ABSTRACT

OBJECT-RELATIONAL DATABASE AS A DATA SOURCE FOR INTERACTIVE DYNAMIC WEB APPLICATION

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The specialized Information system for data of water quality monitoring for the Danube River Basin has been developed. This Information system enables efficient environmental water related data management and its verification was performed by using the data from the *Environmental Programme for the Danube River Basin (EPDRB)*, in which we actively participated (Pečar-Ilić, Ružić 2001). For the efficient development of such complex information systems the new, modern approach should be applied. It comprises the following items (Pečar-Ilić 2001):

- *Object-Oriented (OO)* approach - *OO* analysis and design by applying *CASE* tools based on *Unified Modeling Language (UML)* during object modeling
- Iterative and incremental development based on the system architecture model (serves as a framework for detailed development of the system structure and for iterative development of a specialized information systems with similar characteristics)
- Application of object technologies (program systems, development tools and languages)
- *Web* as a platform for interactive dynamic applications

In this paper the most significant aspects of the *OO* modeling of the database for the surface water quality monitoring within the *EPDRB* have been brought out. Database was implemented in *Oracle® Object-Relational DataBase Management System (ORDBMS)* and served as a data source for the interactive dynamic *Web* application for temporal and spatial presentation of relevant data. The use of *ORDBMS* as a database server in a *Web based three-tier client/server architecture*, such as integrated Information system architecture, has many advantages when compared to the use of relational *DBMS*. The main concepts influencing the increase in *Web* application performances have been described.

Specialized Information system for the data of water quality monitoring for the Danube River Basin was developed with the main goal to enable efficient environmental water related data management. The development process of the specialized Information system was based on the defined architecture of the Integrated information system for temporal and spatial presentation of complex data (Pečar-Ilić 2001). Its formal architecture description included additional class (object types) specializations in *UML* package diagrams, which correspond to spatial objects and the database source. They were necessary to describe the monitoring of the surface water quality in the Danube River Basin (Pečar-Ilić 2001).

From our own experience and then the activities within the *Information Management Sub Group (IMESG)* of the *EPDRB* we could analyse the existing data management process and recognized the procedures that could significantly improve such data management (Ružić,

Pečar-Ilić 2000). A *Data Exchange File Format (DEFF)* relational database implemented in *Paradox RDBMS* was used for the storage, processing and exchange of the collected data within the *EPDRB* (Kuipers 1996). For this reason, we started the analysis with *DEFF*.

For efficient object-oriented modeling, the use of *CASE* tools that support *UML* as a standard notation for object development methods was crucial. Nevertheless, although the *UML* supports a great number of existing *OO* methods and *OO* programming languages, it does not represent the standardization of the *OO* development process itself (OMG 2001). During *OO* modeling the *Oracle® Object Database Designer (ODD)* has been applied. *ODD* is based on most of *UML concepts* supporting *reverse engineering* method as well as *iterative* development process (Oracle® 1999a). By applying *reverse engineering* method with the use of *ODD CASE* tool the following procedures were performed (Pečar-Ilić 2001):

- Connection through *ODBC* to the existing *DEFF* system
- Capturing the data structure from *DEFF* database schema
- Generation of the object type model (corresponds to the *UML* class diagram) as well as the server model based on the captured database schema
- Tuning and improving the produced models

In Figure 1 the type diagram containing object types and their associations necessary for the description of surface water quality monitoring is presented (Pečar-Ilić 2001).

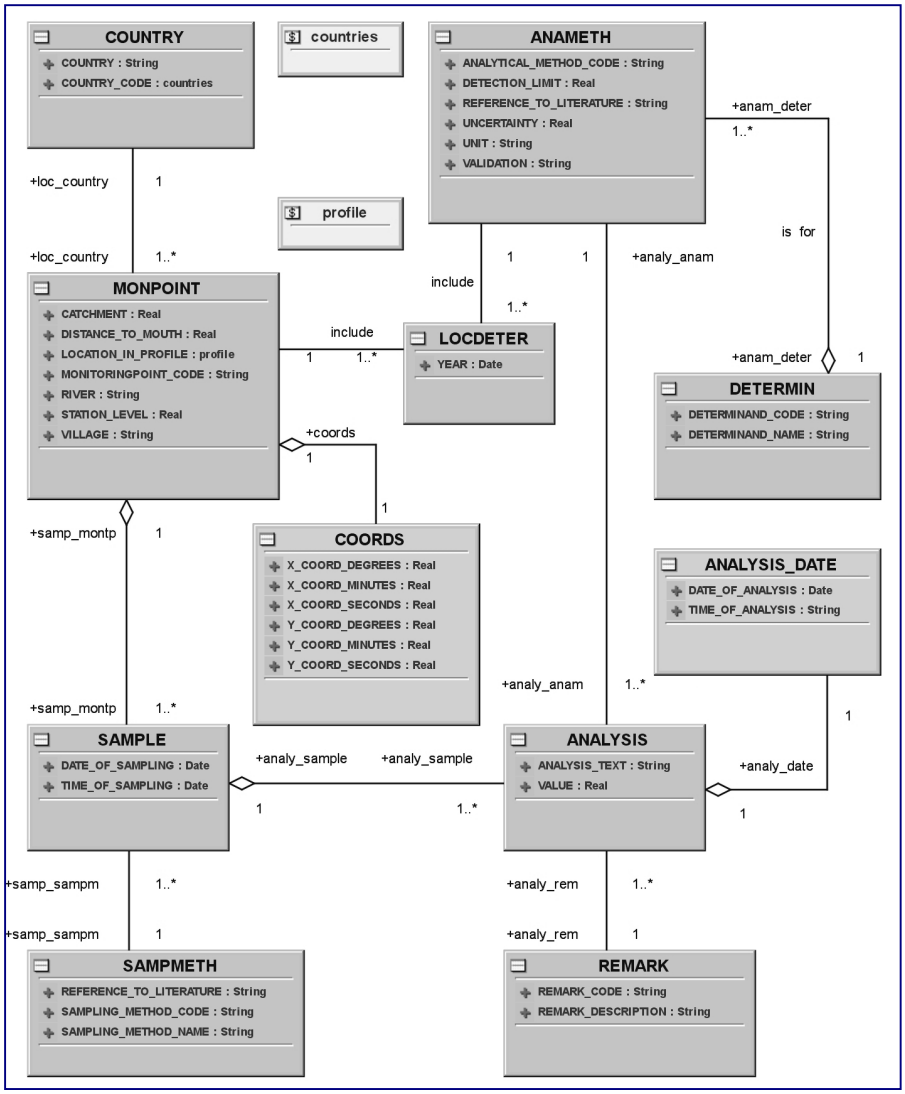

Figure 1. Type diagram for surface water quality monitoring in the Danube River Basin

In this object type diagram different types of associations are presented according to the well-known *UML* specifications for class diagrams (Oracle® 1999a). For example, *weak aggregation* (describing *whole-part* relationship) has a diamond on the comprising object type. For the object types shown in Figure 1 the attributes have been defined but not the operations. Namely, this results from the server model (produced in *ODD* by transforming the object type model) implementation in *Oracle® ORDBMS* as a *relational design with Oracle 8 object views* (Pečar-Ilić 2001). *Object views* represent a concept that provides object-oriented view on a hidden relational or object tables through *Oracle 8* object types (Oracle® 1999b).

In Figure 2 some objects in the *deffdb* user's schema of the database are presented. For example, this *deffdb* user's schema contains *Oracle 8* object types, object views, packages, stored procedures and relational tables. *Oracle 8* object types names have the extension '_T', while object views have the extension '_T_V' (Oracle® 1999b).

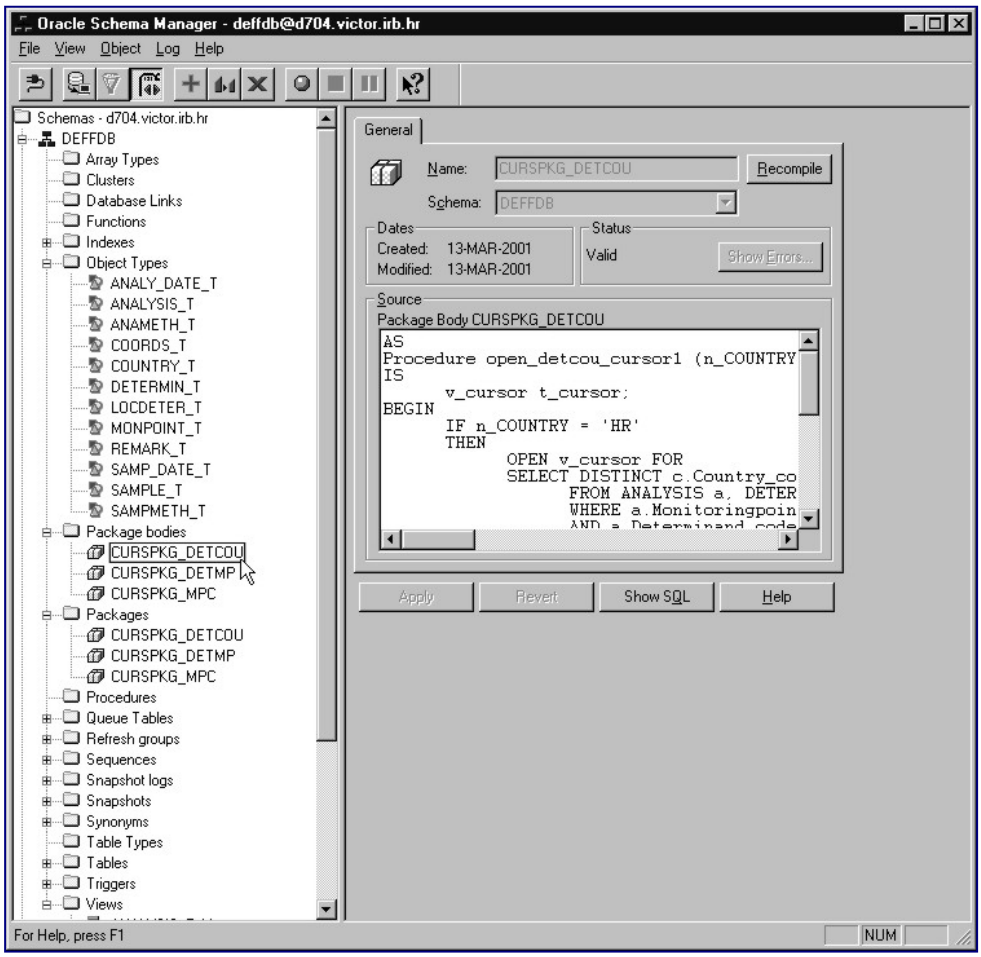

Figure 2. Example of the *CURSPKG_DETCOU* package body content in *deffdb* user's database schema presented by *Oracle Schema Manager*

In addition, *Oracle 8* packages containing stored procedures were also defined. Packages and stored procedures represent stored subprograms, which is the concept that provides *Oracle® ORDBMS* to enable reuse of defined and tested program code (Oracle® 1999b).

Depending on particular vendors, *ORDBMSs* more or less remain on object-oriented systems. They support both, the relational and the object aspects of the real world, thus in that context they represent the hybrid between *RDBMSs* and *OODBMSs*, providing the

combination of object-oriented and relational data structures (Stonebraker, Brown 1999). Nevertheless, the universal object-relational data model does not as yet exist while there are many variations of similar models whose characteristics depend on the level and the nature of performed variations. Regarding database design, the main advantages of *Oracle® 8 ORDBMS* are the reusability of objects for creating new complex objects (by building them in the table columns or rows) and well-structured design (by using objects, the database architecture based on components could be created). The main disadvantages of *Oracle® 8 ORDBMS* could be identical with general disadvantages of similar object-relational *DBMS* technology. For example, the increase in complexity is caused by the support of both, the relational and object-oriented systems. Another problem is database objects migration from one *ORDBMS* vendor to another, which is possible only if the transformation from the *OO* to relational design is performed, since the *OO* design requires a completely new database architecture (Oracle® 1999b).

Dynamic *Web* application has been developed, which enables spatial and temporal presentations by selecting the objects from a digital map (Pečar-Ilić, Ružić 2001). It is based on the information from object-relational database for the surface water quality monitoring in the Danube River Basin. The use of *Oracle 8* packages and stored procedures had a great influence on increasing the *Web* application performance. We applied these concepts while building-in automatic categorization of average parameters values procedure, as additional knowledge in the database, necessary during automatic generation of thematic maps. The *Oracle 8* packages with stored procedures were also used in *Active Server Pages (ASP)* scripts since they represent concepts for decreasing the number of calls between the client, *Web* server and database server. These combinations were crucial in the cases when large amount of data are transmitted through the network by application (Pečar-Ilić, Ružić 2001).

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