

Extending UML for Modelling Geographical Information Systems

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Abstract. On this work we present a Unified Modelling Language profile for representing Geographic Information Systems, given the problems faced in this area in the modelling of some specific concepts associated to the field such as: geospatial information modelling, geographic class interaction and specific hardware devices. We describe some examples using class diagrams and deployment diagrams through the Software Development Process of one case of study. This is a part of one more general profile that should include specifications for some other kinds of Unified Modelling Language diagrams required for Geographic Information Systems modelling. The proposed profile helps on direct modelling over software development standard methodologies and besides using conceptual modelling. Based on the presented sample diagrams, it can be used on GIS modelling and also extended for other diagrams beyond class and deployment diagrams, given that most of the target UML classes (mapped classes) are the commonly used when modelling using UML. The proposal also respects existing specific variants commonly used when developing this kind of applications in Web environment.

Keywords: UML profile, UML diagrams, GIS modelling, UML GIS extension, metaclasses.

1. Introduction.

The Unified Modelling Language (UML) is the preferred language for modelling software around the world. It is used from low-scaled applications in the academy to high-scale applications in the industry. Even when UML have been demonstrated be useful over the years, it lacks some features when applications become more and more specific and complex. In the Geographic Information Systems (GIS) domain, as in some others, there are some unsatisfied necessities: (1) associated to the limitations of UML sintaxis or semantics, which does not allow representing domain specific concepts, or (2) when we need to restrict or adapt UML constructors, which are generic and many. [1].

UML creators defined the UML profiles, which are a mechanism for adapting UML metaclasses to more specific domains, for example in EJB and COM platforms, available from version 1.x and refined for UML 2.x. [2].

There are some proposals related to GIS development, mainly related to representing geographic data and in some cases associated to international standards for representing geospatial information [3] and [4]. Besides, there are other proposals of visual languages as UML extensions, like OMEGA, for personalized GIS applications development [5]. In [6] the authors propose an UML profile for geographic databases design, introducing the starting classification for objects named "geographic".

Even when exists some proposals, following [7] there still been many unsatisfied requirements, mainly related to restrictions and events concerned to geographic objects. When developing GIS software, existing diagrams are too general for guiding GIS development software and for representing domain specific concepts. Besides, none of proposed UML profiles is commonly used by designers inside developing teams, sometimes given by their ad-hoc nature. Because of that, it is needed to develop generic proposals for representing GIS features in a better way.

This work is structured as follows. After this introduction, section 2 depicts the followed steps in the definition of the proposed UML profile, its stereotypes, tagged values and target UML classes. Then, section 3 explains the different Object Constraint Language (OCL) constraints. Section 4 shows a sample case of study using the proposed profile and, finally, section 5 presents conclusions and future work.

2. Profile definition.

There are some basic rules that we must accomplish when defining UML profiles, established in the section 18.1.2 of [2]. A profile can be defined as an UML package, stereotyped as <<profile>>, which extends to a metamodel or to another profile. Three elements are needed: stereotypes, constraints and tagged values. The figure 1 shows the designed GIS UML profile.

From the figure:

1. Each stereotype has an identifier (name) and the target metaclasses over it can be applied. On this case, nine stereotypes are defined as shows Table 1. For example, the <<NetConnector>> stereotype only can be applied over the UML classes (class), and they should specify a communication protocol.

Stereotype	Target UML Metaclass	Description
Layer	Class	Representation layer
GObject	Class	Geographic object
View	Class	Map view
Map	Class	Map
DBServer	Node	Database server
ApplServer	Node	Application server

MapServer	Node	Map server
NetConnector	Association	Network
GClientDevice	Device	Client device

Table 1. Description of defined stereotypes and target UML metaclasses

2. Stereotypes have tagged values, which are meta-attributes associated to a metamodel metaclass extended by a profile. All tagged values should have name, type and stereotype. For example, the stereotype <<NetConnector>> can have a tagged value named "protocol", with type ptype (enumeration) that indicates the communication protocol used by any class stereotyped <<NetConnector>>. In a profile, tagged values are represented as attributes of the class defining the stereotype (See Figure1).

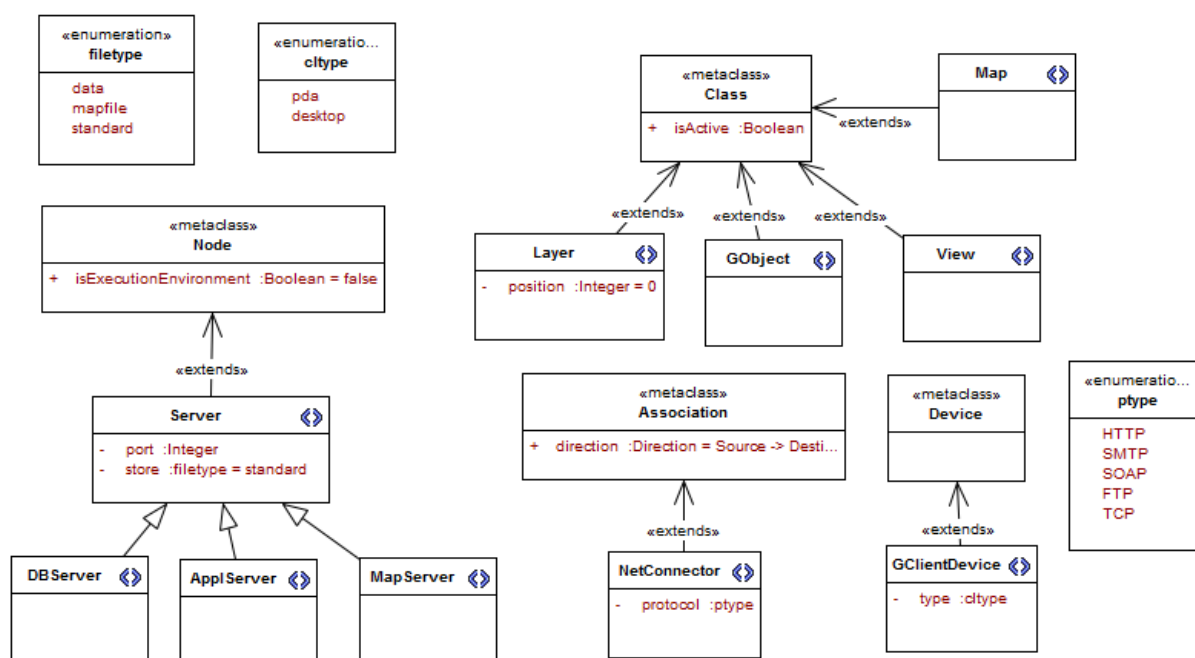


Fig. 1 Stereotypes of the GIS profile.

The aforementioned profile allows adapting elements from the UML metamodel to the GIS domain, helping to represent GIS applications in a better manner, easily understandable for team specialists (architects, analysts, developers), which improve enormously the efficiency of development process.

3. OCL restrictions.

One of the principal elements established in [2] for the UML profiles definition, in order to define "well-formed" profiles that could be exchanged by different CASE tools, are OCL constraints. They help avoiding designer's wrong actions, foreseeing future problems in the implementation and, of course, future software failures, mainly caused by diagrams misinterpretations.

The preferred language for constraints definition is OCL, even when they can be defined using natural language, which could introduce ambiguities. Given that OCL is a formal language, it is chosen for the definition. Some of the defined OCL constraints are the following:

```
context UML::InfrastructureLibrary::Core::Constructs::Node
self.isStereotyped("DBServer") implies store=data
self.isStereotyped("AppServer") implies store=standard
self.isStereotyped("MapServer") implies store=mapfile
```

The aforementioned constraint is associated to UML nodes and defines the type of server to be represented and the value for the store attribute. For example, if we need to represent a map server, the value of the store attribute on this case should be mapfile, given that a map server use the configurations established in a mapfile for representing spatial elements.

4. Case of study

In this section we present a case of study based on the development of a SIG application, representing in a class diagram the domain-specific elements such us: geographic objects, layers and views (which may group layers). Figure 2 shows the resulting UML class diagram.

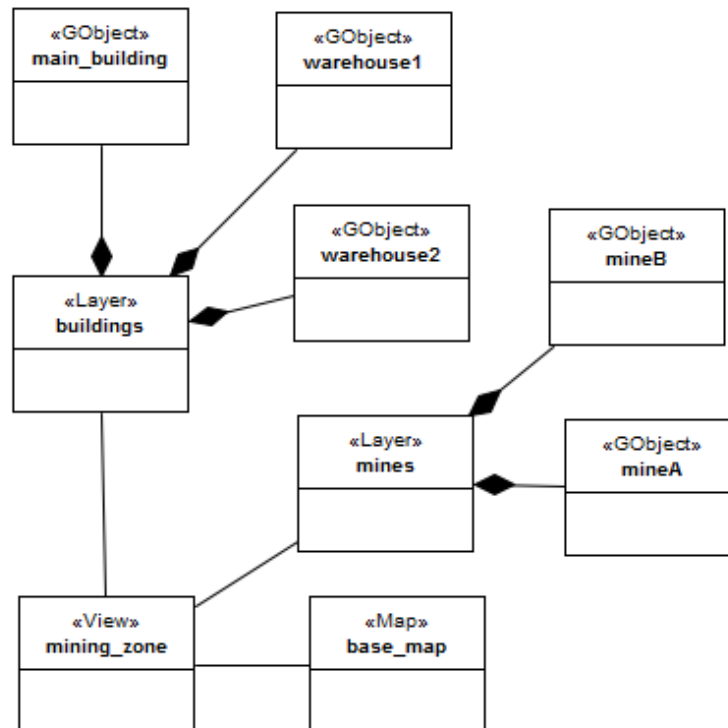


Fig. 2 Sample domain model (class diagram)

Using the View stereotype we can warrantee the representation of some polemic issues on domain elements modelling mainly associated to conceptual incongruences like behavior of things on scale change (Zoom). For example, using high scale, a building can be represented as a point, but on lower scale it should be a polygon, so the fact is that there is only one geographic object but two different views.

Other sample diagram is the deployment diagram, in which standards elements in many kinds of applications can be represented, but including domain-specific elements like mobile clients, map servers, etc. Figure 3 shows an example of deployment diagram for GIS. The samples are based on a real project for mining GIS software, in which fleet control and mining activities management is a key issue.

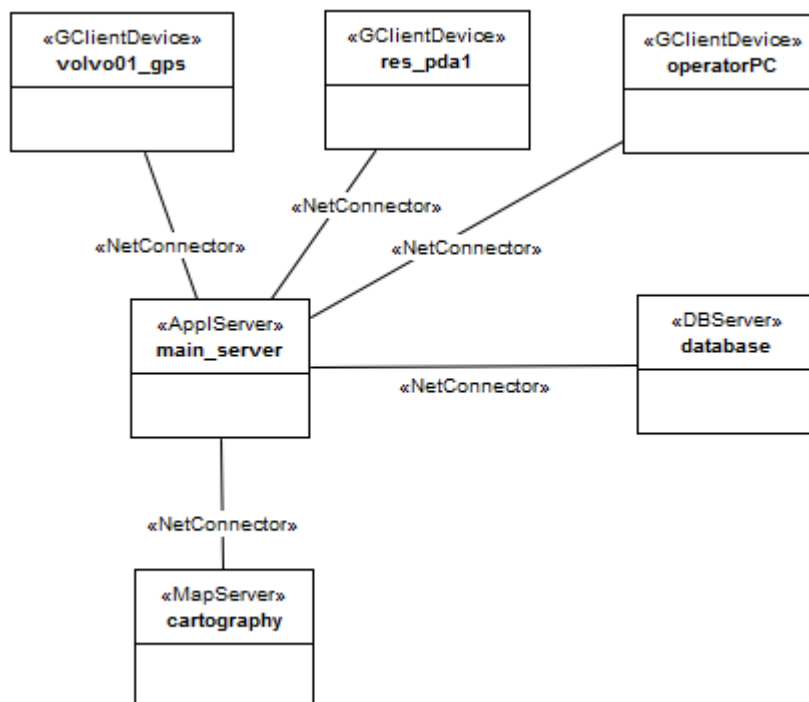


Fig. 3 Sample deployment diagram.

5. Conclusions

This work extends UML profiles as a mechanism for adapting UML modelling advantages for GIS modelling. The proposed profile helps on direct modelling over software development standard methodologies and besides using conceptual modelling. Based on the presented sample diagrams, it can be used on GIS modelling and also extended for other diagrams beyond class and deployment diagrams, given that most of the target UML classes (mapped classes) are the commonly used when modelling using UML. The proposal also respects existing specific variants commonly used when developing this kind of applications in Web environment, like specified in [8]. It is important to say that some existing CASE tools do not support creation of UML profiles, and if do, they follow UML 1.x specifications, without completely verify OCL constraints. This proposal is supported in Enterprise Architect 9, which allows creating UML 2.0 profiles.

6. Future work

The present profile should be extended for wide concepts of the GIS domain, explicitly specifying its usage for other important UML diagrams. Even when it has been tested in real applications, it can be refined for better results on helping GIS modelling and also prepared for Model Driven Engineering. On future activities we will explore some software-specific elements, tightly associated to class diagrams, commonly used for describing process before developing. We have identified some other ad-hoc stereotypes that should be helpful in direct process modelling, improving the implementation process.

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References

- [1] Vallecillo, A. and Fuentes, L.: Una Introducción a los Perfiles UML. [online]
<http://www.lcc.uma.es/~av/Publicaciones/04/UMLProfiles-Novatica04.pdf>. (2009)
- [2] Unified Modelling Language: Superstructure version 2.1.1. (2007)
- [3] Bordeur, J., Bédard, Y., and Proulx, M.: Modelling Geospatial Application Databases using UML-based Repositories Aligned with International Standards in Geomatics. 8th ACM Symposium on GIS. Washington D.C. (2000)
- [4] Pinet, F., Kang, M. And Vigier, F.: Hunter, J.: Spatial Constraint Modelling with a GIS Extension of UML and OCL: Application to Agricultural Information Systems. [book auth.] Uffe Kock Wiil. Metainformatics: International Symposium MIS 2004. Berlin: Springer-Verlag, pp. 160-178. (2005)
- [5] Pinet, F. and Lbath, A.: A Visual Modelling Language for Distributed Geographic Information Systems. Proceedings of 2000 IEEE International Symposium on Visual Languages. IEEE. (2000)
- [6] Kang, M., Pinet, F. and Schneider, M.: Hunter, J.: Agile Website. [online].
http://plone.itc.nl/agile_old/Conference/greece2004/papers/3-3-5_Kang.pdf. (2010)
- [7] Friis-Christensen, A., Tryfona, N. and Jensen, C.: Requirements and Research Issues in Geographic Data Modelling. GIS'01, November 9-10, 2001. - Atlanta, Georgia, USA: ACM. (2001)
- [8] Conallen, J.: Modelling Web Application Architectures with UML. Communications of the ACM, n.10: vol. 42. (1999)