystone of the SMA (System Multi Agents) using a high level communication. Methodologies of design of GIS pass by complex processes obliging the designers to knowing well the applicability and the various decisional needs.Consequently, for the same application, two designers can have two different points of view and obtain two different conceptual models of data, therefore the process of integration of these warehouses of data becomes complex. For that, the objective of our approach is to define a conceptual model, being able to be expressed by a formal spatio - temporal ontology, which must be used as conceptual framework to allow the interworking of the complex systems for solving the geographical problems.

Key words: GIS, ontology, SMA, Interworking, warehouse of spatio - temporal data.

1 Introduction

The development of Internet technologies opens new horizons in the field of the sharing of information. Geographical information does not escape this tendency and the needs for models, methods and tools adapted to represent, handle and share geographical information become crucial. The sharing of information passes by their comprehension and an automatisation of the processes of analysis, of extraction and update of this information. Ontologies are a promising way to describe and to share the information approved by a community of people. The types of ontologies can be considered according to their contents and their uses. Taxonomic ontologies of thesaurus type define terms to provide a vocabulary of reference to harmonize the names indicating of the data in various applications. The terms are organized in hierarchy of generalisation/specialisation and the relations of synonymy, of composition… can be specified. Word Net [1] is the most representative of ontologies of the thesaurus type. One can regard this type of ontology as the first generation of ontology. This type of ontology is primarily used to bring a common comprehension of a vocabulary. But the needs for modeling and sharing of more complex information led to an evolution of ontologies towards richer models. (VAN HEIJST, 1997) Descriptive ontologies go beyond the definition of taxonomies and aim at modelling a field or an activity. They are closer to the definition of conceptual diagrams of data bases and attempt to model information using concepts and of semantically rich relations. Ontology then brings knowledge on a field or an activity which can be used by an designer to model particular applications. These ontologies can be used as a tool for comprehension of the structures of data describing the concepts of the field (in this case they can not have authorities), or, if they have instences, they can be used like data bases, in particular while being accessible to the public via the Web. Many environments like KAON (MOTIK, 2002), DOGMA (JARRAR, 2002) and DAML+OIL (HORROCKS, 2002) were proposed to model and manage ontologies.But, this work does not offer concepts specifically dedicated to modeling of geographical information.A significant challenge is thus the evolution of traditional descriptive ontologies worms of ontologies really making it possible to take into account and to manage geographical information. We will call these ontologies, geographical ontologies. (SPACCAPIETRA, 1999) (MURMUR) Geographical ontologies contain:

[1] www.cogsci.princeton.edu/wn/

1) Ontologies of space more specifically devoted to the description of the concepts which characterize space like a point, a line… etc. these ontologies are typically elaborate by great organizations of standardization. OpenGIS proposes by the means of GML a language to structure and exchange geographical information. In particular, GML brings a quasi-standard on the definition of the geometries of the objects. **2)** Ontologies of geographical fields like an ontology modelling the concepts of the hydraulic data, or an ontology describing the concepts of the data of the electrical supply networks. They are the ontologies "trade", developed by a community of user of the concerned field. **3)** Spatialized ontologies (or spatio - temporal), which are ontologies of which the concepts are localised in space. A temporal component is often necessary in complement for the modeling of geographical information, because the geographical applications also handle very often temporal data, even spatio - temporal. Ontologies of space and geographical fields can be of thesaurus type if they are limited to the description of vocabulary or descriptive if they include a more complex description or semantically richer of space or field considered. Spatio - temporal ontologies are typically descriptive and can apply to very contained requiring a modeling located in space and time. (Cullot, 2005) the objective of this work is to define a model, being able to be expressed by a formal spatio - temporal ontology to be used as a basis for a platform of design, implementation and simulation of complex systems which allow the semantic interworking of the GIS thanks to the integration of several sources data relating to the warehouses of space data using the systems multi agents to satisfy the various decisional needs. Our point of view in this article will be rather directed design to provide a theoretical framework to the modelisator that can think his model and to formalize it in a coherent language.

2 Contribution

Like all ontologies, geographical ontologies can be used for exploration, but also the extraction of information and for the interworking of GIS. Recent work such as (HORROCKS, 2002) shows the use of ontologies to solve semantic heterogeneity using architecture of the type ODGIS (Ontology-Driven GIS) (El Fallah-Seghrouchni, 2001) dedicated to the integration of GIS.. Systems such as DOGMA (JARRAR,2002) (MURMUR) are resulting from the data bases.They are based on the constraints of identification, cardinality or integrity which are prone to change from one application to another, whereas the structure of the data remains stable.For that, the authors propose a model in two parts:a part (the structure of the data) independent of any particular application, and several alternative of constraints, each one constituting a personalization of general ontology for a given application. Our contribution consists in working out a spatio - temporal conceptual model inspired of the model MADS (Parent, 1997) which makes it possible to define types of complex objects, their attributes and their fields, relations between the types of objects, the relations between the objects and some relations for the modeling of the evolution or the extension of objects. Our approach is deduced from ontology AGR of Ferber, (Ferber, 2005) (Ferber, 2006) and is adapted to our context of interworking of the GIS. For that, we based itself in our design of the MSIS (Spatio temporal Model for the Interworking of the GIS) on the following concepts:(Langlois, 2009)

a. Geographical space E

Space E is a preset organization able to receive points represented by geometrical co-ordinates.Space E is structured in the form of a skeletal geometrical reference frame (dimensionnality, origin point, axes and units, size, morphology).The points of E are created according to needs', in the form of *localizations (absolute or relative)*.Space E is provided with a mathematical structure of metric space (Euclidean).

b. Social space

Just as geographical space, social space is conceived like a preset organization to identify the agents and thus to differentiate them from each other.This space can be structured by one or more formed social organizations of components or by relations between agents.

c. Time

Temporal space is also a preset organization, which is structured by a temporal reference frame in which all the dynamic entities of a model fit.This reference frame is defined by an origin, a unit of time, an elementary step of time, and a maximum duration.

d. Geographical object

A geographical object is an object of a geographical layer of information (in general imported of a GIS) which does not have dynamics and which will fit in a space organization.It has *a space influence* in space E, it is a subset of E .A geographical object has space attributes which are used to describe its geometry (form and localization) and of the not space attributes which are called descriptive attributes.when we create an agent, the geometrical and the descriptive attributes are in general recopied in the agent.

e. Agent

One calls here agent an object which has a dynamics, i.e. the possibility of changing in the course of time.This change can affect its support:if this one undergoes an isometric transformation which, with each step of time, carries out a translation followed by a rotation, it is said that the agent is ***mobile*** (its support remains invariant compared to a local reference mark attached to the agent).If its space attributes undergo another type of geometrical transformation, it is said that the agent is ***deformable***.When the transformation takes place on the nonspace attributes of the agent (interns or relational) one speaks about ***dynamics evolutionary*** (intern or relational) of the agent.When agents or objects (matter, flow, energy, etc.) change in the course of time into other agents or other objects, like chemical reactions, dynamic layers (regrouping), or possibilities of reproduction, one will speak about ***transformationnelle dynamics***.

f. Environment of an agent

The environment of an agent is the whole of the entities which can be perceived or modified by the agent.It is its vicinity without itself.These entities can be more or less close to him in space terms (forced space, borders, contacts, distances, accessibilities) or social (social group, economic bonds, of capacities etc), but they can sometimes also be very distant. The total behavior of an agent is the combination of simpler processes, than elementary behaviors are called and which are the expression of elementary competences of the agent.A competence is expressed by a method of transformation of certain internal attributes of the agent or some of its exits, of which mobility, according to its attributes present and of the state of its environment. The definition of a competence can result on the level from the editor from model from a whole of rules containing from the elementary functions from acquisition, evaluation, action and observation (Langlois, 2009).The combination of these functions by various operations produces the final competence, which confers on the agent its potential perception, of cognition and action. A competence is known as ***innate*** (or ***permanent***) when it is constitutive of the agent, i.e. appears as of its creation, and remains until its death.An organization or its components offers to its agents of passage additional competences, called ***competences acquired*** (or ***temporary***), variable according to the type of component on which it is.They make it possible to each passenger to adapt his behavior to the environment (space or social) of the moment.***A behavior*** is thus the expression temporalized of a process resulting from the execution of a competence from the agent, acquired or innate.Several models of description of competences are considered:

1) Diagram of transition (Dubos-Paillard, 2003): To define reactive behaviors modifying of the qualitative states, according to rules which take into account at the same time the internal state of the agent and its perception of the environment.

2) Diagram of the type Forrester (Forrester, 1968): To define quantitative behaviors which are expressed by differential equation modelling the evolution of variables which represent stocks or controls of flow and channels which represent flows between these stocks.These diagrams apply normally to a compartmentalized system, but one can think that they are also transposable with a distributed organization.

3) Activity chart (standard UML): to describe a temporal organization (El Fallah-Seghrouchni, 2001), sequences of actions or transformations in time, more or less synchronized or coordinated, carried out by the same agent or between several agents which interact.

In our design, we propose in what follows, some diagrams UML, allowing to define the ontological entities and the connections between these entities.We distinguish two subclasses from agents:mobile agents and fixed agents like two types of behavior:individual behaviors and collective behaviors.

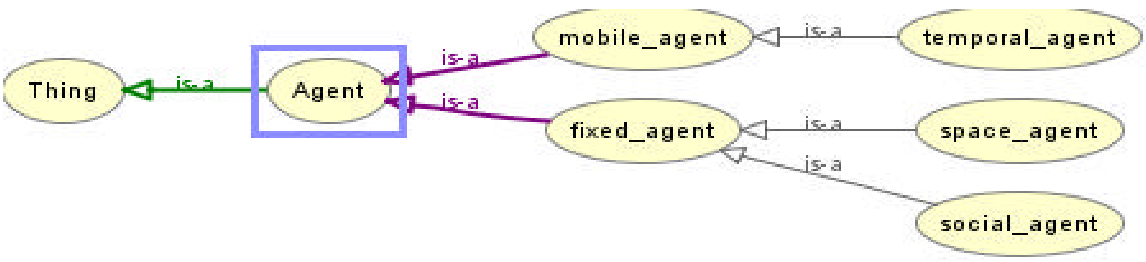

FIG. 1- Extract of ontology describing an agent.

Seen interior, the system is represented as an organization of agents which composes it and which interacts between them.Thus the collective behavior is present not only outside, by the environment in which other agents evolve/move, but it is also inside as soon as one observes the agent in his internal complexity like an organization of agents the component.So that the agents communicate in a simple way it is necessary that the messages between them are comprehensible, and to reach that point, it is necessary to integrate an ontology common to all the agents to make it possible to find the definition of a term, to control the semantics of the messages sent and to simplify the communication between agents.The geography is a discipline which juggles with the scales of observation.These scales can be taken into account in the GIS through various layers of information.For that, we will detail the concept "layer" in what follows.

The agents of our SMA must share the same spatio temporal ontology which contains the concepts and the relations necessary to the geographical and temporal localization to allow the follow-up, the control and the filing of the various events relating to a geographical object. In our model, an event, described spatially, temporally and semantically, is a partial representation of a phenomenon

The various models suggested in the literature for the modeling of ontologies find their bases in fields such as the artificial intelligence, the representation of knowledge or the data bases. Work resulting from the Artificial Intelligence more lays the stress on the aspect reasoning and techniques of inference. Logics of description make very particular great strides for the development of ontological models (MCGUINNESS, 2001).In the systems based on the logic of description, the base of knowledge comprises TBox which contains the description of the concepts and the roles (diagram) and ABox which contains the authorities.The concepts can primitive or be defined by axioms comprising of the operators of union, intersection and negation.They can be organized in hierarchy of generalization/specialization (inclusion). The roles are binary relations between the concepts.Constraints of values (cardinalities) can be given.The definition of concrete fields makes it possible to introduce types of data like the entireties, the rationels or as we will see it below the polygons for the management of the geometries.Mechanisms of reasoning (subsumption) make it possible to classify and control the validity of described information. By studying the terms of the ontological concepts, we noted that the true semantics of a concept is expressed often better by the authorities and their relationships to ontology, rather than by metadata. We recommend that the approaches of mapping based on authorities use associations existing between the concepts of ontology and the authorities.This association is named "annotation".For example, GPS points and the points of space altimetry (Dennouni, 2004) are described or annotate by the concepts of spatio temporal ontology.The annotations provide bonds between the concepts of ontology and the authorities which can be documents, flat files, data bases, etc.An annotation of an authority is composed of its reference URI, a reference URI on the concept of ontology and the references on the possible relations towards the other authorities. In the field of geography, we find several types of annotations.The study of these annotations led us to define three kinds of annotations:

1. A warehouse of authorities and data annotated by only one ontology; in other words, a specific ontology which develops a base of authorities For example, in our case one must define an ontology of geographical regrouping of entity (group, ensemble… etc.)

2. Several ontologies which develop several warehouses of different authorities connected by semantic relations. For example, if in is based on the concept "refered image" and the concept " space layer" one can easily deduce a satellite warehouse of image and another warehouse from vectorial layers… etc.

3. A warehouse of authorities annotates by several ontologies.To define, a warehouse of data which allow the definition of the various sets of themes layers of a GIS, one must be based on the authorities of spatio temporal ontology.

Our proposal for the design of a model of interworking of GIS is based on the MDA step which makes it possible to separate the conceptual concerns from the achievements operational.The cycle of development thus separates PIM model and PSM model by privileging the refinements on PIM model and PSM model. (Phan, 2007)

The transformations on level PIM are composed in two types:

1) The implementation of function which exploits the information of the space and temporal annotations present in PIM model to create the space and temporal owners correspondant.

2) The translation of the stereotypes in element of modeling UML of the generalization /specialization type between the stereotyped class and the geometrical or temporal primitive corresponding.(Artale, 2003) The transformations on PSM level uses DBMS platforms to treat the strategies of transformation of the relation with UML direction (association, aggregation, etc.) Our methodology suggested for the integration of the layers is based on the following architecture which allows the interworking of the GIS using the SMA.**(FIG. 2)**

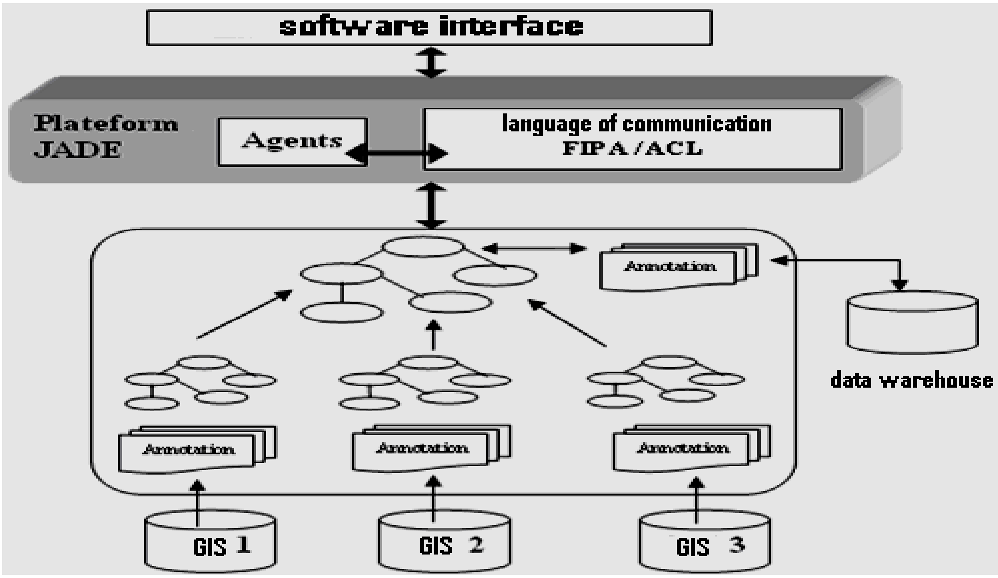

FIG. 2- Architecture allowing the interworking of the GIS using ontology.

3 Conclusion

Geographical ontologies have a promising future because they are used for the automated division of information in fields where the data are complex to model and expensive.They must play a significant role of reference for the interworking of the systems. Their development is conditioned by criteria related to the field of geographical information.We endeavoured in this article to present a step of interworking geographical based on a spatio temporal ontology common to the unit of the wishing GIS provided with a local ontology to cooperate for decisional or different need.We also showed that the basic conceptual models of spatio - temporal data are excellent candidates for the modeling of geographical ontologies which allow the interworking of the GIS but the integration of the temporal components and representation multiples seems to us a challenge significant to raise.For that, we also stressed the various conceptual diagrams of our system MSIS like on the technical architecture of our future prototype in the course of implementation.We are conscious that it is necessary to use logics of description to allow the intentional definition of the geographical concepts and to ensure their integrations in mechanisms of inference in the future.

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