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ISO AND OGC COMPLIANT DATABASE TECHNOLOGY FOR THE DEVELOPMENT OF SIMULATION OBJECT DATABASES

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ABSTRACT

Due to the wide range of tasks of modern simulation systems in military context, most simulations take place in an isolated application with preprocessed simulation data. A first step towards running cross domain simulations is to bring together the simulation data schemas. The use of international standards on data modeling, data storage and visualization is prerequisite to achieve such a system for describing, accessing and pursuing simulation data in an interoperable way. For this ambitious task standards of data modeling and simulation, namely the Extensible Markup Language (XML), the Geography Markup Language (GML) and the Synthetic Environment Data Representation and Interchange Specification (SEDRIS) are combined. In compliance to the International Organization for Standardization (ISO) and the Open Geospatial Consortium (OGC) a simulation object database (SODB) which is perfectly suited for interoperable access and the use in cross domain simulations is presented.

1 INTRODUCTION

For the mutual integration of various simulation systems for the purpose of simulating joint exercises under "fair fight” conditions (Siegfried 2011), it is essential to analyze the existing methods and data schemas cross sectional. This background raises the question about the configuration and the environments of these systems at the beginning of exercise scenarios and during their execution.

An abstract view on this problem leads to several existing norms and standards. The origin of these standards is both the domain of spatial data with the ISO 19100 series of standards (XML/GML) and the domain of simulation systems with SEDRIS ISO International Electrotechnical Commission (IEC) 18023. CPA Systems is looking for the enclosing parenthesis of these different approaches to synchronize them in a technical data processing system.

Within current projects like “Distributed, Integrated Test Bed” (VIntEL-Project, original title: “*Verteilte Integrierte Erprobungs-Landschaft*”) or “Development of a simulation object data base, including a service architecture for distributed simulation systems” (SODB-Project, original title: “*Aufbau einer Simulationsobjektdatenbasis einschließlich einer Service-Architektur für verteilt operierende Simulationssysteme*“) concepts and methods for data supply for future simulation systems are developed.

In the wake of these investigations and developments the main focus is on:

- Best support of simulation based international standards
- Immediate interoperability and sustainability by the combination of modeling standards and modern database technology
- Integration and high availability of very large spatial datasets
- Interplay of various simulation systems under "fair fight" conditions due to semantic data models

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- Reuse of all database content, for instance preparations of troop movement, individual training scenarios or mobile vehicle systems.

The central solution is to achieve conformity of the simulation data supply through the use of international norms and standards of the ISO and OGC. With respect to the OGC service architecture this leads to a consistent data supply in distributed simulation systems. The data consistence is the main aspect to improve High Level Architecture (HLA) based simulations and facilitates the integration of federates with varying thickness and bandwidth.

2 BACKGROUND

2.1 SEDRIS

"SEDRIS is an infrastructure technology that enables information technology applications to express, understand, share, and reuse environmental data. SEDRIS technologies provide the means to represent environmental data (terrain, ocean, air and space), and promote the unambiguous, loss-less and non-proprietary interchange of environmental data" (SEDRIS Home). SEDRIS was established in 1994 under the patronage of the Department of Defense (DoD). Today SEDRIS is used by a global community in the field of simulations.

SEDRIS is a combination of ISO/IEC standards for describing, interacting and exchanging environmental data, as well as modeling their structure, syntax and semantics. With regard to GML, SEDRIS offers a more general way of data modeling. In SEDRIS abstract contexts, e.g. a relation between objects and their semantic can be modeled independently. Therefore SEDRIS differentiates between classes and their meanings and comes with an abstract class model (the Data Representation Model (DRM)) and an abstract meaning library (Enviromental Data Coding Specification (EDCS)).

2.2 GML

The OGC is an association of industrial enterprises as well as representatives from universities and administrations. The association aims to support the development of standards and norms in the context of spatial data. Most of the OGC specifications relate to modeling 2D and 3D vector data. Due to its generalization GML is one of the most interesting OGC-specification for the wide range of simulation systems. GML – especially GML3 – is a XML syntax which allows the description and the exchange of vector based spatial data. The basic modeling concept of GML offers 2 and 3 dimensional geometries with respect to the European Petroleum Survey Group (EPSG) spatial reference systems, topological relations, object oriented meta data schemas, complex attribute types, linking spatial and non-spatial objects and relations based on the Unified Modeling Language (UML) like aggregations or compositions. The basic types of the GML syntax refer to specifications of the ISO 19100 series. To ensure ISO compliant data modeling an application needs to define its application schema in a GML based XML-Schema. In other words, every GML based application consists of its own application schema, which is written in the language of XML Schema Definitions (XSD).

3 RELATED WORK

Gustavson et al. (2005) illustrate that the aim of Service Oriented Architectures (SOA) in simulation context "is to minimize unnecessary dependencies among systems and software elements while maintaining functionality". Motivated by the idea, that "SOA [..] achieves a level of flexibility and agility that most object-based architectures have failed to deliver, including the HLA", they present the need and a way of integrating SOA to simulations. In addition to this general approach, Tu et al. (2011) describe a more concrete combination of HLA and SOA with an implementation of Web-Service-Federates. Bernard et al. (2001) focus in contrast to Gustavson et al. (2005) and Tu et al. (2011) on integrating OGC compliant Web-Services like the Web-Feature-Service (WFS) to HLA based monitoring of (low frequented) meteorological data. In contrast to the aforementioned approaches, Rossmann et al. (2011) present the use of object oriented databases in context of wood and forest simulations with SupoportGIS. In difference to our approach they used a proprietary data schema but did not make use of an existing standard like SEDRIS. An integrated and ISO/OGC compliant approach, which combines SOA and HLA with object oriented databases in context of modern simulation systems, is still missing.

4 SIMULATION OBJECT DATABASES (SODB)

The central approach is to achieve compliance of the data supply to the international norms and standards of ISO and OGC. To implement a SODB, SEDRIS is mapped into an XML/GML application schema. This application schema is compliant to ISO 19100 series of standards and specifications of the Open Geospatial Consortium (OGC). With this artifice we achieve the following benefits:

- Product neutrality of the SODB with respect to interoperability and data infrastructure
- Well-defined and standardized structures to access objects in the SODB
- Use of GML databases (e.g. SupportGIS -Database) for the persistent management and continuing of simulation objects
- Widespread expertise in dealing with ISO/OGC-compliant data repositories

4.1 Establishment of Data Register (Catalogues)

The prerequisite for the derivation of a SEDRIS application schema is the availability of a SEDRIS-Register compliant to ISO 19135 (Geographic information - Procedures for registration of items of geographic information). A register is an abstract enumeration of unique identifiers of items, for instance the data types of a programming language. A register catalog consists of several different registers.

The basis for the implemented register catalog is the SEDRIS data model. This data model is described in UML format and available at the project site (http://sedris.org/drm.htm) as PDF-File. Corresponding raw data can also be obtained in MS Visio format or accessed as HTML/XML structures. These structures contain the dictionary (DRM) and will be used for several registers directly (See Figure 1 for an example of a register and Figure 2 for a sketch of the workflow).

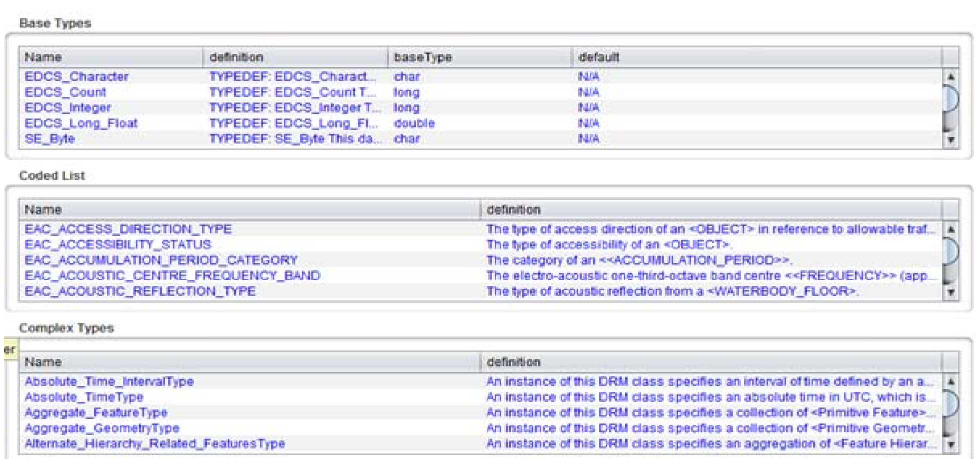

Figure 1: The SEDRIS DRM is included by several registers. Information is read directly from SEDRIS HTML/XML structures. Here: Data type register.

For the SODB the following registers for the derivation of the SEDRIS/GML schema are used:

- Term register: Contains all definitions and descriptions of object types. It represents a dictionary for further registers. The term register does not contain any relations or constraints.
- Data type register: Defines and describes all usable data types from basic types like Strings, Floats, Boolean and Dates to Enumerations and Code lists to further complex data types. Properties like inheritance, aggregation and composition are taken into account and mapped without loss (see Figure 1).
- Unit register: Contains all units of measurement, which will be used in the SODB. The unit definitions are compliant with the ISO 19103. Makes use of the Système international d'unités (SI).
- Model register: Contains information about models and reads object types with attributes and relationships directly from the DRM.

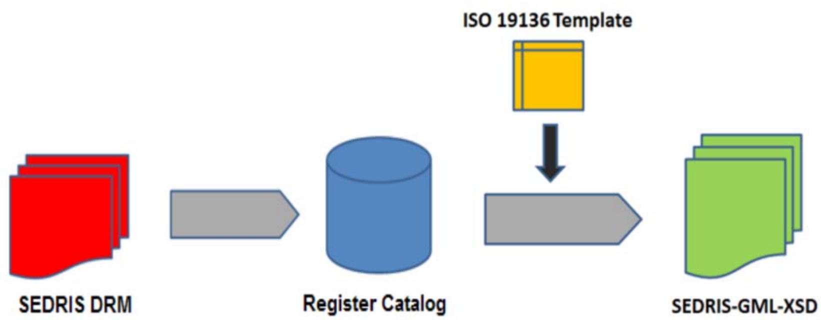

Figure 2: Workflow from SEDRIS DRM to the SODB schema.

In the use case of a SEDRIS/GML based SODB the user chooses the content of the SEDRIS DRM which is necessary for his simulation scenario (for examples see section 6). The ISO 19136 GML Encoding Rules Template is used to map the registry to GML. Therefore the template is converted manually in to SEDRIS Encoding Rules for example by adding new rules. A verbal form of a single rule could be: *New destination class "Areal_Feature" extends SEDRIS class "Areal_Feature". Add new typed attribute "geometry" of type "GML Surface"* (see Figure 6). With respect to these ISO 19136 based SEDRIS-Encoding Rules the SEDRIS application schema is generated automatically.

Based on this requirement a Register-Management-Tool (RegManTool), that can manage any number of catalogs and registers, was implemented. Rules and dependencies to other catalogs can be changed by the modeler at any time. The construction of registers is compliant to the specifications of ISO 19126 (Dictionary), ISO 19110 (Catalogues) and ISO 19135 management (Procedures for item registration). With the goal of sustainability and reusability in data modeling the software is modular and can manage different registers including their dependencies. Key terms and definitions are stored in separate registers and merged by reference. Data duplication and inconsistencies originating in the life cycle of a register is prevented.

4.2 Object-Oriented Data in Object-Relational Databases

The mapping of object-oriented data models into object-relational databases is implemented by the workflow, which transfers any XSD schema (for example a XSD file generated by the RegManTool) into a generic SQL table structure. This strategy enables the database to manage different geo-spatial data schemas and thus respond to individual requirements of various data.

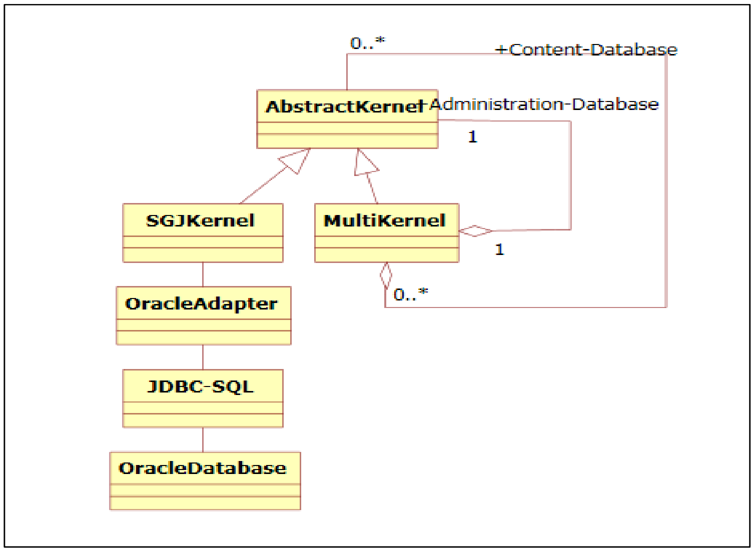

Figure 3: Multiple SODB-(SupportGIS) Kernel Architecture

With SupportGIS-Java (SupportGIS) CPA Systems offers a system that provides an implementation of the workflow described above. The system accepts data schema from various sources and converts them into a table structure of a database (See Figure 4). Using the XSD files the raw schema is converted and stored in an ISO/OGC-compliant structured schema. The result is always the semantic description of the data model in the physical tables of the data base management system (DBMS). Thus the transfer of almost any special application schema in a general database system is possible.

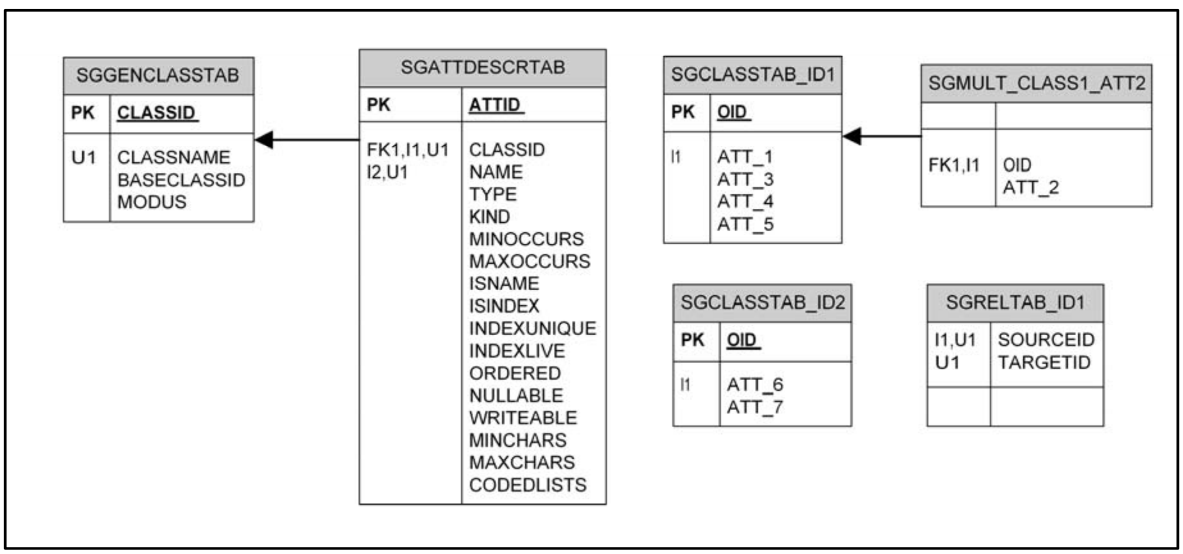

Figure 4: Derivation of abstract classes into the tables of an object-relational database

4.3 From a Registers Catalog to an Object-Oriented SODB

Using SupportGIS, the creation of the SEDRIS-GML database from the derived application schema is fully automated. For this purpose, SupportGIS interprets the corresponding XSD file and transfers it into the table structure of an object-relational database such as PostgreSQL or Oracle (see section 4.2). Figure 5 shows the access structures and individual components of the SODB.

The general information exchange of the SODB can be established by several OGC based Services (see section 7). Alternatively, the SODB can be accessed via the SupportGIS-API, a JDBC interface with a geo-specific extension of SQL 4. This SupportGIS-API provides an abstract Java Kernel (XML) API to access all relevant functions of the generic Kernel. All applications will be developed on this layer and run behind the different implementations, in a particular SGJKernel, or, for certain applications, a multiprocessor Kernel that integrates a variety of SGJKernels (see Figure 3).

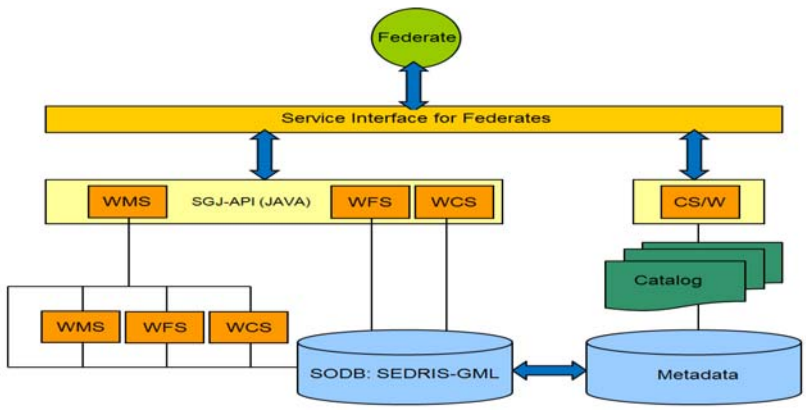

Figure 5: The SODB in the context with the OGC service architecture and the SupportGIS-API for HLA based simulations through a Service Interface.

5 EXAMPLES

5.1 Modeling Real World Objects in SEDRIS/GML

Figure 6 shows the independence between DRM and EDCS in SEDRIS. The classes "Classification_Related_Features", "Union_Of_Features" and "Areal_Feature" from the SEDRIS DRM describe an abstract object hierarchy by two separate 1-n relations. The hierarchy has no further semantics and could be applied to any other use case. A specific object meaning is only assigned by the relation to the "Classification_Data". In this example, the DRM classes are matched to the hierarchy of a city using the EDCS meanings for cities, buildings and walls. In general, the DRM can be seen as the grammar and the EDCS as the dictionary of SEDRIS.

In addition to the abstract object hierarchy and the semantics, the geometry is modeled by GML. At this point, GML can be understood as a kind of geometrical instantiation of objects. The GML - geometry is independent from both the semantics and the hierarchy.

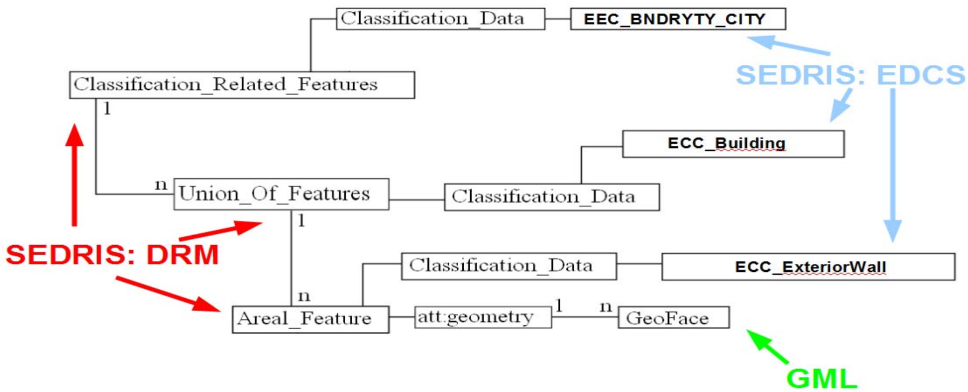

Figure 6: Modeling city objects from walls to buildings to cities with SEDRIS/GML using SEDRIS EDCS, SEDRIS DRM and GML

5.2 OpenFlight and SEDRIS/GML

Most of the simulator systems, especially in the field of virtual reality simulations (e.g. flight simulators) support the open data format OpenFlight (OF). Hence the ability of OF in a simulation database is necessary. To make the conversion between the SEDRIS data format and a target format such as OF as simple as possible, it is reasonable to look for similar structures in OF and SEDRIS DRM. Most of the nodes of the OF schema can directly be matched to SEDRIS classes. Table 1 shows the comparison between SEDRIS DRM and OF Record Types.

Table 1: Comparison of OpenFlight and SEDRIS DRM

Description	**OpenFlight**	**SEDRIS DRM**
Group node	Group record	Union of geometry hierarchy
Geometry node	Mesh record	Union of primitive features
Level Of Detail (LOD) node	LOD record	LOD related geometry
Switch-node	Switch record	State related geometry
Polygon	Face record	GML_Surface

6 USECASE

“The VIntEL-Project is a multi-year effort aiming at increasing the reliability and applicability of distributed simulations and strengthening the credibility of the simulation results” (Siegfried 2011). Successes and the current status of the project are presented at regular intervals on meetings with live presentations. During the meeting in fall 2012 the access and interaction of various simulation systems developed by different manufactures will be tested for a SODB. Within the tests, static objects like buildings, houses and trees are loaded initially from the SODB. The changes of dynamic objects such as impact craters, gates, demolition of buildings occur during the lifetime of the simulation and will be updated in the SODB via HLA or Web-Services. For this scenario a database schema is generated from the SEDRIS DRM. To produce a SEDRIS/GML compliant schema, the registers for the aforementioned workflow were built up from a subset of the SEDRIS DRM and GML. Figure 7 shows an example of building class instances. Of course, the created schema meets the requirements of the participating simulators and with that it is able to provide all necessary data.

Figure 7: Buildings in a SEDRIS/GML ISO/OGC compliant SODB. Every Building is an instance of SEDRIS class Union_Of_Features that links to multiple instances of SEDRIS class Areal_Feature. Every Areal_Feature consists of multiple GML_Surfaces (image: Bundeswehr, armed forces of Germany)

7 SUMMARY

From the basic standards ISO 19119, ISO 19109, ISO 19107, ISO 19108 and ISO 19111 arise abstract descriptions, rules and terminology for the modeling of spatial data. These standards create conditions that are supported by any ISO-compliant spatial data modeling. Such conditions are e.g. the interpretation of a feature as a model of a real world object (ISO 19109), the description of the spatial reference of geometrical and topological properties (ISO 19107) or the definition of space (ISO 19111) and time (ISO 19108) as reference systems.

With regard to these standards we describe a mapping of the properties of model objects into the tables of an ISO/OGC compliant object-relational database. The logical data model of the SEDRIS/GML database is complemented by standard SQL operators which facilitate special SQL functions for fast spatial data queries in the database. Affected are these structures:

- Classes
- Attributes
- Relations
- Geometrical features

8 CONCLUSION

The presented standardization strategies accelerate the data collection, due to its broad applicability. This leads to the benefits of standardized service oriented architectures (SOA). So called geo-data-infrastructures offer a wide range of different data sources through uniform access methods. They can also be used for concepts of data continuation and versioning of data resources.

These strategies provide optimal conditions for an adaptation for data supplement of simulation applications. Merging SEDRIS structures with GML specification enables a standardized service-oriented infrastructure for the supply of SODBs including the following services:

- <u>Web Feature Service (WFS)</u>
    - Read access of vector data of the SEDRIS-GML database.

    - Transactional Web Feature Service (WFS-T)
    - Continuation of the vector data
- Web Map Service (WMS)
    - Read access to the OGC compliant Styled Layer maps, vector graphics data via WCS or the integrated raster images (satellite images, aerial photographs)
- Web Coverage Service (WCS-T)
    - Read access and continuation of raster images or image based height maps

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