Towards a method of design of real-time GeoProcessing Applications for Geospatial databases

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ABSTRACT: *Despite the increase of applications related to spatial or spatiotemporal databases, the assistance brought to the designer of these bases remains very poor. As in the classic data base domain (not spatial) the use of conceptual models, methods and tools of design is very current, in the real time geoprocessing application domain it is an exception. Yet, these databases are very often complex and would require a phase of detailed design. The subject of this article is to present the disadvantages of different existing methods and we propose profile UML dressing real time constraints in the field of real time geoprocessing applications. The GRT (Geographic Real Time) profile target the design of real-time geoprocessing applications.*

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1. Introduction

Nowadays, the field of the geoprocessing applications is in full rise and the number of software-tools specialized in the handling of the space-time data has known a considerable growth during the last decade. Several methods dedicated to the design of GIS applications have been proposed throw the existing literature and some CASE (Computer-Aided Software Engineering) tools helping designer to generate urban and geoprocessing applications have been implemented (AIGLE [1], PERCEPTORY [2], etc.).

Currently location based real time applications became increasingly numerous since they appear in various fields, such as the management of alarms in GSM network (Global System of Mobile communications), the management of fleets of vehicles, applications of real time decision-making support in the management of air pollution that monitors a network of sensors feeding the space-time data bases and so on.

Moreover there is a real need of using spatial localization in urban real time applications.

These applications raise several problems. In fact, their architecture must support mathematical models and algorithms which have important capacities of calculations; also it is difficult to take account of the real time granularity.

They also present major problems at the design stage because of the absence of a specific standardized formalism. Moreover the existing methods are inefficient to answer the problems of design of the real time geoprocessing applications. Thus we propose a UML profile to allow the designer to design real time geoprocessing applications.

2. Design Methods Of Goprocessing Application

Several geoprocessing methods are dedicated to GIS: MODULR [3], Géo2 [4], MECOSIG [5]-[6], POLLEN [7], GeoOOA [8] [9], OMEGA [1]-[10]-[11], MADS [2]-[12]-[13]-[14], T-OMEGA [15]-[16]-[17]-[18]-[19], OMT-G [20], GeoFrame [21] and GeoUML [22]. These methods which focus on the design of GIS applications don't integrate specific concepts for geoprocessing real time applications. While using these methods, one does not manage to model the space phenomena which vary in real time. With these methods it is difficult and sometimes impossible to model constraints relating to real time applications.

3. Real Time Methods

Real time software design activity can be divided into two types according to two complementary points of view :
• Static design which consists in a systematic description of all the software components (data and functions) and their interactions in terms of visibility and dependence.
• Dynamic design which focalises on the real time architecture description of software. Its objective is to meet temporal constructs and to provide the functioning system security.

These methods are dedicated to the design and formalisms of the traditional time-real applications, such as: SADT (Structured Analysis and Design Technique), SART (Structured Analysis for Real Time), DARTS (Design Approach for Real-Time System), HOOD (Hierarchical Object Oriented Design), UML (Unified Modeling Language), UMLRT….

However these methods do not take into account the spatial localization and the space-time phenomena since they are designed for real time the traditional applications independently of the location (with GPS for example) such as automats, machine's operations and so on.

4. Problems of Real Time Geoprocessing Application Design

Further to the design of several real time geoprocessing applications, we noted that most part of the existent methods do not meet the designer's needs and are insufficient regarding these applications .

In order to illustrate disadvantage of existing methods we will focus as an example: management of fleets of vehicles. Mobility and flexibility are two basic and crucial elements in modern industrial society. Every day, people and goods must be rapidly transported at a low price and in full security. This is why we are focusing on the management highway network and essentially on the way to manage rescue services on a toll highway after events such as accidents, traffic jams and so on [23]. In fact, it consists in the connection of a GIS with a real time system dedicated to provide with information concerning the positioning of various vehicles located in the territory under control.

When an incident occurs on a highway a series of complex decisions is put into effect by the highway exploitation staff. The objectives of this application are the effects analysis of an incident, that is to warn the other vehicles on the highway and to warn technical means on highways: ambulances, trucks, etc. We suppose that the highway control centre is equipped with a station having a GIS software. On the machine ports a radio transmission module is connected. The control centre allows the management of the position of the different vehicles. The vehicles and the technical means are equipped with GPS system and a transmission system. The application is made up in different models such as the control centre, the sub-system of localization, the sub-system of communications, etc.

The figure (Fig. 1) below represents a part of the conceptual model with MADS method.

In this model we used temporal relations ("connect", "connect-1", "connect2" and "help") which allow keeping trace of the life cycle of its instances [11], aggregation relations ("compose", "compose1" and "compose2") which allow to express that a highway network is composed of urgent bands, edges and vertex and topologic relation ("In") which allows ton express that the geographical position of the technical agent must be integrated in the line representation of the urgent band.

Among the problems we have met on the conceptual level:

- Delays cannot be designed in the real time, furthermore they are linked to the dispatching of technical means;

- Error cannot be designed by choosing technical means;

- The different real time interventions scenarios can not be designed in case of incident;

- It is difficult to design treatments and enchainment of states.

- It isn't possible to specify at design stage the time of reaction and the time of acquisition. We consider three types of real time, lets T1 and T2 two times defined by the designer of real time geoprocessing applications such as T1<T2 :

i) Real Time (RT): immediate real time RT = T1,

ii) Middle Real Time (MR): T1< MR< T2,

iii) Relaxed Real Time (RR): RR>T2.

We can not introduce at design level the concept of human intervention, one must know that to design an intervention it is necessary to have: an event shutter release, a continuity of actions

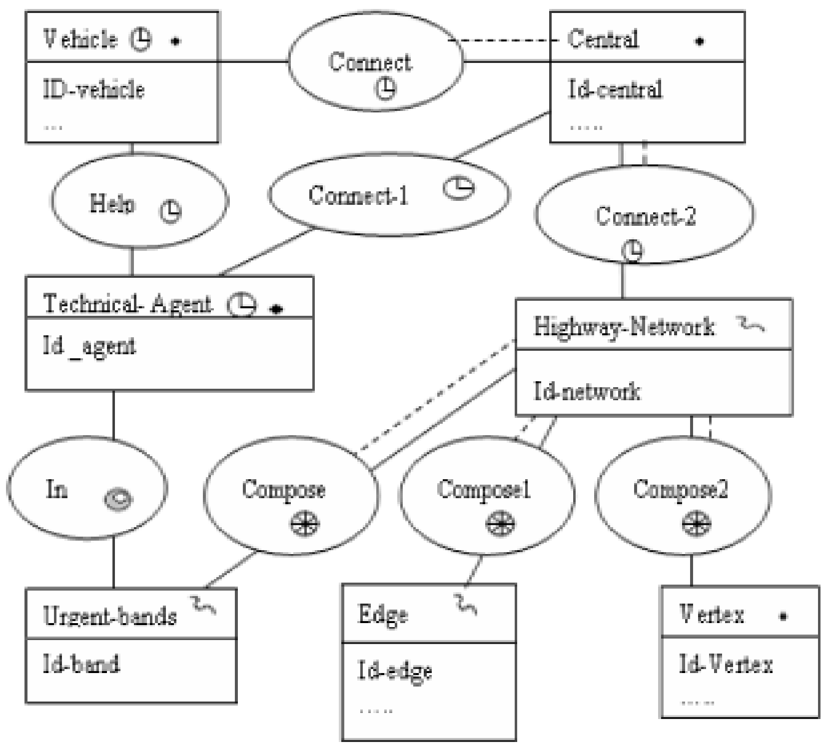


Figure 1. A part of the conceptual model with MADS method

5. A GRT UML Profile

On the basis of a design methods literature review of Geoprocessing Applications and real time methods we found that the most part of existent methods do not meet the designer's needs.

We propose a UML profile dressing real time constraints in the field of real time geoprocessing applications. The GRT (Geographic Real Time) profile targets the design of real time Geoprocessing Applications. GRT profile has been proposed on the basis of an extension of a class diagram, an activity diagram, a diagram of state transition and we added other diagrams such as priorities diagram and interventions diagram.

In the present article we present the class diagram, the activity diagram and the interventions diagram.

5.1 The GRT class diagram

The class diagram expresses in a general way the static structure of a system, in terms of classes and relations between these classes. We have realized an extension of the class diagram of UML. The class diagram of GRT processes all the concepts of the method T-OMEGA, as well as the various geometrical and temporal concepts defined in the MADS method and we have added specific extensions to real-time Geoprocessing Applications.

At the level of the profile, the designer must be able to distinguish between the geometry of storage and the geometry of display. During the creation of a class, we give the choice to the designer to define the used type of geometry to use and he/she can even define both types of geometries. We propose two stereotypes: one for the geometry of storage and the other for the geometry of display. The profile has to offer, as in most of design methods for the SIG, the possibility of associating geometry with the object classes and with the attributes. We have added an attribute "geo" to the classes whose the value corresponds to the geometry associated with an object. We have used the various geographical types defined in MADS such as Géo, simple Géo, complex Géo, simple area, complex area, line, line set, oriented line, oriented line set, point and point set. Every geographical type can be visually represented by a stereotype. We have opted for the initiative of design of stereotypes treated in T-OMEGA. We remind that at the level of this step, we define first of all the set T types to be used, then we define stereotypes ST and we finally define the various operators to use to define the combination of geographical types. The designer can also make a combination of geographical types. To define the combined geographical types, we have used both operations AND and OR dealt with in T-OMEGA on the set T with various geographical types previously quoted. The definition of the combined geographical types is made by graphic combination of pictograms. So the designer can define the geographical types combined for both treated types of geometry: the geometry of storage and the geometry of display. We also give the choice to the designer to define spatial associations. The various topological associations are: adjacency, disjunction, equality, crossing, covering and inclusion. In our formalism we have used the various concepts of temporality defined in MADS and in T-OMEGA. The temporality can be associated with any concept of the model. A class, an attribute and an association can be temporal or not. And the spatiality can be temporal as well. Given that, ans to treat real-time applications we have to notice the importance of the frequencies of acquisition of data and the frequencies of reaction for the real-time geoprocessing applications. In this diagram we let the choice to the designer to define the frequency of acquisition of data and the frequency of reaction. The designer can also define the speed of storage, the speed of display and the mode of functioning work: synchronous or asynchronous. We have defined these attributes as being special attributes which are specific to the profile GRT.

The figure (Fig. 2) below represents an example of class according to the GRT profile.

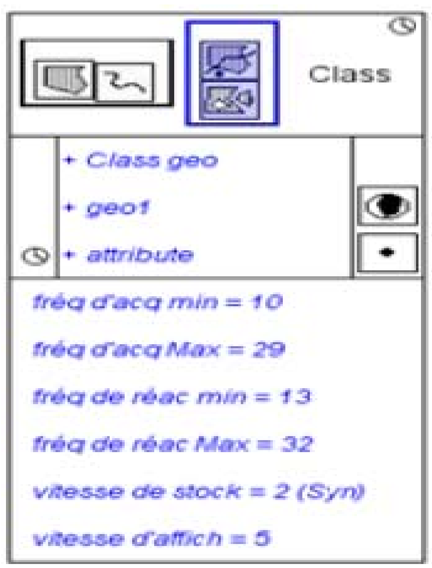


Figure 2. Presentation of a class according to the GRT class diagram

5.2 The GRT Activity Diagram

This diagram focuses the designer's interest on the transitions between states [24]. It represents the disjunction and the synchronization of events and also the dichotomy of the transitions. An activity is a machine in two states where the crossing of the transition between these last ones is conditioned by the end of the activity. In this profile we have made an extension in the diagram presented here. To meet the needs of the designer during the design of real time geoprocessing application, we have used the concepts applied in the real time UML profile : the profile TURTLE. We can model the various geographical objects which are instances of classes conceived at the level of class diagram of the profile GRT.

We have also emphasized on the real time operators by the integration of symbols for the presentation of both types of time: the determinist time and the not determinist time (Table 1).

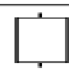
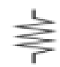
	Determinist time	Not determinist time
Symbols		

Table 1. Representation Of The Notion In The GRT Activity Diagram

We define a “determinist time” when the duration is precise, and when the duration is unpredictable we define it as “a not determinist time”. We can specify the maximal duration for every time type, by clarifying the time unit used (seconds, minutes, hours and days).

The figure (Fig. 3) below represents an example of activity diagram according to the GRT profile.

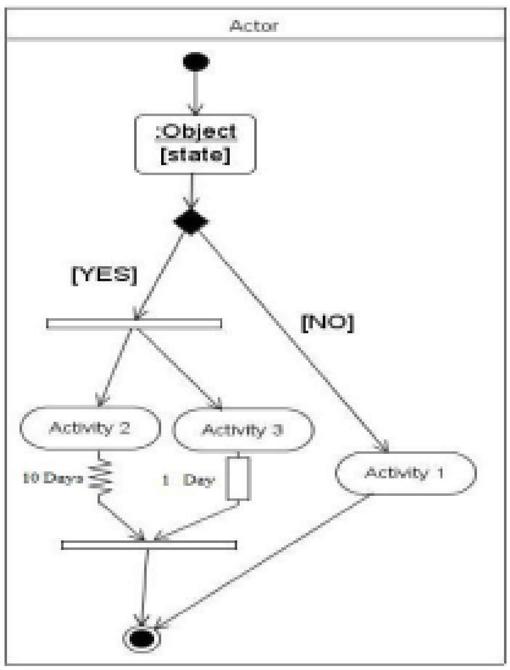


Figure 3. Presentation of an activity diagram according to GRT

5.3 The Interventions Diagam

Knowing the importance of the interventions for the realtime geoprocessing application, we give the possibility to the designer to define an interventions diagram in which he/she clarifies the various possible interventions according to a chronological order.

An interventions diagram is an extension of the sequences diagram, by basing it on the concepts of the TURTLE profile, so that it is adaptable to the real time geoprocessing applications. This diagram shows interactions between objects according to a temporal aspect. The representation concentrates on the expression of the interactions. It represents an interaction between objects by insisting on the chronology of sending the messages. Objects communicate by exchanging messages. Besides the classic synchronous and asynchronous messages, and the operators of buckles and alternatives, these diagrams support real time operators allowing on one hand, to associate with an event a symbol “Tempo” (to clarify that it takes place at a real time) and on the other hand, to associate with two events an interval of time which can pass by between the occurrence of these two events (Table 2).

	Tempo	Interval of time
Symbols		Duration

Table 2. Representation Of The Time Operators In The Interventions Diagram

Except for the added temporal constraints, we can also define any type of objects: simple classic objects or geographical object types. The geographical objects type can be visually represented by stereotypes.

In this diagram, we also give the possibility to the designer to express the combination of more than two geographical basic types previously defined.

The figure (Fig. 4) below represents an example of interventions diagram according to the GRT profile.

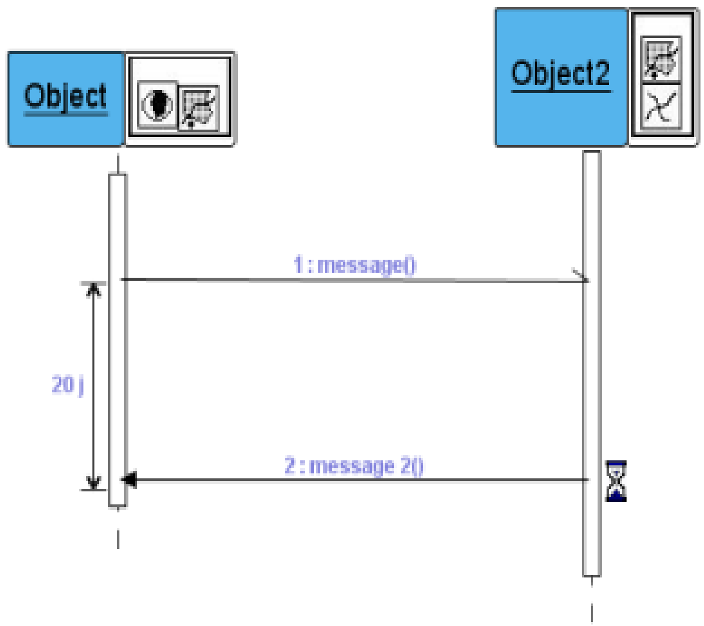


Figure 4. Presentation of intervention diagram according to GRT

4. Conclusion

The design and the modelling of the real time geoprocessing applications should make it easier to formalize the specifications and to bring coherent software tools compared to the user’s needs and constraints related to the reactivity and possibly the mobility of the system’s components.

Thus, we must take into account, at the design stage, the way to model by making the distinction between the phases data storage, the data posting and the processing. Especially, one must note that for the real time applications, the processing of data differs from an application to another according to the type of time used and the variation from the spatial localization Duration and the shape according to time. The phase of the treatment is very important and it is not treated with the folding screen by the various existing methods.

To face these problems we propose a profile being based on extensions of UML in order to take into account at the conceptual level the problems of communications and localization of the data and applications. We founding our formalism on the useful concepts, we propose a footbridge between the two types of methods (semi-formal dedicated to geoprocessing and traditional real time methods). In the present article we define our profile and our contribution consists in taking into consideration, in the same formalism, the designer’s needs to model a real time geoprocessing application. In order to validate our approach a prototype has been developed in java.

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