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Modelling of Designing a Conceptual Schema for Multimodal Freight Transportation Information System

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Abstract—Modelling of building processes of a multimodal freight transportation support information system is discussed based on modern CASE technologies. Functional efficiencies of ports in the eastern part of the Black Sea are analyzed taking into account their ecological, seasonal, resource usage parameters. By resources, we mean capacities of berths, cranes, automotive transport, as well as work crews and neighbouring airports. For the purpose of designing database of computer support system for Managerial (Logistics) function, using Object-Role Modeling (ORM) tool (NORMA–Natural ORM Architecture) is proposed, after which Entity Relationship Model (ERM) is generated in automated process. Software is developed based on Process-Oriented and Service-Oriented architecture, in Visual Studio.NET environment.

Keywords—Seaport resources, business-processes, multimodal transportation, CASE technology, object-role model, entity relationship model, SOA.

I. Introduction

GEORGIA strives to become a country which has European values, to integrate politically and economically with Europe. This is supported by geographical location of Georgia on the one hand, that the country lies at the crossing of several economic regions, giving unique opportunity to be transit country between Europe and Asia; while on the other hand, Georgia has the potential to become transportation and logistics centre of the Caucasus region [1].

Transportation infrastructure in Georgia is inconceivable without development of sea ports, with special importance dedicated to Batumi, Poti and Kulevi sea ports, as well as Anaklia sea port in the future perspective. They play one of the key roles in serving sea freight, that is important not only for our country but for Transcaucasian and Central Asian countries, since the most convenient and shortest route of the Eurasian corridor lies through Georgia.

In order to respond to developing model of effectively managing Georgian maritime transport and reacting to modern challenges, Georgia needs to develop new strategy of managing transportation system, which will be based on comprehensive approach and not only issues of optimal management of sea transport infrastructure processes will be considered but environmental factors as well, that are of current importance, accompanied by ecological processes.

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II. Description of Multimodal Transportation System

Sea port structures vary; they comprise of a territory and aquatory, rail and automotive ways, various objects of telecommunication, civil and manufacture facilities, storehouses, security structures, berths, coast protection structures and others (Fig. 1). Dynamic objects of a sea port are ships (passenger, cargo, mixed), rail wagons (closed, open, special), cranes (port, bridge, cable, crawler, motor, rail), shipment machinery (auto, electric, etc.), cargo (bulk, general), teams of workers, etc. [2].

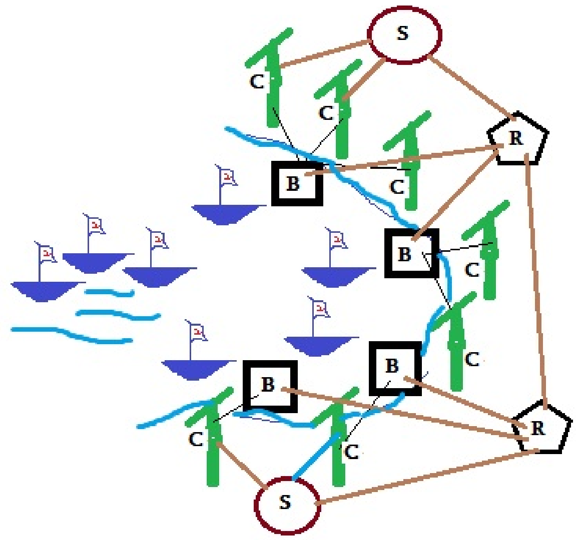

Fig. 1 Sea Port Model: B-berth, C-crane, S-storage, R-railway

Modes of transport (Road, Sea, Air) differ as from technical as well as from economical point of view [3]. Moreover, there does not exist an ideal mode of transport, in the area of international shipments often questions arise regarding which mode of transport (or a combination of modes) should be used under specific transportation conditions given. When making decisions related to the aforementioned, various factors come into play that help managers to make an optimal decision. For the object "shipment" following factors are considered: shipping cost; freight value; transit time; reliability of shipments, regular basis of shipments, accessibility to a given transport mode, etc.).

Assessment of a mode of transport in a shipment generally takes place based on use of expert knowledge and experience in the field. [4].

In order to conceptualize what are the risks related to each of the transport mode, we need to get more familiarized with their characteristics: sea transport, rail transport, motor transport, air transport. To construct their respective data model we use the object-role modeling method [4-6].

NORMA (Natural ORM Architect for Visual Studio) is a free and open source plug-in to Microsoft Visual Studio. It supports ORM 2 notation, and can be used to map object-role models to a variety of implementation targets, including major database engines,

Fragment of the ORM diagram is given on Fig. 2 which describes fragment of a conceptual scheme for objects in multimodal transportation.

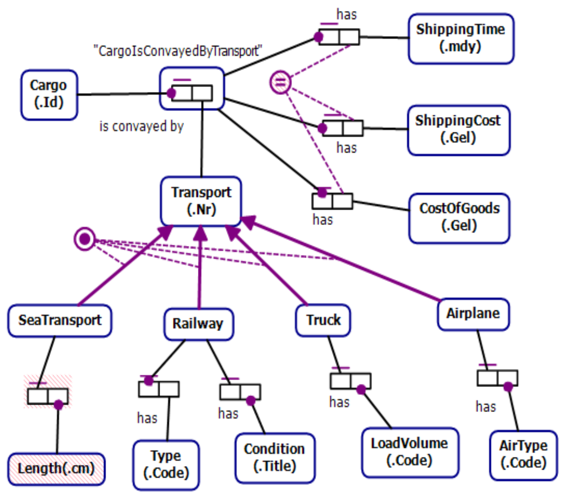

Fig. 2 Fragment of a conceptual scheme with ORM

Predicates describe here the following facts:

Cargo **is an entity type**.
Reference Scheme: Cargo has Cargo_Id.
Reference Mode: .Id.
Fact Types:
Cargo has Cargo_Id.
Cargo is convayed by Transport.
Cargo is convayed by Transport.

Transport **is an entity type**.
Reference Scheme: Transport has Transport_Nr.
Reference Mode: .Nr.
Fact Types:
Transport has Transport_Nr.
Cargo is convayed by Transport.
Cargo is convayed by Transport.
Each SeaTransport is an instance of Transport.
Each Railway is an instance of Transport.
Each Truck is an instance of Transport.
Each Airplane is an instance of Transport.
Cargo is conveyed by Transport.
Each Cargo is convayed by **exactly one** Transport.
It is possible that more than one Cargo is convayed by **the same** Transport.

ShippingCost **is an entity type**.
Reference Scheme: ShippingCost has ShippingCost_Gel.
Reference Mode: .Gel.
Fact Types:
ShippingCost has ShippingCost_Gel.
CargoIsConvayedByTransport has ShippingCost.
CargoIsConvayedByTransport has ShippingCost.
Each CargoIsConvayedByTransport has **exactly one** ShippingCost.
It is possible that more than one CargoIsConvayedByTransport has **the same** ShippingCost.

CostOfGoods **is an entity type**.
Reference Scheme: CostOfGoods has CostOfGoods_Gel.
Reference Mode: .Gel.
Fact Types:
CostOfGoods has CostOfGoods_Gel.
CargoIsConvayedByTransport has CostOfGoods.
CargoIsConvayedByTransport has CostOfGoods.
Each CargoIsConvayedByTransport has **exactly one** CostOfGoods.
It is possible that more than one CargoIsConvayedByTransport has **the same** CostOfGoods.

ShippingTime **is an entity type**.
Reference Scheme: ShippingTime has ShippingTime_mdy.
Reference Mode: .mdy.

Basic operations taking place at sea ports are: load – unload (freight) operations or direct means (Ship to rail wagon, ship to automobile, ship to ship), or using port storage facilities. In order to organize freight operations in a convenient way port is divided into industrial districts, each specializing in handling a specific type of cargo. For this reason, port has relevant berths, mechanization, storage space, necessary contingent of port workers [2].

Port is managed using the central control (dispatcher) - regional control units.

Main task in efficiently managing the port is planning of round-the-clock and shifts work activities: Round-the-clock and shifts work plan is drawn based on load/discharge district requests on work personnel, vehicles, wagons, etc. Daily-shift work plan takes into account fulfilment of following activities: serving of ships (loading, discharge) directly and also in terms of storehousing, wagon (load, discharge), vehicles, workforce deployment, maneuvering (ships transfer, berth/unberth), etc.

Round-the-clock requests are drawn taking into account the fulfilment of the planned daily norm because if the norms are not fulfilled, port is financially responsible. In addition, port has to plan and fulfil the plan of daily discharging the wagons (within average daily norms). Otherwise, port is charged by the railway for each hour of wagon detention.

Port Operational Management Problem can be formulated as the sequence of activities providing the following [1], [2]:

1) Reduce ships and railway wagon detention time to the minimum;
2) Load-unload mechanisms used at maximum capacity (cranes, special machinery and so on);
3) Direct shipments used at maximum (where possible).

Let us discuss solution to this problem for one of the port districts. Fig. 3 gives example of a sea port's freight district structure (general scheme). Berths (B), Storehouses (S), Railway line branches (R) connected with communication lines, by means of which ships, cargo, portal cranes (C) autoloaders, and other objects are moved.

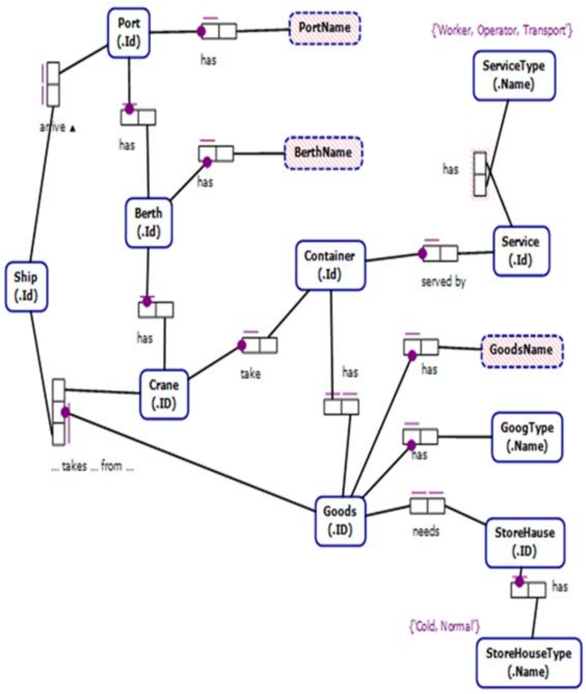

Fig. 3 ORM with Objects and Predicates

Positioning of dynamic objects in space within fixed period of time defines situation of port district structure. Functioning of port district is outwardly reflected on its structure as change of situations. Formalization of this structure during functioning of port districts is connected (in the form of D-networks) with introducing notion of elementary nodes (source-inflow, outflow, converters) and establishing connections among them.

Source-inflow models entrance patterns of ships, cargo, rail wagons and other objects into the port district (business processes, business rules).

Converters model functioning of berths, storehouses and other reload points, as well as time delays, taking place along with movement of dynamic objects in the port. If D-Network is built for a given structure of port's district, connections among its nodes are consistent with the existing communication lines [2]. Consistency among communication lines and types of dynamic objects (ships, cargo, cranes, etc.) moving on this line is established by means of object behaviour rules [3]. For instance, ships of category I-III for handling purpose may be received at only berths 1 and 2. Ships of other categories may be handled at any berth. Type of cargo and types of storehousing facilities are taken into consideration.

Ship: Name (Identifier), length, type, condition, exploitation costs per hour of anchorage, draught of ship, storage limit, load capacity, volume, location, start processing, end processing, etc.

Converters that play flow commutation role in objects are gathered into a single commutator. Sources that correspond to ships model patterns of cargo vessels (coal, ore, wood, etc.) entering the port. There exist also vessels that carry fruits, vegetables, sugar, salt and other types of products. Objects formed from the source-entrance go via commutator either to converter or outflow current. Role of this current is performed by ships and trains that receive cargo and further move out of the port area. Outflow objects and converters have characteristics with values that change once they enter the commutator exit. Change in values of characteristics occurs in accordance with the graphs of converters and source passages.

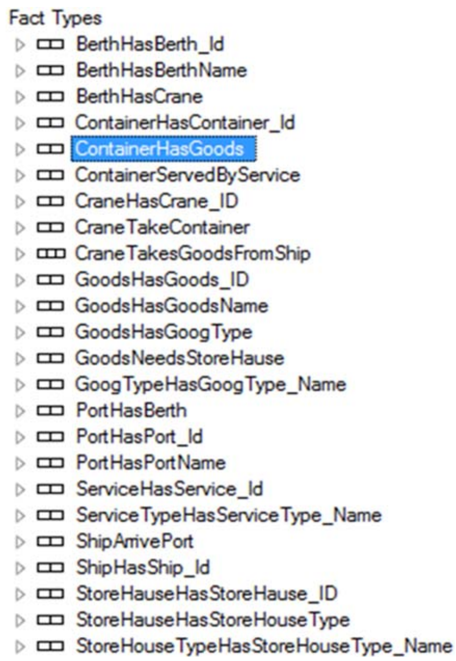

Fig. 4 Basic facts and predicates in ORM

Airport: Airport_ID, Airport Name, Location, Country, Latitude, Longitude, Altitude, Timezone, etc.

Freight Trucks: Identifier, type, dimensions, volume, load capacity (kg), etc.

Converters are characterized by the following features:

- B – Berth: Identifier, length, depth, allowable load, specialization, release time, bandwidth (Power), attribution to district, etc.
- S – Storehouse: Identifier, type, area, floors, busy percentage, allowable load, attribution to district, etc.
- C – Crane: Identifier, type, lifting capacity, maximum arrow length, minimum arrow length, lifting height, hook release (sink) depth, lifting speed, rotation speed, hook height change speed, speed, total weight, location, etc.
- Service staff: Port workers running the means of reloading. They work in crews (permanent or operational) in number of 4 to 16 persons.
- Crew: Identifier, type, qualified members, number of members, location, type of work to be performed, output norm, technological work scheme, etc.

Transformation of values of object time characteristics takes place in delay lines.

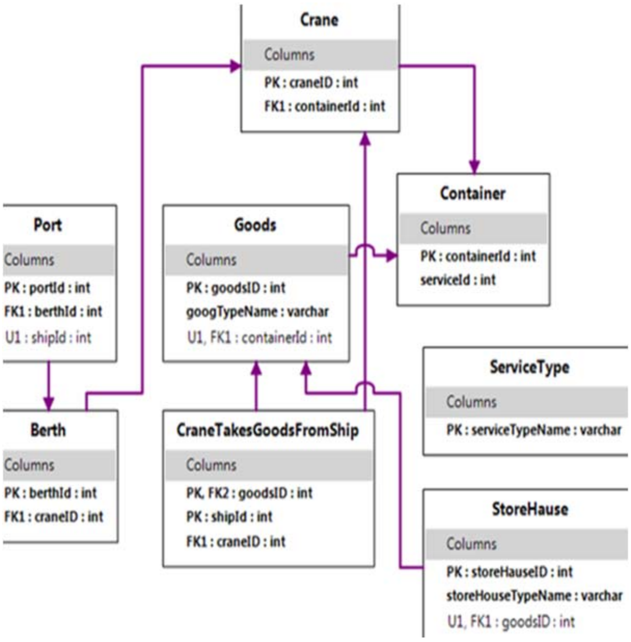

Fig. 5 Conceptual Scheme with ERM model

III. Building of Conceptual Mode – ORM/ERM

Object-Role Modelling (ORM) is primarily a method for modelling and querying an information system at the conceptual level. ORM is so-called because it pictures the world in terms of objects (entities or values) that play roles (parts in relationships).

Unlike Entity-Relationship (ER) modelling and Unified Modelling Language (UML) class diagrams, ORM treats all facts as relationships (unary, binary, ternary etc.) [6].

NORMA (Natural ORM Architect for Visual Studio) is a free and open source plug-in to Microsoft Visual Studio. It supports ORM 2 notation, and can be used to map object-role models to a variety of implementation targets, including major database engines, object-oriented code, and XML schema [6].

First of all we analyze problematic demands area, definition of a technical assignment. This is the formation of facts. From these elementary facts are defined the ORM-model. Afterwards we build the ORM-diagram (Fig. 3).

Initially we analyze the requirements of a technical task of the problem area, from where established the facts. The basic facts are determined by means of the ORM-model, which will be built after the ORM-Diagram (Fig. 4). Once the conceptual schema has been specified Norma tool promote obtain Entity Relationship Model (ERM). As seen before, the ORM schema maps to a 3 table relational schema (Fig. 5). Predicates describe here the following facts.

IV. Procedure of Database Building

NORMA software generates the DDL code to create the relational schema. Solution Explorer show a code currently generated for SQL Server (Fig. 6).

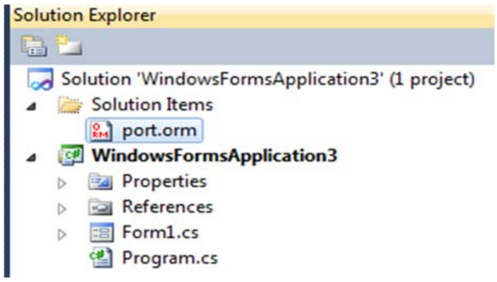

Fig. 6 DB Ms SQL Server

V. Conclusion

For the Georgian economy it is of great importance to raise port working capacities and increase their efficiency, using extensional (for instance, building a new port in Anaklia, extension of an existing one, etc. based on investments), as well as intensional methods. The latter involves optimization of usage of the existing resources. We suppose that once simulation model of a seaport – as of managing a complex system is developed (for instance, based on Petri coloured stochastic nets or Queuing theory using Markov processes) it will become possible to build a decision support system to be used in making optimal decisions. Development of multimodal infrastructure in a sea port area and its effective management will considerably contribute to solving problems raised in the present work.

References

[1] Meyer-Wegener K., Petriaschvili L., Surguladze G. (2014). Decision Support System for Optimization of Seaport Resource. III internat. Scientific Conference "Computing / Informatics, Education Sciences, Teacher Education", Batumi, Georgia.

[2] Gogichaishvili G., Surguladze G. (2014). Concept of Automated Management of Multimodal Freight Transportation Business Processes. Transactions of Georgian Technical University. Automated Control Systems - No 2(18), pp.45-50.

[3] Virginia Multimodal Freight Plan. (2013). Draft Report. Prepared by Cambridge Systematics, Inc. 8573.230. http://www.cppdc.org/Transportation_Data/Virginia_Multimodal_Freight_Plan_11.01.13_Draft_Final_with_appendices.pdf.

[4] Halpin T., Object-Role Modelling: an overview, Microsoft Corporation, http://www.orm.net/pdf/ormwhitepaper.pdf.

[5] Halpin T., Curland M. (2006). ORM 2 Constraint Verbalization Part 1, Technical Report ORM2-02. http://www.orm.net/pdf/ORM2_Tech-Report2.pdf.

[6] Wedekind H., Surguladze G., Topuria N. (2006). Design and Implementation of Data Bases of Distributed Office-Systems with UML. ISBN 99940-57-17-0. GTU. Tbilisi. 2006. pp237.