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Information and Data Modelling for Enterprise Interoperability

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ABSTRACT

This article proposes an approach based on the combined use of information standards and model transformations with the aim of facilitating interoperability in enterprises. The implementation of the approach employs visual modeling through a software environment for model-driven software development. Real application cases of the proposed approach have been developed based on specific data models.

Keywords: Visual Paradigm, BPMN model, ER Diagram, MySQL, Reverse Engineering.

INTRODUCTION

Interoperability is essential for effective cooperation and smooth exchange of information [1]. To achieve this goal, information modelling and data modelling play a key role by providing a unified approach to describing business processes, information assets, and rules.

By using information and data models together, it is possible to collect, store, process and distribute heterogeneous information in such a way that it is accessible and useful for all stages of design, as well as for the preparation of project documentation.

The paper proposes an approach based on the joint use of established information standards for the management of information, processes and data in enterprises and transformations of data models to facilitate interoperability between different systems and components. In the implementation of the approach, visual modeling was used through a software environment for model-driven software development. Real cases of application of the proposed approach based on specific data models in enterprises and organizations have been developed.

The analysis of the available environments for information modeling and data modelling has convincingly deduced the Visual Paradigm software environment due to the following functionalities: support of all types of UML (Unified Modelling Language) diagrams for visual representation of various aspects of software systems, maintenance and connection with Business Process Model and Notation (BPMN) diagrams for modelling business processes and workflows, maintaining and connecting to Entity

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Relationship (ER) diagrams for data modeling, capabilities for automatic code generation in various programming languages (Java, C++, C#, etc.), capabilities for reverse engineering to create models from existing code, automatic generation of documentation based on the models, etc. Visual Paradigm allows you to integrate various models and generate the following database management systems (DBMS): MySQL, MariaDB, Oracle, HSQL, SyBAse ASE, PostgreSQL, BD2, Firebird, SQLite, etc.

ENTERPRISE INTEROPERABILITY

The standard ISO 15704:2000 defines the term "enterprise" as "one or more organizations sharing a certain mission, goals and objectives to offer a product or service". The concept covers all types of organizations: companies, non-profit organizations, supply chains, virtual enterprises, as well as parts of companies [2].

ISO 11354-1:2011 provides a structured approach to understanding, evaluating and managing interoperability in the context of system architectures, information exchange and business processes. The standard proposes a framework for interoperability in three areas: levels, barriers and approaches. The standard defines the following 4 levels of interoperability: data, services, processes, business, 3 levels of barriers to the implementation of interoperability: conceptual technological and organizational and 3 approaches to achieving interoperability: integration; unification and federation (Fig.1).

Further in the article, various methods implemented to facilitate interoperability in enterprises are shown and discused.

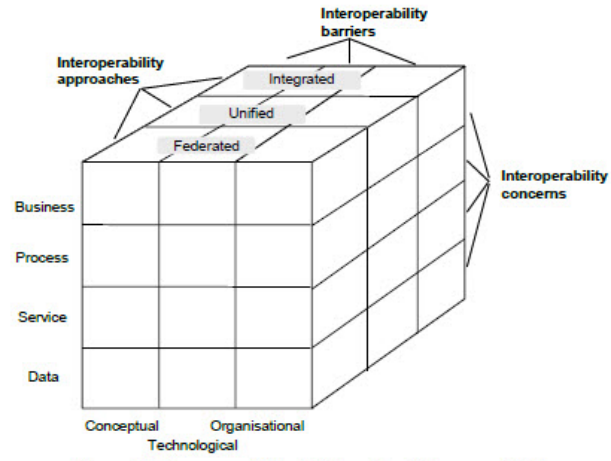

Fig. 1. Interoperability framework according to ISO-11354.

BPMN MODEL, ER DIAGRAM

The Business Process Model and Notation (BPMN) provides standardized semantics for describing processes. This allows different organizations to interpret models in the same way, which reduces the risk of misunderstandings. Models in BPMN are abstract in nature and can be run on a variety of environments, including business process management systems (BPMS). This ensures portability and facilitates integration between heterogeneous information systems. BPMN was created in unison with other initiatives such as BPEL (Business Process Execution Language) and UML (Unified Modelling Language). This facilitates the transformation of models to actionable specifications. In this way, automation and interchange are enabled. BPMN supports both the organizational and semantic and technical dimensions of interoperability. In the context of interoperability, BPMN is an essential tool of syntax at the orchestration level, it also describes the choreography of the processes "... Orchestration scenarios, from a syntactical perspective, require orchestration languages at different levels and with different goals, including Business Process Modelling and Notation (BPMN) and Petri Nets..."[3]. From an organizational level design perspective: the process also involves modelling the business processes to ensure that they are compatible and supported by the technical infrastructure. Shared workflows and protocols for collaboration between departments are developed or organizations. Tools like BPMN are essential for visualizing and synchronizing processes.

To investigate the joint use of information modelling and data modelling, an information model for database design has been developed. In the Visual Paradigm software environment, a process model has been created for the automated design of relational databases using the visual business process modelling language BPMN**.**

In the same project, ER models have been created on the "Enterprise data" database for storing, maintaining and updating information in any enterprise. The models are graphically represented by BPMN information model and ER data models in the Visual Paradigm software environment (Fig. 2).

The information model visualizes the design of a database for an arbitrary enterprise. Through the elements of the model, the stages of the life cycle of the process, from the point of view of a business project, are presented. The created algorithm follows the process from conceptual design, through business negotiations, to the implementation of the final design of the database. In order to achieve interoperability in a system, strict management of requirements and the implementation of adequate controls in the design and development process are necessary. This requires a systematic approach, covering both business processes and the information structure. For maximum efficiency, the model is decomposed and references to the ER models of the database are inserted. according to established criteria.

Based on the information BPMN model of database design processes, a database architecture design has been created through the implementation of conceptual, logical and physical ER models. The conceptual ER model is made up of eleven entities. Each of them is made up of a set of columns with a strictly defined specification: primary and secondary keys, type and maximum size of content, domain, etc. Relationships between the tables are included one-to-one, one-to-many, many-to-many. The conceptual model of the database is upgraded to a logical one, and it, in turn, to a physical one. When you switch to a physical model, many-to-many relationships and the tables that are related to them are represented by one-to-many relationships, and new tables are automatically created. In the physical model, sample data for the purposes of the study are introduced.

ER models are linked to the BPMN model and can be accessed from the respective levels of the BPMN model (Fig. 2).

The created ER models of the "Enterprise data" database are used to store, maintain and update information in any enterprise, whose activity is related to the production and

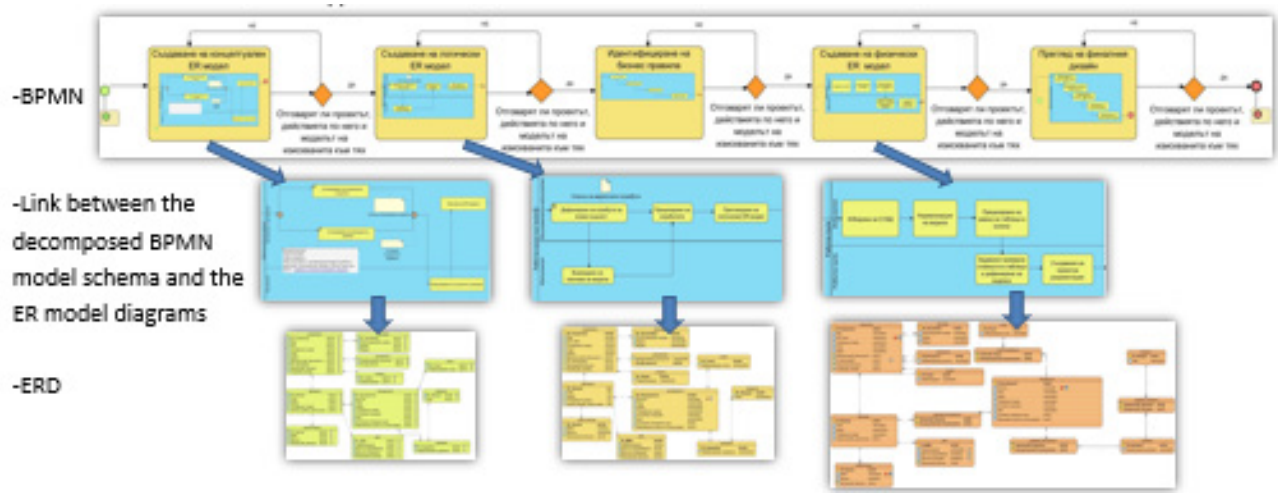

Fig. 2. Connection of the BPMN model with the ER models of the database architecture.

distribution of goods and own production - for the administrative structure of the company, employees, contractors, raw materials, products. Key to the project is the synchronization between the BPMN model (process logic) and ERD (data structure), which ensures overall coherence between processes and data, which is the basis for the successful construction of interoperable systems.

DATABASE DESIGN: FROM ERD TO RELATIONAL DATABASE

In the Visual Paradigm environment, data models are automatically created from the physical ER model in two DBMS - MySQL and MariaDB (Fig. 3). The ER model of the "Enterprise data" database project is implemented in both DBMS - MySQL and MariaDB through automated scripts created in the environment of Visual Paradigm DDL from SQL commands for creating tables, indexes, constraints and other objects. Online synchronization of the databases and the ER model has been implemented through the phpMyAdmin web application.

REVERSE ENGENEERING: FROM RELATIONAL DATABASE TO DATA MODEL UPDATE

A process of reverse design of the database has been implemented, related to changing the database by changing the ER model in the Visual Paradigm environment.

Through the phpMyAdmin menu, a new table is created in the "Enterprise data" database. In the Visual Paradigm environment, the database is analyzed after the change, the difference is detected, and the new structure is created. A database schema is obtained through its implementation, i.e. by defining its essences and the relationships between them. This approach can be applied to the whole system or to individual parts of it. Key elements for the implementation are: primary keys, foreign keys, constraints, relations. The database that undergoes a change is first visualized using an ER model and the correction is reflected. Thus, the project was modified. Finally, the adjustments are applied to the database.

OBJECT- RELATIONAL MAPPING

To facilitate enterprise interoperability, the approach that uses standard reference architectures and information models is developed and discussed here. Standard reference models are created at a high level of abstraction, independent of a specific industry or software implementation. In the implementation of the approach, the models provided by the ISO/IEC 62264 standard, which are the basis of RAMI 4.0, proposed for Industry 4.0, were used [4, 5]. The basic information

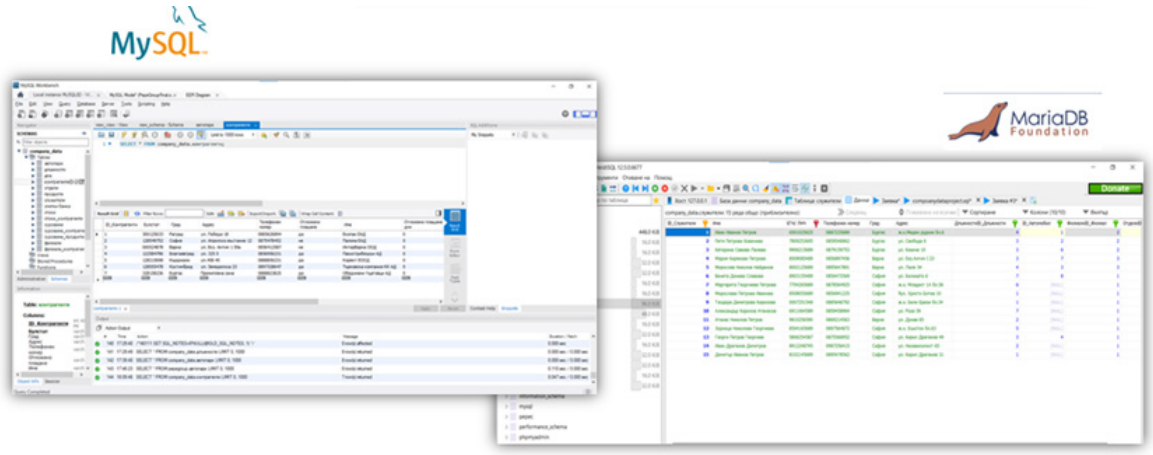

Fig. 3. View of databases in different DBMS.

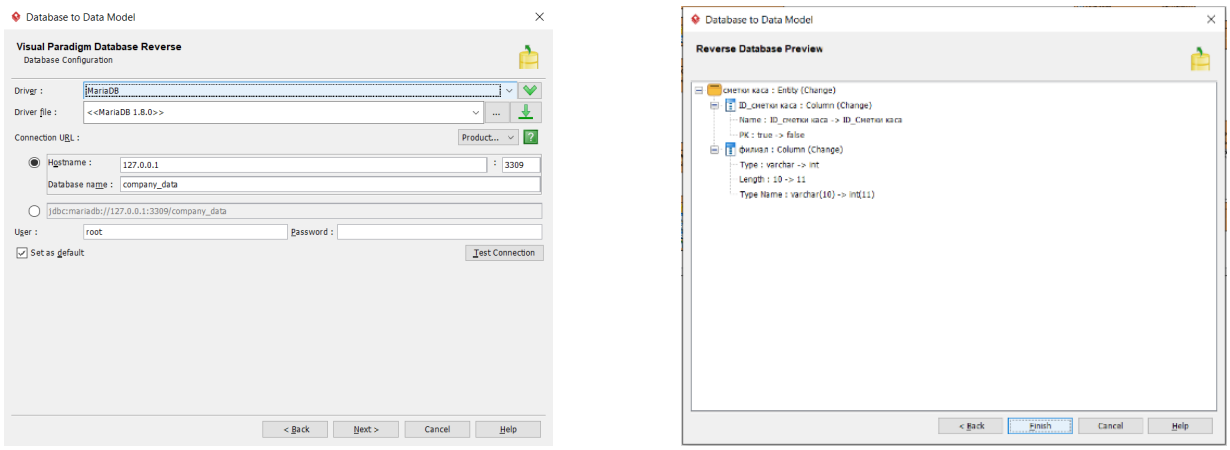

Fig. 4. Reverse engineering.

Fig. 5. Object- relational mapping of model Personnel.

according to the standard is structured in resource models: Personnel, Equipment, Materials. The use of models and terminology based on established standards (IEC 62264, RAMI 4.0) shortens the development time for interoperable systems and provides opportunities for reuse of models and data structures.

Transformations of object models from the ISO/IEC 62264 standard from UML class diagram to relational models have been implemented [6].

The created ER diagrams in the Visual Paradigm environment are used to generate databases in the various database management systems supported by the software environment.

DATABASE DESIGN FOR PROJECT MANAGEMENT AND INVENTORY OF MATERIAL ASSETS IN THE DEPARTMENT OF PRODUCTION AUTOMATION

To assist the Department of Production Automation in the project management activities and to connect with the inventory activities of the Department's tangible assets, a relational database has been created in an MS Access environment.

Interfaces to the database have been created for entering the data from the projects and from the inventory of the tangible assets of the department (Fig. 6).

The Microsoft Access product was chosen

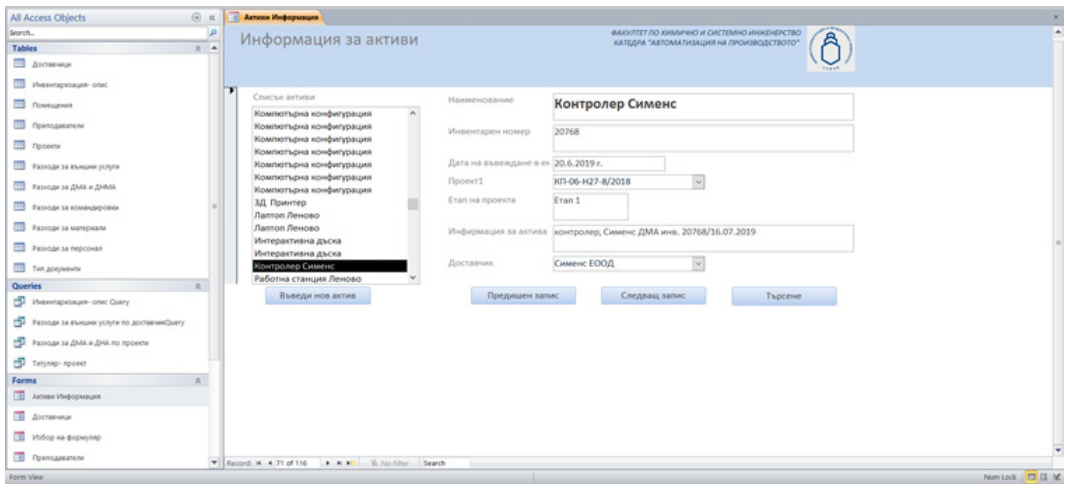

Fig. 6. Form of assets for inventory purposes.

as a means of implementing the database due to its wide availability and easy integration into a working environment. Through Open Database Connectivity (ODBC), Matlab provides access to databases within its software environment. ODBC offers a universal interface for connecting to various database management systems. A stable and efficient connection has been implemented, which allows automated data extraction, analysis and visualization in MATLAB.

CONCLUSIONS

The proposed approach uses legacy information systems, implying their joint use with new and different systems through the joint creation and use of information and data models through the methods of law and reverse engineering in software environments for visual modelling and implementation of models in different technologies and platforms.

Acknowledgements

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REFERENCES

1. G.S.S. Leal, W. Guédria, H. Panetto. Enterprise interoperability assessment: a requirements engineering approach, International Journal of Computer Integrated Manufacturing, 33, 3, 2020, 265-286, doi: 10.1080/0951192X.2020.1736636
2. ISO 15704:2000 - Industrial automation systems - Requirements for enterprise-reference architectures and methodologies. ISO/TC 184/SC 5. Geneva
3. S. Rinderle-Ma, J. Mangler, D. Ritter, Fundamentals of Information Systems Interoperability: Data, Services, and Processes, 2024, 1-51.
4. ISO/IEC 62264-1, "Enterprise-Control System Integration, Part 1: Models and Terminology, CEN/CENELEC Management Centre, Brussels, 2013.
5. VDI/VDE/ZVEI, GMA Status Report: Reference architectural model Industry 4.0 (RAMI4.0), 2015.
6. D.G. Gocheva, I.A. Batchkova, G.T. Popov, Ontology-Based Data Access and Model Transformations for Enterprise Interoperability, Machines, Technologies, Materials, 10.12, 2016, 16-19.