Describing GGOS objects using standardized methods

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Abstract. GGOS can be considered as the set of the interrelated objects, which are assigned to each of the GGOS pillars. Both the multiplicity and the diversity of the GGOS object, but also the diversity of the objects interrelations bring about the complexity of the information structure of GGOS.

To assure better understanding of the universe of discourse, deeper and more systematic analysis and interpretation of phenomena in the field of GGOS, in terms of the standardized methods and IT techniques and knowledge (such as UML, model driven approach of systems designing and the methodology based on the ISO 19100 series of geographic information standards), the strict description of the information structure of GGOS should be provided. Such a description is the step in the process of designing and deployment of the computerized knowledge bases and the expert systems.

In the paper some examples of GGOS issues in the terms of selected IT techniques are presented. There is both the description of the static structure of GGOS (e.g. class diagrams, the objects catalogue) and the dynamic one (e.g. activity diagrams, use case diagrams).

The methodology being under discussion in this paper is a new assumption, which may be useful for doing research on the fields of each of GGOS pillars and interrelationships between them.

Keywords: conceptual modeling, expert system, UML, GGOS, ISO 19100 series of geographic information standards

1 Introduction

From the information perspective GGOS can be considered as the set of the interrelated objects, which are assigned to each of the

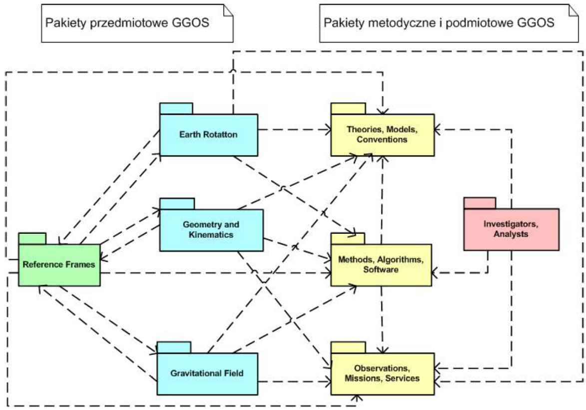

Figure 1. *Information categories of GGOS objects Source:* **?**

GGOS pillars. The following categorization of these objects can be distinguished: 1) phenomena, parameters and features which are the own characteristic of pillars; 2) theories, models and conventions; 3) methods, algorithms, software; 4) observations, missions, services; 5) investigators, analysts (Fig. 1)

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One of the modern technology of designing of the expert systems, called Model Driven Approach (MDA), consists of the following steps (Fig. 3):

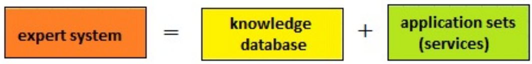

Figure 2. *Designing of the expert system*

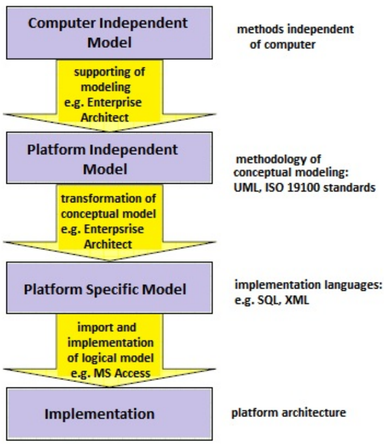

Figure 3. *Schema of the MDA technology*

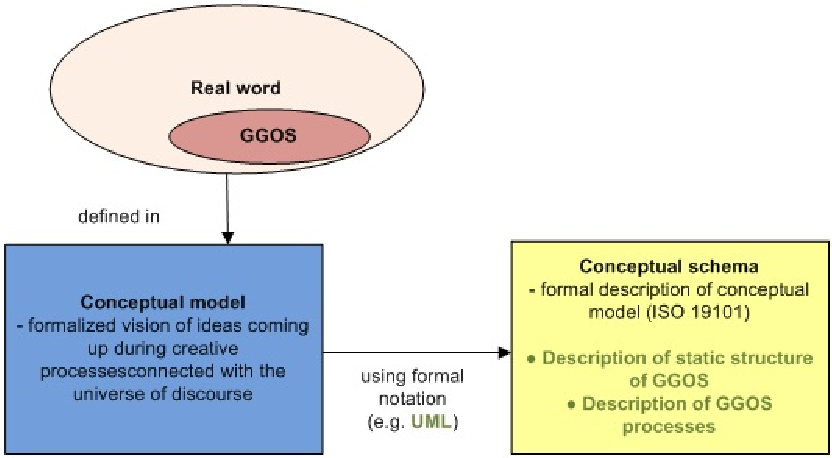

Figure 4. *Conceptual modeling of the GGOS universe of discourse*

The main phase of the MDA technology is the conceptual modeling and the result of it is the most important part of the whole process - platform independent model (PIM), which is described by using one of the formal notation (e.g. UML), Fig. 4.

2 Static structure of GGOS - the conceptual model

The main rules and formal notations, which are used for designing and implementing the GGOS expert system, are described in the following ISO 19100 standards:

- ISO 19109: Rules for application schemas. It defines General Feature Model (GFM), which shows rules for identifying object types, attributes, operations, constraints and relationships between object types of the universe of discourse and the rules for their logical structure in the form of an application schema.
- ISO 19110: Methodology for feature cataloguing. It defines rules for describing and classification of object types, at-

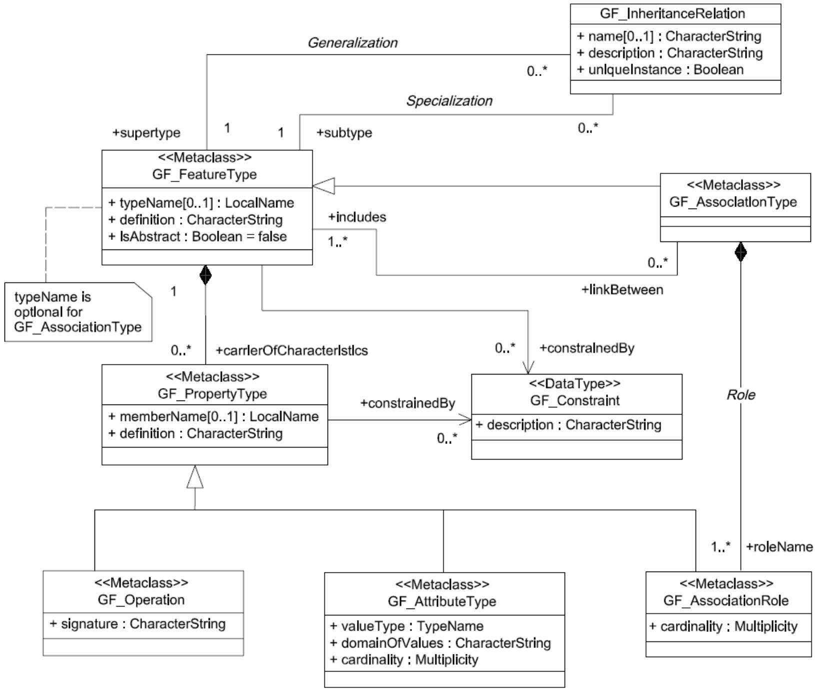

Figure 5. *General Feature Model - GFM (according to ISO 19109)*

tributes, operations, constraints and relationships between object types.

General Feature Model in terms of UML is presented in Fig. 5. As the example of applying the GFM rules, the UML class diagram describing object type "Time" from the UML package (pillar) "Earth-Rotation" is presented in Fig. 6.

Each object type in the application schema should be, according to GFM, the instance of the class "GF_FeatureType". In the same manner should be specified an attribute, as the instance of the class "GF_AttributeType", a generalization, as the instance of the class "GF_InheritanceRelation", and an association, as the instance of the class "GF_AssociationType". For the object type called "Time" some of the properties presents Tab. 1.

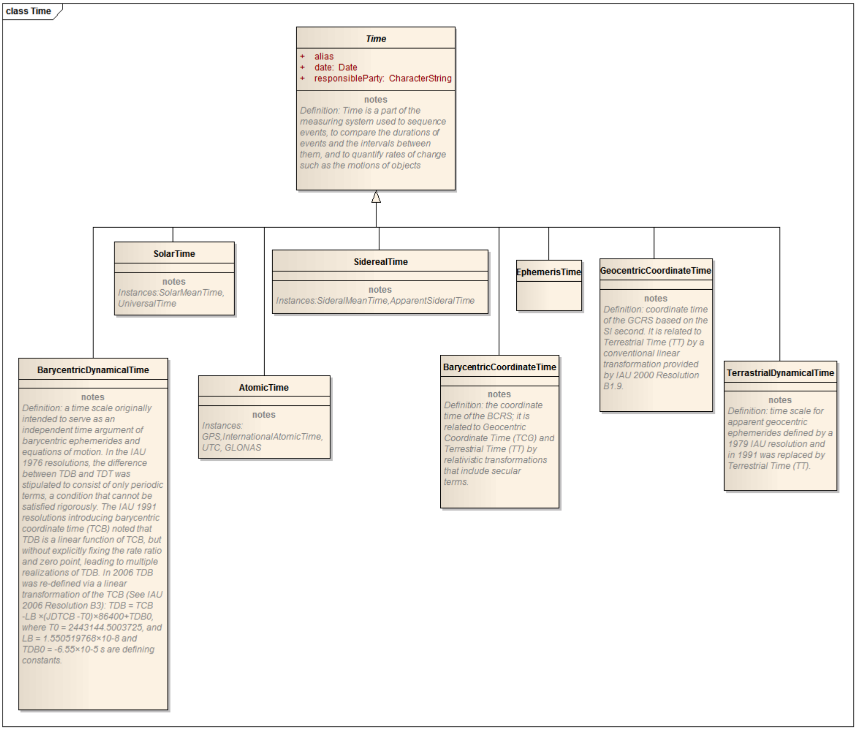

Figure 6. *The application schema of Time*

Table 1. *Properties of the object type "Time" in accordance with GFM*

Object Type as the instance of "GF_FeatureType"	Time
Name of object type	Time
Definition	...
Is it an abstract type ("isAbstract") ?	true
Attributes as the instance of "GF_AttributeType"	alias, date, responsibleParty
Generalization relationship as the instance of "GF_InheritanceRelation"	SolarTime, SiderealTime, EphemerisTime,...

Table 2. *The catalogue definition of object types "Time" and "SolarTime"*

Class FC_FeatureType (identity = 31)	
Attribute FC_FeatureType.typeName	"Time"
Attribute FC_FeatureType.definition	"Time is a part of the measuring system used to sequence events, to compare the durations of events and the intervals between them, and to quantify rates of change such as the motions of objects"
Attribute FC_FeatureType.isAbstract	TRUE
Role FC_FeatureType.inheritsTo	FC_FeatureInheritanceRelation (identity = 27)
Role FC_FeatureType.featureCatalogue	FC_FeatureCatalogue (identity = 1)
Role FC_FeatureType.carrierOfCharacteristics	FC_FeatureAttribute (identity = 4)
FC_FeatureAttribute (identity = 5)	FC_FeatureAttribute (identity = 6)
Class FC_FeatureType (identity = 34)	
Attribute FC_FeatureType.typeName	"SolarTime"
Attribute FC_FeatureType.definition	-
Attribute FC_FeatureType.isAbstract	FALSE
Role FC_FeatureType.inheritsFrom	FC_FeatureInheritanceRelation (identity = 27)
Role FC_ FeatureType.featureCatalogue	FC_FeatureCatalogue (identity = 1)
Role FC_FeatureType.carrierOfCharacteristics	-

A feature catalogue defining object types, attributes, operations, constraints and relationships between object types allows to improve the use of data. The structure of the feature catalogue in UML presents Fig. 7.

Table 2. presents some definition of object types in accordance with ISO 19110 standard.

In the same manner (mannerin accordance with the structure defined in ISO 19110, Fig. 8) attributes (Tab. 3) and generalization relationships (Tab. 4) can be specified.

Both the application schema (Fig. 6) and the catalogue of object types, attributes, relationships (Tab. 1-3) describe the static information structure of the aspects of GGOS and represent PIM in terms of the MDA technology (Fig. 3). In accordance with the MDA technology assumptions every single Platform Independent

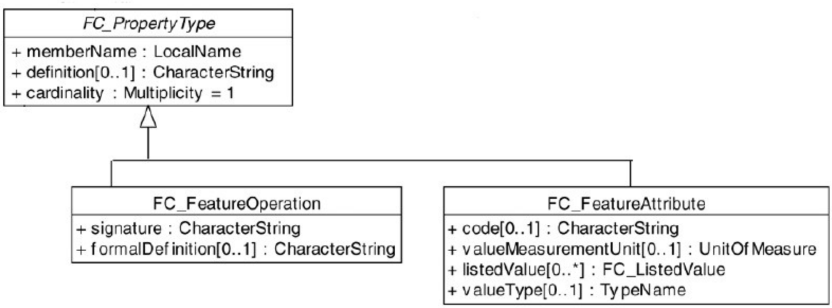

Figure 7. *Object types cataloguing (according to ISO 19110)*

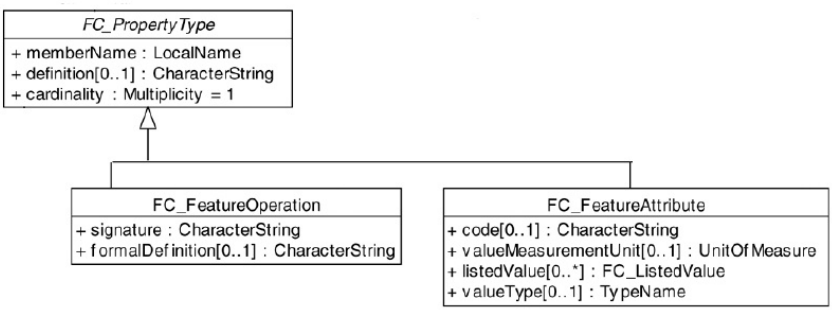

Figure 8. *Attributes cataloguing (according to ISO 19110)*

Table 3. *The catalogue definition of the attribute "responsibleParty" of the object type "Time"*

Class FC_FeatureAttribute (identity = 4)	
Attribute FC_PropertyType.memberName	"responsibleParty"
Attribute FC_PropertyType.definition	-
Attribute FC_PropertyType.cardinality	1
Role FC_PropertyType.featureType	FC_FeatureType (identity = 3) FC_Binding (identity = 6)
Role FC_PropertyType.constrainedBy	-
Attribute FC_FeatureAttribute.code	-
Attribute FC_FeatureAttribute.valueMeasurementUnit	-
Attribute FC_FeatureAttribute.valueType	CharacterString

Table 4. *The catalogue definition of the generalization relationship between object types "Time" and "SolarTime"*

Class FC_InheritanceRelation (identity = 27)	
Attribute FC_InheritanceRelation.name	-
Attribute FC_InheritanceRelation definition	"An object is classified as a specialization of another object."
Role FC_InheritanceRelation.subtype	FC_FeatureType (identity = 34)
Role FC_InheritanceRelation.supertype	FC_FeatureType (identity = 31)

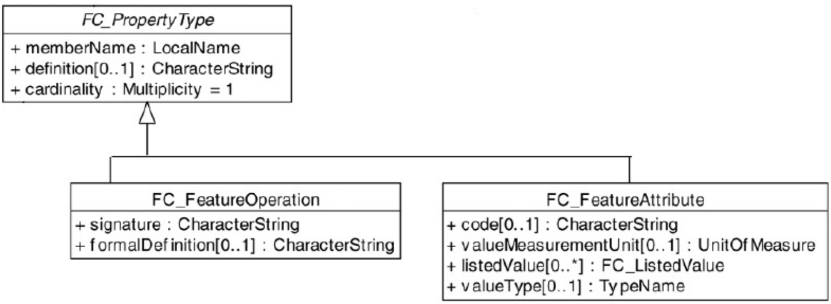

Figure 9. *The extract from the logical structure of the database (platform specific model) for the object type "Time"*

Model can be transformed (often in the automatic way, by using appropriate software, e.g. Enterprise Architect) to some variety of the platform specific models (PSM). Fig. 9 presents one of the PSM - the DDL model, as the result of the automated transformation of the UML class "Time" from PIM (Fig. 7).

The lexical form of the logical model is a script (e.g. SQL, XML), which can also be generated in the automated way. The example of the SQL script for PSM "Time" presents Tab. 5.

The physical structure of The database for the specific platform is the artifact of the last phase of the MDA process. The physical structure can be generated from the script automatically after running the script in the appropriate software (e.g. MS Access, Fig. 10).

Table 5. *SQL Script for the object type "Time"*

```
CREATE TABLE Time (alias CharacterString, date Date, name CharacterString,
responsibleParty CharacterString, timeID Integer NOT NULL);

ALTER TABLE Time ADD CONSTRAINT PK_Time PRIMARY KEY (timeID);
```

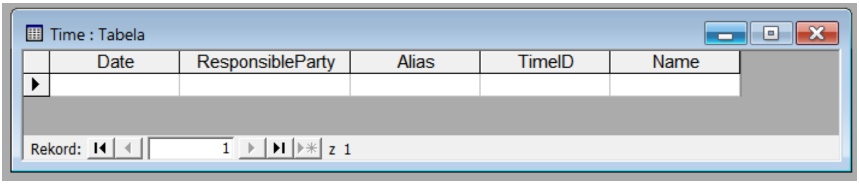

Figure 10. *The table "Time" generated from the application schema (Figure 10)*

3 Description of GGOS processes

The GGOS processes are the mutual relationships between object types both in and between each of the pillar.

Describing (modeling) these processes, which are inherent dynamic part of the information structure of GGOS, is by using the conceptual schema language - UML - use case and activity diagrams.

Use case diagrams allow to describe the sequence of the actions and their varieties (""use cases"), which a system can perform by the interactions with the qualifier called an "actor". In the case of transformation of the celestial and terrestrial references, actions are defined by a few of use cases (transformation actions), and the "actors" of these actions are "UT1", "PolarMotion" and "Precession" (Fig. 11).

Activity diagrams are used to model the behaviors of a system, and the way in which these behaviors are related in an overall flow of the system. The logical paths a process follows, based on various conditions, concurrent processing, data access, interruptions and other logical path distinctions, are all used to construct a process, system or procedure. Fig. 12 presents the activities, which allow to define the mean place of the stars.

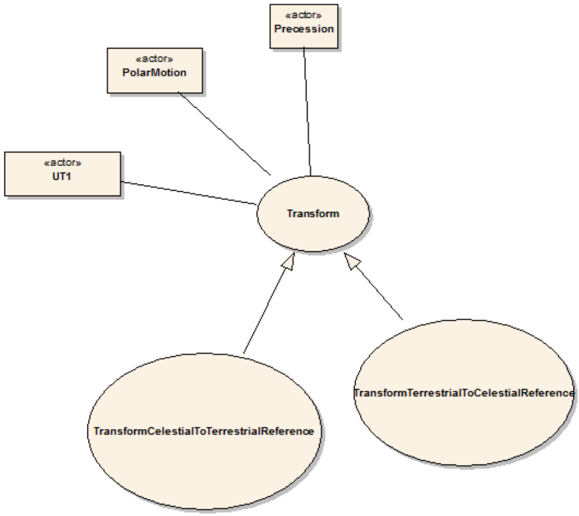

Figure 11. *The UML use case diagram of transformation of celestial and terrestrial references.*

4 Summary

Both the static and the dynamic structure of GGOS need to be described in the terms of the expert systems and the databases. The aim of such a point of view is better understanding of the universe of discourse, deeper and more systematic analysis and interpretation of phenomena and the optimization of the search programs. To fulfill postulates mentioned above, some standardized methods and IT techniques and knowledge are needed, such as UML, model driven approach of systems designing and the methodology based on the ISO 19100 series of geographic information standards. This paper presents some examples of GGOS issues in the terms of selected techniques

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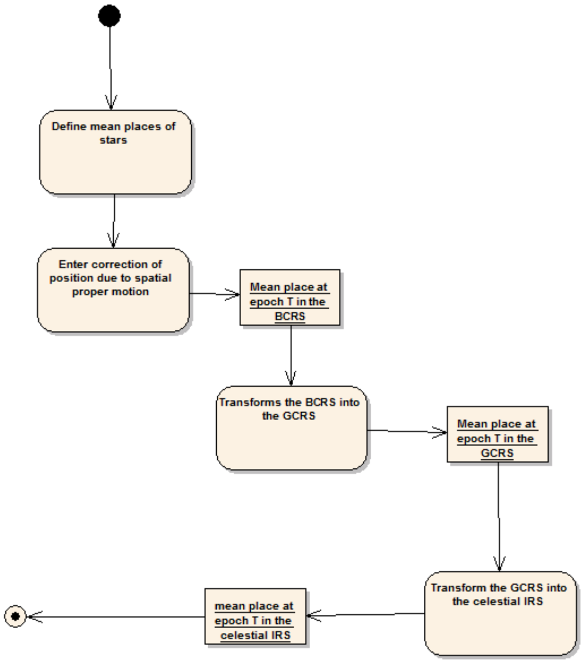

Figure 12. *The UML activity diagram of definition of mean places of stars.*

ical and observing segments of the Global Geodetic Observing system GGOS”) of the Polish Ministry of Science and Higher Education.

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