Scientific Journal of Silesian University of Technology. Series Transport
Zeszyty Naukowe Politechniki Śląskiej. Seria Transport

Volume 108 **2020**

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: https://doi.org/10.20858/sjsutst.2020.108.6

Journal homepage: http://sjsutst.polsl.pl

Article citation information:
Izdebski, M., Jacyna-Gołda, I., Gołębiowski, P., Gołda, P., Pyza, D., Żak, J. Decision problems in designing database architecture for the assessment of logistics services. *Scientific Journal of Silesian University of Technology. Series Transport*. 2020, **108**, 53-71. ISSN: 0209-3324. DOI: https://doi.org/10.20858/sjsutst.2020.108.6.

Mariusz IZDEBSKI[1], Ilona JACYNA-GOŁDA[2], Piotr GOŁĘBIOWSKI[3], Paweł GOŁDA[4], Dariusz PYZA[5], Jolanta ŻAK[6]

DECISION PROBLEMS IN DESIGNING DATABASE ARCHITECTURE FOR THE ASSESSMENT OF LOGISTICS SERVICES

Summary. This paper presents decision problems which occur in designing database architecture for the assessment of logistics services. In the work, it was emphasized that the key stages in database design is to define a database model comprising a set of rules that characterize the structure of data in the database and a list of operations that can be performed on the data entered into the database. Research presented in the article is conducted as part of the project on the European Portal of Logistics Services (EPLOS) implemented on the basis of an agreement with the National Center for Research and Development under the EUREKA program. As part of the research carried out as part of the project, the principles of functioning of distributed architecture were developed and evaluated for the services offered by carriers or logistics operators operating on the international market. These include operators providing air services, international road, intermodal, sea transports, etc. The article indicates that the purpose of the database responsible for processing information in cargo intermodal connections is not only to collect input data on aviation and road infrastructure, but also to

[1] Warsaw University of Technology, Warsaw, Poland. Email: mizdeb@wt.pw.edu.pl
[2] Warsaw University of Technology, Warsaw, Poland. Email: ilona.golda@pw.edu.pl
[3] Warsaw University of Technology, Warsaw, Poland. Email: pgolebiowski@wt.pw.edu.pl
[4] Air Force Institute of Technology, Warsaw, Poland. Email: pawel.golda@itwl.pl
[5] Warsaw University of Technology, Warsaw, Poland. Email: dpz@wt.pw.edu.pl
[6] Warsaw University of Technology, Warsaw, Poland. Email: jolanta.zak@pw.edu.pl

save the results generated by computational modules. At work, the modular database structure for assessing logistics services consisting of among others from dynamic data module, archive module, data entry module, optimization algorithm calibration module was proposed. Catalog structure and rules for supplying the database with data on the example of a railway operator were presented in detail.

Keywords: database architecture, logistics services, the European Portal of Logistics Services

1. INTRODUCTION

Research presented in this article was conducted as part of the project on the European Portal of Logistics Services (EPLOS) implemented based an agreement with the National Center for Research and Development under the EUREKA program. On the air services market, the growing importance of logistics operators in cargo transport can be noticed in both domestic and international relations. The choice of a logistics operator to implement specific logistics services is quite a difficult and complex decision problem. This is primarily due to the need to consider many factors posed by buyers of cargo logistics services on the one hand, and on the other hand, the capabilities of logistics operators [3-6, 13, 16, 17].

The use of appropriate tools supporting the decision of logistic service buyers in this area reduces the costs of providing the service and increases the satisfaction of customers reporting the demand for logistics services [21, 22]. Systems supporting decision making in logistics and transport issues are one of such systems. These issues relate to various areas of operation of logistics operators, carriers [15, 16, 24], storage processes [18], selection of the location of warehouse facilities [1, 17, 19] and intermodal transport terminals [30].

Databases are a basic element in the design of complex information systems, which take into account the large amount of information processed [32]. Information processing in the database is possible due to the database management system, which is based on defining specific IT procedures [2, 4].

Designing database architecture for the logistics services market is a big challenge for all participants in the process, including logistics service operators, transport organisers, etc. According to the first works 9, the database is a collection of record information that can be placed in appropriate tables adequate to write matrix tables in information systems. The tables have an appropriate function assigned to specific, specific thematic issues, for example, technical or economic parameters of a given process or elements of equipment of the examined system. Importantly, the information in databases is collected according to strictly defined rules and then processed by algorithms and database management systems [20, 30].

As numerous studies in this area indicate, database design usually proceeds according to several stages, considering [11, 14]:

- defining the purpose of creating (designing) the database – stage I,
- choice of query language – stage II,
- selection of system catalogue capacity – stage III,
- defining transaction algorithms – stage IV,
- defining database recovery algorithms – stage V,
- defining systems controlling access to databases – stage VI,
- defining data transmission tools – stage VII.

The process of creating databases requires knowledge of many rules and relational rules between various elements (directories) of data. Therefore, when designing database architecture for the assessment of logistics services implemented on the international market, one should consider:

- IT aspect – creating database architecture as an IT system,
- subjective aspect – data resources – types of data catalogues that are necessary for system users.

In terms of the first issue, it is necessary to define a database model including a set of rules that characterise the structure of data in the database and a list of operations that can be performed on the data entered into the database. The database model is often presented in graphic form. From an IT point of view, the data management system that is entered into the database, for example, operations of adding, editing, modification, etc. is important.

In the aforementioned stages of database design, it is important to develop appropriate algorithms and methods to maintain the correctness of the database, that is, a set of rules that allow not only the consistency and correctness of data and database, as well as their efficiency to be maintained.

The logistics services market concerns a wide spectrum of services and includes many participants who take part in the implementation of services at various levels of their implementation. For example, for the design of warehouse facilities, a range of input data from various thematic areas is necessary [14].

1. THE ESSENCE OF DATABASE DESIGN IN LITERATURE

As previously mentioned, the most convenient tool for collecting and processing large amounts of data are databases. Different database models are used, defined as sets of rules or principles characterising the structure of collected data and allowed operations performed on them.

It follows, therefore that each database model has its characteristics. Some of them may be of advantage when it comes to the work of systems for assessing logistics services implemented on an international market, while some may be serious obstacles to their use. The important element for each model is the base diagram.

There are many database models in the literature on the problem. Typical types include [2, 7, 9, 12, 19, 21]:

- a hierarchical data model in which data is arranged in a tree structure ordered from the general (for example, data on means of transport) to the detail (for example, data on components of means of transport),
- relational data model, in which the connections between data in the database are mathematical relations (for example, means of rail transport remain in relation to warehouse trucks),
- network (graph) data model, which was created based on a hierarchical model - an important modification is that the possibility of creating many (∞) to many (∞) relationships have been introduced,
- the object-oriented data model that was developed as a combination of relational database concepts, object-oriented programming languages and object-oriented paradigms,

– a data model in the form of a semantic network, which can be presented as a set of objects related to each other by relationships (for example, means of external transport is a type of means of transport).

In the case of a relational model, the data is stored in the form of tables that are connected by mathematical relations. This allows one to consider all possible relationships between individual elements. Furthermore, access to data is quick and there is no need to know the structure of the database to find specific information [7].

In the hierarchical model, access to data is difficult due to the tree structure. To get to a particular data one should look for it from the general to the detailed. As a result, the access time to data is extended, and there is a need to know the structure of the database. In the network model, however, only many-to-many relationships are allowed.

The efficiency of processing large amounts of data depends on the implemented database management system. In the literature on the problem, the Database Management System (DBMS) is defined as a program that allows access and performs operations on data through the use of appropriate search and compilation mechanisms [19, 20]. The management system controls the physical structure of the data, determining how to access the data, determining how to update the data, creating and deleting it. The implementation of the system is necessary for it to function properly.

Database management systems can act as a "client-server", that is, an architecture in which the role of the client application and server application is clearly separated. In such cases, the database management system acts as a server application, that is, the database must be simultaneously shared among many users [7] This architecture can be used to separate applications such as IBM DB2, Informix Dynamic Server, Firebird, MariaDB, Microsoft SQL Server, MySQL, Oracle Database and PostgreSQL. In case the database does not have to be shared between several users at the same time, applications that do not require client-server architecture are used. These applications are Microsoft Access and Kexi.

The method and principles of performing tasks in a given system forced the use of an appropriate client-server architecture among which we can distinguish a two-layer architecture, whose main task is to limit the amount of data sent through the network. It comes down to the fact that the system has been divided into two parts. The first is responsible for maintaining data consistency and storage. The second is responsible for downloading, displaying and processing data that is sent to the server to remember or generates queries to obtain information. Two interpretative forms of the "thin and fat client" are shown in Fig. 1.

The use of two-layer architecture, despite its flexibility, is not applicable to large systems due to a large number of functions that the application must perform using multiple server "data sources". The solution to this problem resulted in the creation of the concept of three-layer architecture, particularly the third layer, independent of the application and server, however, responsible for information processing as shown in Fig. 2.

Decision-making problems in developing databases occur at the stage of constructing the database management system and at the stage of integration of the entire user application with the developed database. Development of the Database Management System (DBMS) is one of the main problems that occur in the construction of databases. The database management system is an organised set of tools enabling the definition of a database as well as downloading and modifying data contained in it. This management system is a universal software that has an interface with a user application and a database.

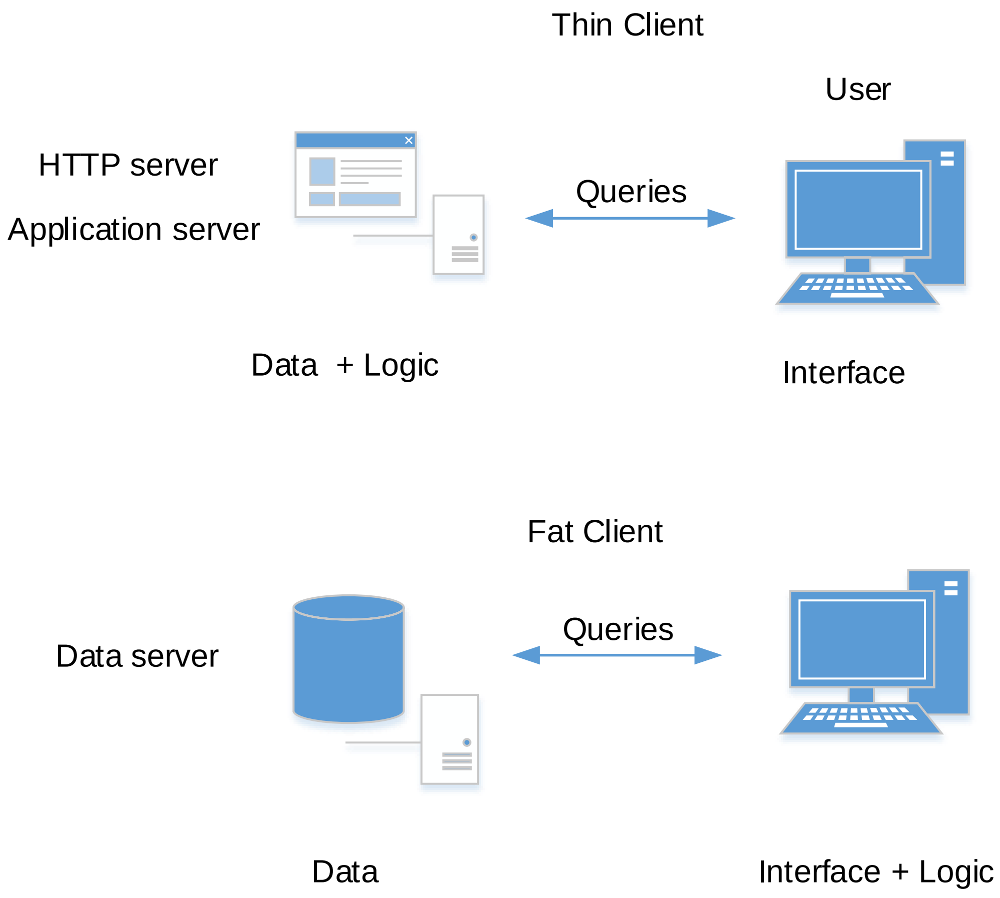

Fig. 1. Two-layer architecture imaging "thin fat client”

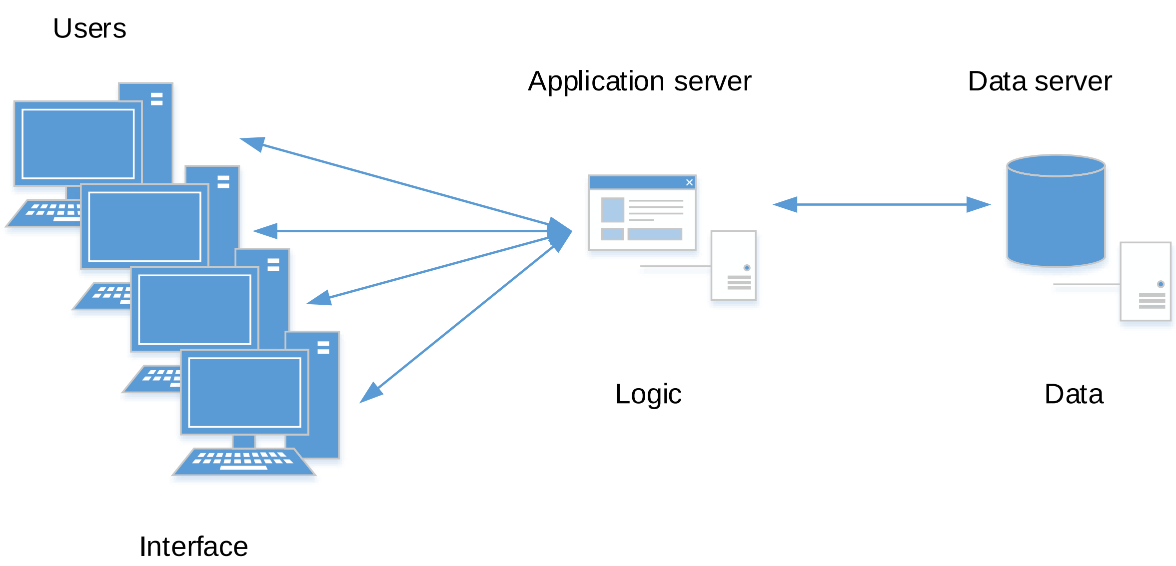

Fig. 2. Imaging three-layer architecture

The basis of operation of each IT system [24] is the exchange of data both between individual program modules and between the program and the user. The number of exchanged data and the number of operations that must be performed on the data necessitates the use of professional tools to collect and perform operations on many types of data.

A typical IT system diagram is shown in Fig. 3.

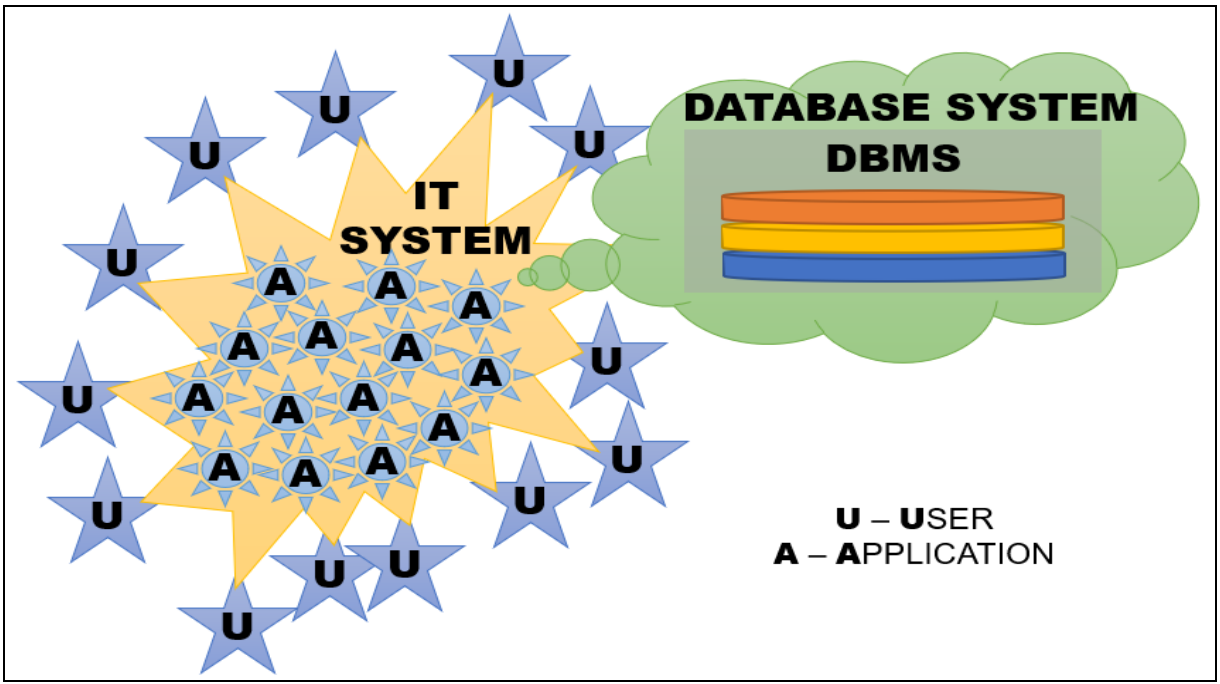

Fig. 3. Typical IT system diagram

In Fig. 3, easily notable is a database system that consists of a database and a database management system (DBMS). As mentioned above, a database is an instrument on which data describing reality are stored according to strictly defined rules [5]. The DBMS is responsible for the proper storage and collection of data. Therefore, it allows [11]: data administration, ensuring data integrity and security, disaster recovery, access to collections of many users at a given moment, granting access rights to particular types of users and optimisation of the database work.

2. THE CONCEPT OF DATABASE ARCHITECTURE FOR THE EPLOS SYSTEM

As part of the research carried out as part of the project on the European Portal of Logistics Services, the principles of functioning of distributed architecture were developed and evaluated for the services offered by carriers or logistics operators operating on the international market. These include operators providing air services, international road, intermodal, sea transports, etc. We know that the purpose of the database responsible for processing information in cargo transport using intermodal connections is partly to collect input data on aviation and road infrastructure and also to save generated results by calculation modules. In general, three types of data can be distinguished: static data obtained from the description of the characteristics of individual participants in the entire process, dynamic data resulting from the work of modules and additional data.

A general view of the database architecture for the EPLOS system, which is ultimately to be the European Logistics Services Portal, is presented in Fig. 4.

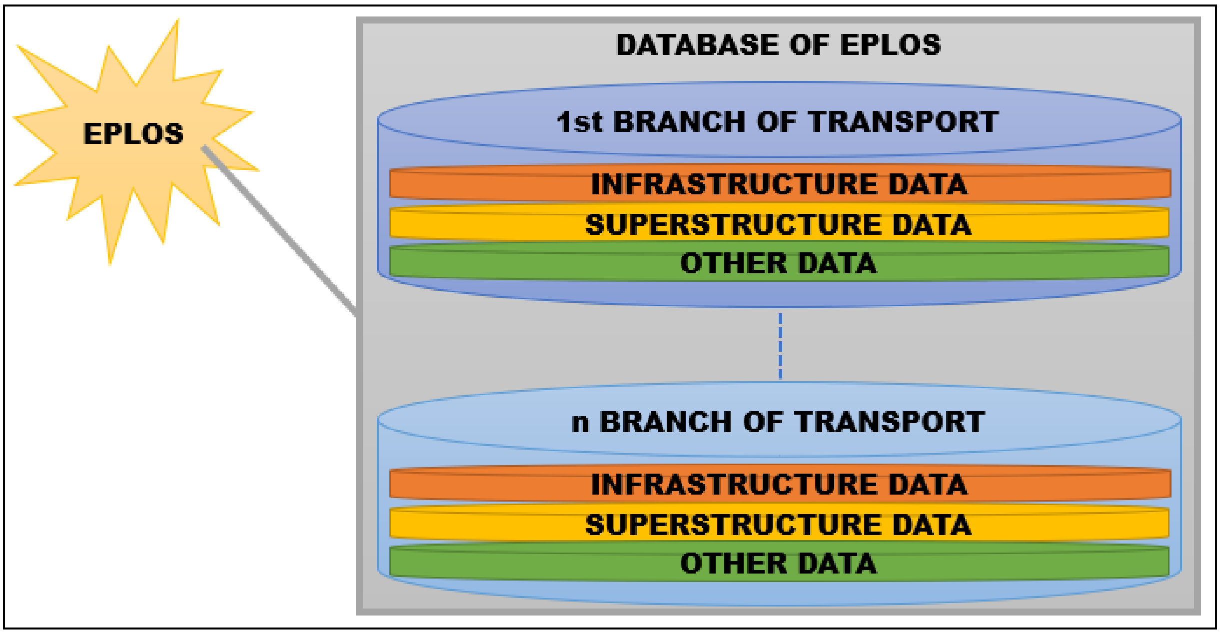

Fig. 4. The concept of the EPLOS database

The general concept of the database dedicated to the European Logistics Services Portal can, therefore, be presented as follows; Individual parts of the database are data on individual branches of transport [16, 21, 32, 33]. Therefore, railway transport data will be stored separately, separately for road transport, separately for intermodal transport, etc. To properly group the data in the database, it was decided that the data for individual branches of transport be stored in three separate groups: infrastructure data (both linear and point), data on the superstructure and other data [8, 12, 13, 28, 29]. Specific parameters will be stored within these groups.

In databases, rows are called records. Each record contains data related to a specific element and is independent of other items in this table, for example, in the "aircraft" table, the row will contain information about one specific aircraft served at a given airport: its identification number, type, and carrier. Each column in the database is called a field. Each field of the table stores information of a specific type for each record, for example, in the "aircraft" table, the "registration number" column is a field that contains the registration numbers of all aircraft served at a given airport.

The same type of data is stored in each column. The type of data stored determines the size of the column. Access offers several types of data:

– text – text type. The maximum field size is 255 bytes,
– memo – notebook type. The maximum field size is 64,000 bytes,
– number – a number type. Field size from 1 to 4 bytes,
– currency – quota type, reserved for money. The field size is 8 bytes,
– date/time – allows one to save the date and time in the field. The field size is 8 bytes,
– yes/no – logical type, true or false. The field size is 1 bit,
– counter – this type of data is consecutive natural numbers, generated automatically.

The tables are connected by logical dependencies called relationships. If the data repeated many times in the records are moved to a separate table and shared with the key, data redundancy can be avoided (repeated storage of the same data). The process of catching and eliminating duplicate data is called normalisation. Relationships between tables are defined by means of common fields and there can be the following dependencies:

- 1 on 1 – one to one relationship,
- 1 on n – one to many relationship,
- n on m – many-to-many relationship.

An example of the first type of relationship could be the situation: one aircraft can be served at one stop. Meanwhile, there may also be a situation where one aircraft can be operated at several parking spaces, so this is an example of the second type of relationship. A classic example of the third type of relationship is the situation that occurs at each airport: one aircraft is served at one parking space, but many other types of aircraft can also be served at this parking space.

There is a structure of interdependence between the data within the database, this is the data integrity. This means that, for example, data from one table cannot be deleted as long as it is referenced in other tables.

To sort data and gain quick access to it, database systems use index files. Sorted key field values are stored in them, for example, reader ID and their respective record numbers. Sorting or searching for data is therefore limited to sorting and viewing the index file. Updating and searching the index file does not take much time, and for one database can be created multiples of such files according to different sorting criteria.

SQL is an abbreviation of Structured Query Language. It is a language developed by IBM for the implementation given by E.F. Codd rules for relational databases. SQL is a structured language defined by syntax rules. The user can use SQL commands interactively or using an interface such as the QBE grid.

The data supply module allows for implementation, control and management of objects, which are presented in Tabs. 1to 3 and in Figs. 5 and 6.

The basic data sets stored in the database to assess logistics services implemented internationally as part of the European Logistics Services Portal are data on companies from the TSL sector, in particular, for transport and forwarding companies concerning:

- charges for using the infrastructure,
- traffic restrictions,
- current traffic volume,
- infrastructure technical parameters, including in particular:
  - for speed limit,
  - permissible axle loads on the road,
  - for limiting the total weight and permissible gross weight, or restrictions for ADR vehicles,
  - limitations of the vertical gauge.
  - for railway lines additionally: permissible length and gross weight of trains and limitations of the horizontal gauge,
  - for waterways additionally: navigability classes.
- infrastructure services, including in particular:
  - petrol stations,
  - car wash,
  - guarded parking lots,

- unguarded parking lots,
- ports.

– transhipment terminals for data on:
  - access restrictions,
  - serviceability,
  - terminal type,
  - the owner of the terminal,
  - terminal equipment,
  - the scope of services rendered.

– warehouse facilities as regards data on:
  - access restrictions,
  - additional services,
  - the owner of the object,
  - the scope of services rendered,
  - the equipment of the facility,
  - the surface of the object.

Tab. 1

Sample aircraft implemented to the simulation tool

Aircraft				
LIGHT	MEDIUM	MEDIUM	HEAVY	HELICOPTERS
CESSNA C-150	ATR-42	BOEING B-737-800	BOEING B-747	EUROCOPTER EC-35
CESSNA C-172	ATR-72	AIRBUS A-320	BOEING B-757	S-60 BLACKHAWK
DIAMOND DV-20	DE HAVILLAND DASH DH-8D	AIRBUS A-321	BOEING B-767	MI-8
AERO AT-3	SAAB 340	MCDONNEL DOUGLAS MD-82	BOEING B-777	ROBINSON R--44
CESSNA C-208	M-28 SKYTRUCK	EMBRAER E-195	BOEING B-787	W-3 SOKÓŁ
BEECHCRAFT BE-20	LOCKHEED C-130 HERCULES	GULFSTREAM IV	AIRBUS A-330	BEL-427
BEECHCRAFT BE-35 KING AIR	FOKKER F-50	FOKKER F-100	AIRBUS A-340	SW-4 PUSZCZYK

Source: authors' study based on a printout from a simulation tool

Tab. 2

Planned aircraft arrival table

STA	FLIGHT	CODE	ORG	TMO	ATA	OBL	A/C	REG	RWY	POS-A	PAX	REMARKS
19:30	W1442		Rome	19:30	19:39	19:45	320	HALPL		000		19:46
19:55	LH3024		Dusseldorf	19:41	19:50	19:53	CR9	DANCK		035	60	19:53

19:55	W6151		Gdansk	19:52	20:00	20:07	320	HALPZ		047		20:07
20:05	LO3826	Lo5443	London Luton	20:05	20:12	20:17	320	HALWC		091	62	20:17
22:00	LO0280		Prague				319	CSTTK		020	60	
22:25	OK700		London Stansted				DH4	SPEQH		035		
21:20	L0536	Nh6731	Brussels				AT3	SPLNE		019	56	EX 21:20
21:20	L0320		Prague				E95	SPLDG		012	49	EX 21:25
21:25	L0280	LO5041	London Heathrow				E70	SPLLF		042	126	DE 21:50
21:25	L0320		Milan				734	SPLII		037	64	DE 21:55

Source: authors' study based on a printout from a simulation tool

Tab. 3

Planned aircraft departure table

FLIGHT	**DES**	**SDT**	**APT**	**OFB**	**ADT**	**PAX**	**CHECH-IN**	**GATE**	**RWY**	**POS-D**	**A/C**	**REg**
LO1442	Cracow	19:35	KRK	20:02	20:11	27	219	32	23	019	E70	HALPL
LH3024	London Heathrow	19:40	LHR	20:36		51	241	12	23	012	320	DANCK
W6151	Oslo	19:40	OSL	20:18	20:24	128	233	18	23	036	733	HALPZ
W3826	Vienna	19:55	VIE	19:52	19:59	43	241	5	23	031	E70	HALWC
LO333	Paris	20:00	CDG	19:57	20:06	44	212	42	23	024	E75	CSTTK
OK700	Helsinki	20:00	HEL		20:14	64	271	41	23	008	E90	SPEQH
AY0536	Bergamo	20:05	LTN	20:12	20:20	54	208	44	23	013	320	SPLNE
FR3320	Praga	23:50	LHR				250	13	23	038	E95	SPLDG
OK 780	Amsterdam	06:05	BOY			85	17	20	23	022	A13	SPLLF

KL1362	London Stansted	06:20	PRG			102	34	31	23	025	320	SPLII

Source: authors' study based on a printout from a simulation tool

On the one hand, these are static data regarding technical and economic parameters, as well as infrastructural equipment of individual participants of the entire process including the implementation of logistics services. Whereas, the second group of data concerns dynamic data constituting the results of the work of individual modules of the designed system.

Remarkable of note is the data necessary to track and visualise the implementation of selected processes. These data can be grouped into several sets - data necessary at the stage of preparation of the load for transport, the performance of services or implementation of warehouse processes or carried out at transhipment terminals. An important group of data that will similarly be located in the database is the previously mentioned parameters.

In functional terms, the database architecture consists of the following modules (Fig. 7):

– permanent data module – contains database tables on infrastructure, means of transport, operators, etc.,
– dynamic data module – designed to handle data that can be added, modified and removed by users during system operation, for example, stoppage times at reloading points, service, transport costs, service costs, etc.,
– archive module – is part of the database intended for storing analysis reports, results of services,
– data entry module – designed to support the user direct input process,
– data presentation module – acts as an intermediary in the process of providing access to data collected in the database for authorised users,
– optimisation and calculation module – the result of the module's operation are reports and data sets regarding logistics service plans, this module is based on the built-in optimisation algorithm,
– optimisation algorithm calibration module – sets and stores the parameters of the optimisation algorithm,
– results verification module – checks the correctness of results generated by the optimisation algorithm,
– data exchange module – it is an interface between applications based on different base systems.

Input data entered into the database are included in the mathematical model describing the analysed problem and processed by the optimisation algorithm.

3. CATALOGUE STRUCTURE AND RULES FOR SUPPLYING THE DATABASE WITH DATA ON THE EXAMPLE OF A RAILWAY OPERATOR

As mentioned in the previous section of this article, the database of the European Logistics Services Portal (EPLOS) has a structure divided into individual branches of transport and each branch is divided into a data subbase related to infrastructure, a subbase related to the superstructure and a subbase related to other elements. Characterising the structure of data catalogues and the principles of supplying data to the database for all modes of transport would be quite extensive. Therefore, this article focuses on the database of railway transport, which is one of the important elements of the logistics service chain and intermodal transport [20, 27, 31].

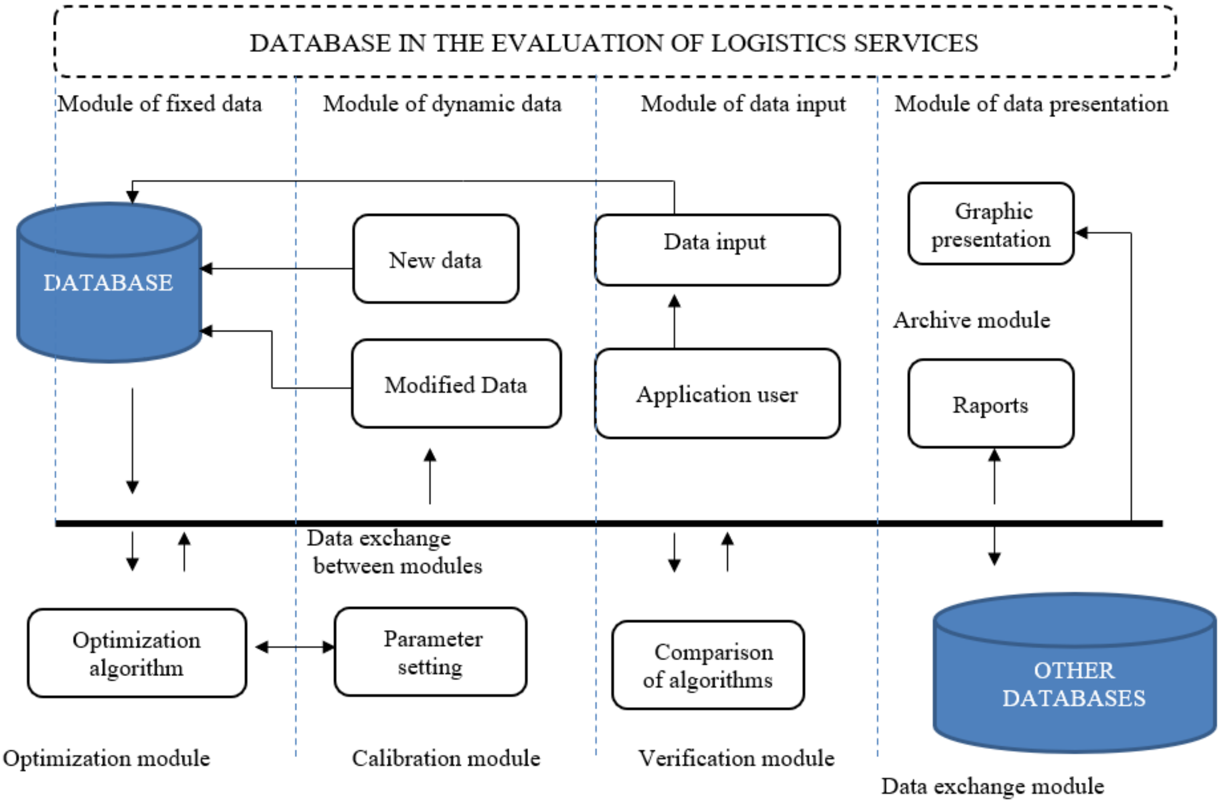

Fig. 7. Database architecture in the issue of logistics services assessment on the international market

The first data subbase of railway transport contains all the necessary information related to railway transport infrastructure. Due to the fact that the project is co-financed by the European Union, it is reasonable to use infrastructure components for the development of the database, which was classified in the Directive of the European Parliament and of the Council 2012/34 / EU of November 21st, 2012 on the creation of a single European railway area [38]. According to this directive, all the elements that make up a given part of the railroad are included, sidings inclusive. By adapting the list to the needs of the EPLOS system, the following elements constituting the railway transport infrastructure can be distinguished [38]:
– lands,
– tracks and subgrade, ... freight ramps, including ... at freight terminals ...,
...
– railway crossings,
...
– access routes for ... goods, including access roads ...,
...

– lighting systems for railway traffic and safety purposes,
...
– buildings used by the infrastructure department, ...

The first transport infrastructure element regarded as important from the viewpoint of the EPLOS system are lands. Their mapping in the portal allows locating specific logistics service providers in space. Furthermore, it allows determining which areas belong to railway infrastructure managers, which will give the portal user the opportunity to search for specific development sites. Therefore, it will be necessary to create a catalogue of railway lands in which individual plots would be appropriately parameterised. An example table structure with data on lands from the database is presented in Tab. 4.

Tab. 4

Table structure with data on railway lands

No.	Land name	Land location	Land area	Others
1	…	…	…	
…	…	…	…	

Source: authors

Similar data for Poland can be obtained using the Geoportal or maps of railway infrastructure managers.

The second important element is data on railway infrastructure. Here, it is necessary to map railway lines located in the area of interest to the project and data on operational points involved in the movement of freight trains. Obtaining this data is necessary, among others to determine the possible start and end point of the shipment, to estimate the distance between the potential shipment point and the potential pickup point, or to determine the approximate time of delivery. Therefore, it will be obligatory to create a catalogue of operational points and a catalogue of railway lines, where the values of individual important parameters would be placed. An example of the table structure with data on operational points from the database is presented in Tab. 5 while regarding railway lines in Tab. 6.

Tab. 5

Table structure with data on operational points

No.	Parameter	V1	V2	V3
1.	Point number	…	…	…
2.	Point name	…	…	…
3.	Point location	…	…	…
4.	Railway line no.	…	…	…
5.	Km of the railway line	…	…	…
6.	Track width at a point	…	…	…
7.	Number of tracks for freight trains	…	…	…
8.	Minimum track length for freight trains	…	…	…
9.	Maximum track length for freight trains	…	…	…
10.	Supported types of freight wagons	…	…	…
11.	Equipment for handling goods (service infrastructure)	…	…	…

12.	Access route for goods	…	…	…
13.	Lighting system	…	…	…
14.	Buildings related to the handling of goods	…	…	…
15.	Neighbouring exploitation points	…	…	…
16.	Distance to neighbouring points	…	…	…
17.	Other	…	…	…

Source: authors

Tab. 6

Table structure with data on railway lines

No.	Parameter	V1	V2	V3
1.	Railway line no.	…	…	…
2.	Railway line route	…	…	…
3.	Length of the railway line	…	…	…
4.	Track width	…	…	…
5.	List of operational points with location	…	…	…
6.	Are freight trains allowed?	…	…	…
7.	Maximum speed of freight trains	…	…	…
8.	Permissible axle load	…	…	…
9.	Approval of a given type of wagon to run	…	…	…
10.	Minimum length of freight trains	…	…	…
11.	Maximum length of freight trains	…	…	…
12.	Price for access to infrastructure	…	…	…
13.	Neighbouring railway lines	…	…	…
14.	Service points where adjacent lines appear	…	…	…
15.	Other	…	…	…

Source: authors

Similar data for Poland and neighbouring countries can be obtained from the Network Statements, which railway infrastructure managers in European countries are obliged to compile. When characterising operational points, it is important to consider freight terminals, dry ports, etc. In addition, the table includes the characteristics of the access route for goods for a given point and the characteristics of buildings intended for goods handling.

The third group of data relevant for the EPLOS portal are data on railroad crossings. They are quite insignificant from the viewpoint of the organisation of freight trains, however, they can be a potential point of transhipment of oversized goods from road transport to railway transport and vice versa. Therefore, there is a need to properly parameterise them. An example of the table structure with data on railroad crossings from the database is presented in Tab. 7.

Tab. 7

Table structure with data on railroad crossings

No.	Parameter	V1	V2	V3
1.	Railroad crossing number	…	…	…
2.	Name of the railroad crossing	…	…	…
3.	Location of railroad crossing	…	…	…
4.	Railway line no.	…	…	…
5.	Km of the railway line	…	…	…
6.	Equipment for handling freight (service infrastructure)	…	…	…
7.	Neighbouring operational points	…	…	…
8.	Distance to neighbouring points	…	…	…
9.	Other	…	…	…

Source: authors

Similar data for Poland can be obtained using the Geoportal or maps of railway infrastructure managers.

The second data subbase of railway transport data contains all necessary information related to the railway transport superstructure. From the viewpoint of the EPLOS project implementation, the important data are the parameters of the wagons with which freight can be transported. Therefore, a catalogue of freight wagons should be created in which their characteristic parameters would be placed. An example of the table structure with data on freight wagons from the database is presented in Tab. 8.

Tab. 8

Table structure with data on freight wagons

No.	Parameter	V1	V2	V3
1.	Wagon type	…	…	…
2.	Wagon series	…	…	…
3.	Wagon dimensions	…	…	…
4.	Wagon load capacity	…	…	…
5.	Permissible axle loads	…	…	…
6.	Track width	…	…	…
7.	Purpose of the wagon	…	…	…
8.	Admissibility of parcel type transport	…	…	…
9.	Other	…	…	…

Source: authors

Similar data for Poland can be obtained from the catalogue of freight wagons of railway undertakings.

The third subbase of railway transport data contains all other information related to railway transport that is not included in the subbases discussed so far. This part of the database stores both parameters that will be entered by the user or generated by the EPLOS system but only in the field of railway transport. Catalogues should include a set of data on the parameters of a freight shipment. An exemplary table structure with data on a freight shipment from the database is presented in Tab. 9.

Tab. 9

Table structure with data on a freight shipment

No.	Parameter	V1	V2	V3
1.	Freight shipment number	…	…	…
2.	Shipment characteristics	…	…	…
3.	Shipping Weight	…	…	…
4.	Weight of one package	…	…	…
5.	Dimensions of one package	…	…	…
6.	Shipment susceptibility	…	…	…
7.	Shipment type	…	…	…
8.	Other	…	…	…

Source: authors

Presently, it is difficult to indicate other catalogues that could appear in the third subbase regarding railway transport.

4. CONCLUSIONS

The choice of a logistics operator to perform specific logistics services is determined by its ability to effectively perform a specific task commissioned by customers. The effectiveness of the task can be assessed by various measures, for example, time, cost of transport, punctuality, safety or reliability in delivering the load to a given pickup location.

The choice of logistics operator takes into account many factors posed by demanding logistics service buyers in the context of the mode of transport, the type of preferred transport as well as the capabilities of logistics operators and the transport technologies they offer.

To effectively provide logistics services, entities existing on the logistics market compete with each other in terms of the quality of these services and the selection of effective transport means that reduce the time and cost of carrying out the tasks assigned. Offering services characterised by the minimum time and cost of their implementation is a key factor increasing the competitiveness of a given logistics operator on the market.

Considering the complexity of problems arising from the implementation of specific logistics services, and the desire to increase the efficiency of the implementation of tasks by operators, it is advisable to use computer support.

Systems supporting decision making in logistics and transport issues related to various areas of operation of logistics operators, carriers, storage processes, and selection of the location of warehouse facilities or intermodal transport terminals. The key element of any decision support system is based on information characterising a given decision problem. This information in the form of input data is processed by the system, saved or transferred to further calculation processes. An important element is the efficient transmission of various types of data between a given system and a database supporting the work of that system.

Designing database architecture for the logistics services market is a big challenge for all process participants, including logistics service operators, transport organisers, etc.

The structure of the database is characterised by the number of relevant catalogues and records, so it depends on the mathematical model of the problem as well as on the optimisation algorithms used to solve the problem, and such a structure should be developed first.

Acknowledgement

This work was performed within the framework of the EUREKA project implemented based on an agreement with the National Center for Research and Development No. EUREKA / EPLOS / 3/2017 on the European Logistics Services Portal (EPLOS).

References

1. Amit Govind, Rose Luke, Noleen Pisa. 2017. „Investigating stock-outs in Johannesburg's warehouse retail liquor sector". *Journal of Transport and Supply Chain Management* 11(a303). DOI: https://doi.org/10.4102/jtscm.v11i0.303.
2. Babaian T., W. Lucas. 2013. "Modeling data for enterprise systems with memories". *Journal of Database Management* 24(2): 1-12.
3. Bagchi P.K. 2000. *On measuring supply chain competency of nations: A developing country perspective*. LERC, Cardiff.
4. Belien J., L. Boeck. 2014. "Municipal solid waste collection and management problems: a literature revie". *Transportation Science, Institute for Operations Research and the Management Sciences (INFORMS)* 48(1): 78-102. USA.
5. Benedikt M., P. Bourhis, C. Ley. 2015. "Analysis of schemas with access restriction". *ACM Transactions on Database Systems* 40(1): 5.
6. Bluszcz M., M. Jacyna. 2010. "Model solution of connections between urban logistic system and national logistic system". *Archives of Transport* 21(3-4): 5-24.
7. Connolly T., C. Begg. 2005. *Database systems: a practical approach to design, implementation, and management*. Pearson Education.
8. Cooper M.C., L.M. Ellram. 1993. "Characteristics of chain management and the implications for purchasing and logistics strategy". *International Journal of Logistics Management* 2(4).
9. Dong Y., A. Goh. 1998. "An intelligent database for engineering applications". *Artificial Intelligence in Engineering* 12(1): 1-14.
10. Directive 2012/34 / EU of the European Parliament and of the Council of November 21, 2012 on the creation of a single European railway area.
11. Elmasri R. 2008. *Fundamentals of database systems*. Pearson Education India.
12. Gołda P., M. Izdebski, E. Szczepański. 2018. "The application of ant algorithm in the assignment problem of aircrafts to stops points on the apron". *Journal of KONES* 25(4): 479-488.
13. Gołda P., M. Kowalski, C. Wasser, P. Dygnatowski, A. Szporka. 2019. "Elements of the model positioning of aircraft on the apron". *Archives of Transport* 51(3): 101-108.

14. Jacyna M., P. Gołębiowski, K. Lewczuk. 2016. "Functions, relations and basic elements of database for the designing of storage facilities". *Conference Proceedings of 8th International Scientific Conference Management of Technology – Step to Sustainable Production*. Poreč.
15. Jacyna M., M. Izdebski, E. Szczepański, P. Gołda. 2018. „The task assignment of vehicles for a production company". *Symmetry-Basel* 11(10): 1-19. DOI: 10.3390/sym10110551.
16. Jacyna M., E. Szczepański. 2013. "Holistic approach to the ecological cargo distribution in urban areas with the use of multi-modal transport". *WIT Transactions on The Built Environment* 130: 53-65. WIT Press.
17. Jacyna M. 2008. "Distribution warehouses and realisation of logistic processes in supply chains". *Archives of Transport* 20(3): 5-20.
18. Jacyna M. 2013. "The role of cargo consolidation center in urban logistic system". *International Journal of Sustainable Development and Planning* 8(1): 100-113.
19. Jacyna M., A. Bobiński. 2016. *SIMMAG jako narzędzie dla wizualizacji obiektów magazynowych w 3D*. [In Polish: *SIMMAG as a tool for visualization of warehouse objects in 3D*]. Warsaw University of Technology Publishing House. ISBN: 978-83-7814-637-7.
20. Jacyna M., J. Kukulski, P. Gołębiowski, S. Jasiński, W. Wychowański. 2018. "Technical-organizational and legal conditions related to the power supply of a railway vehicle equipped with automatic train control system". *Journal of KONES* 25(4): 533-546.
21. Jacyna M., M. Wasiak (eds.). 2014. *Simulation model to support designing a sustainable national transport system*. Warsaw University of Technology Publishing House. ISBN: 978-83-941338-0-1.
22. Jacyna M., M. Wasiak. 2015. "Multicriteria decision support in designing transport systems". *Tools of Transport Telematics*. In Mikulski Jerzy (ed.). Springer. ISBN: 978-3-319-24577-5. DOI: 10.1007/978-3-319-24577-5.
23. Kisielewski P. 2016. "The system of IT support for logistics in the rail transport". *Archives of Transport* 40(4): 39-50.
24. Kłodawski M., R. Jachimowski, I. Jacyna-Golda, M. Izdebski. 2018. „Simulation analysis of order picking efficiency with congestion situations". *International Journal of Simulation Modelling* 17(3): 431-443.
25. Kowalski M., P. Waślicki, J. Żak. 2018. "Selected aspects of the maintenance system optimization of the Polish Armed Forces helicopters". *Journal of KONES* 25(3): 289-297.
26. Kukulski J., M. Jacyna, P. Gołębiowski. 2019. "Finite element method in assessing strength properties of a railway surface and its elements". *Symmetry-Basel* 8(11): 1-29. DOI: 10.3390/sym11081014.
27. Sibilski K., A. Żyluk, M. Kowalski. 2015. „Simulation studies of micro air vehicle". *Journal of KONES* 22(4): 243-252.
28. Sobota A., R. Żochowska, E. Szczepański, P. Gołda. 2018. "The influence of tram tracks on car vehicle speed and noise emission at four-approach intersections located on multilane arteries in cities". *Journal of Vibroengineering* 20(6): 2453-2468.
29. Szczepański E., I. Jacyna-Gołda, J. Murawski. 2014. "Genetic algorithms based approach for transhipment hub location in urban areas". *Archives of Transport* 31(3): 73-83.
30. Urbaniak M., E. Kardas-Cinal, M. Jacyna. 2019. "Optimization of energetic train cooperation". *Symmetry-Basel* 11(9): 1175-1194. DOI: 10.3390/sym11091175.
31. Zieja M., H. Smoliński, P. Gołda. 2015. "Information systems as a tool for supporting the management of aircraft flight safety". *Archives of Transport* 36(4): 67-76.

32. Żochowska R. 2014. “Selected issues in modelling of traffic flows in congested urban networks”. *Archives of Transport* 29(1): 77-89.

Received 27.03.2020; accepted in revised form 19.06.2020