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Integration of information systems in the design of an integrated logistics platform

Each logistics information system has its own storage. This is due to the fact that the companies that form the supply chain are independent and may have different legal statuses, legal documents, etc. But in order to ensure the smooth and adequate operation of the platform when making decisions, it is necessary that the data and applications of one system be recognizable in another system. Therefore, integration is needed at several levels. The main goal of the study is to show possible ways of creating integrations starting from the system design stage. Integration theory is a complex task, so it needs to be comprehensively considered. All integration processes are reduced to data integration and software integration. The analysis of integration methods is carried out, as well as factors that negatively affect the integration possibilities are considered. Solutions of integration problems, to ensure the optimization of the design process (reduction of the design time) and design of the system itself (minimization of the content of the system), and during the operation of systems, optimization of its functioning (behavior) of the system. As a result of the study, the need to create data integration and application integration that allows you to structure data is shown. It should be noted that data can be located at all levels of the system architecture. And the system software can be: software modules, applications and systems. The basis of all types of system software, i.e. applications and an integral system are made up of software modules, design and development of software (i.e. based on programming systems) is based on service-oriented technologies, where the basis of systems is software services. The research carried out can be used in the development of information systems.
Keywords: information system, platform, integration, services, data.

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Кешенді логистикалық платформаны жобалау кезінде ақпараттық жүйелерді біріктіру

Әрбір логистикалық ақпараттық жүйеніңөзіндік қоймасы бар. Бұл логикалық тізбетіқұрайтын компаниялардың тәуелсіз болуына және де түрлізаңды мәртебелері, заңды құжаттары және т.б. барына байланысты болып келеді. Шешімдерқабылдаған кезде платформаның бірқалыпты және адекватты жұмысын қамтамасыз ету үшін, бір жүйенің мәліметтері мен қосымшалары екінші жүйеде танымды болуы қажет. Сондықтан интеграцияны бірнеше деңгейде жасау қажет. Зерттеудіңнегізгі мақсаты - жүйені жобалау кезеңінен бастап интеграцияны құрудың барлық мүмкін жолдарын көрсету. Интеграция теориясы күрделіiс, сондықтан оны жан-жақтықарастыруқажет. Барлық интеграциялық процестер мәліметтердің және бағдарламалардыңинтергациясынаәкеліп соқтырады. Интеграциялау әдістерін талдау жүргізіледі, сонымен қатар интеграциялық мүмкіндіктерге теріс әсерететін факторлар қарастырылады. Жобалау процесін (жобалау уақытынқысқарту) және жүйеніңөзін жобалауды (жүйеніңмазмұнын минимизациялау) оңтайландыруды қамтамасызетету интеграциялық мәселелердің шешімдері болып табылады, ал жүйелер жұмыс істеген кезде оның жұмысын (мінез-құлқын) оңтайландыру болып табылады. Зерттеу нәтижесінде, деректердіқұрылымдауға мүмкіндік беретін мәліметтер интеграциясын және қосымшалардың интеграциясын құру қажеттілігі көрсетілген. Деректер жүйеніңархитектурасының барлық деңгейлерінде орналасуы мүмкін екенін ескеру қажет.

Ал жүйенің бағдарламалық жасақтамасы ретінде: бағдарламалық модульдер, қосымшалар және жүйелер болуы мүмкін. Жүйенің бағдарламалық жасақтаманың барлық түрлерініңнегізі, яғни. қосымшалар мен ажырамас жүйе бағдарламалық модульдерінен тұрады, бағдарламалық жасақтаманы жобалау жәнеәзірлеу (яғни бағдарламалау жүйелеріне негізделген) қызмет көрсетуге бағытталған технологияларғанегізделген, мұнда жүйелердіңнегізі бағдарламалыққызмет көрсетуге негізделген. Жүргізілген зерттеулерді ақпараттық жүйелерді дамытуда қолдануға болады.

Кілтік сөздер: ақпараттық жүйе, платформа, интеграция, қызметтер, деректер.

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Интеграция информационных систем при проектировании интегрированной платформы логистики

Каждая информационная система логистики имеет свое хранилище. Это связано с тем, что компании, которые образуют логистическую цепочку являются независимыми и могут иметь разные юридические статусы, правовые документы и т.д. Но для того чтобы обеспечить бесперебойную и адекватную работу платформы при принятии решений, необходимо чтобы данные и приложения одной системы были узнаваемы в другой системе. Поэтому необходима интеграция на нескольких уровнях. Основная цель исследования - показать возможные пути создания интеграций начиная с этапа проектирования систем. Теория интеграции является сложной задачей, поэтому ее надо всесторонне рассмотреть. Все интеграционные процессы сводится к интеграции данных и интеграции программ. Осуществлен анализ методов интеграции, а также рассмотрены факторы, негативно влияющие на интеграционные возможности. Решения задач интеграции, обеспечить оптимизацию процесса проектирования (сокращения продолжительность времени проектирования) и проектирование самой системы (минимизация содержание системы), а при эксплуатации систем оптимизация ее функционирования (поведения) системы. В результате проведенного исследования показана необходимость в создании интеграции данных и интеграции приложений, позволяющие структурировать данные. Следует отметить, что данные могут располагаться на всех уровнях архитектуры системы. А программным обеспечением системы может выступить: программные модули, приложения и системы. Основу всех видов ПО системы, т.е. приложений и целостной системы составляют программные модули, проектирование и разработка программного обеспечения (т.е. на основе программирования систем) ведется на основе сервис-ориентированной технологий, где основу систем составляют программные сервисы. Проведенные исследования могут быть использованы при разработке информационных систем.
Ключевые слова: Информационная система, платформа, интеграция, сервисы, данные.

1 Introduction

Companies continue to accumulate disparate integration solutions, while, according to one of the recent studies, it is the presence of many tools that negatively affects the implementation of integration projects. The lack of system in the approach to integration, the use of many tools, often with overlapping functionality, the lack of a clear understanding, leads to the fact that the next integration problem is solved for a long time and with excessive costs, and the maintenance of the integration results turns out to be too complicated and expensive.

Companies are showing increasing interest in methods and tools for managing business processes (business process management, BPM), combining disparate operations in various departments in an end-to-end successful business process - more than the basis for a strategic approach to the integration of corporate applications. On the other hand, the development of BPM technologies, in particular the BPMN and BPEL languages for describing and executing business processes, has resulted in the emergence of a large number of proposals for business processes on the market. Forrester analysts believe that the best candidates for an integrated integration system for modern enterprises are integration-oriented business process management systems [1].

But all of these methods and technologies share common limitations - they all do not take into account the semantics of data and applications when integrating.

Based on their created packages of programs and systems that provide data integration of applications and systems. Integration of systems in most cases is a forced measure aimed at improving the efficiency of business processes in which information systems are used. The article discusses the main approaches to the integration of information systems, the proposed methods for solving various problems.

In automated business logistics, a problem arises for the following reasons:

First, the systems business processes are based on web services technologies, therefore, integration between services is necessary; With service-oriented systems design technology, there is a need to integrate software and data from software modules, software applications, software systems, or ecosystems.

Secondly, the supply chain can be implemented by various economic entities with different legal statuses and organizational structure, management management systems. Therefore, for a system of work between them, integration is required.

Thirdly, during the execution of logistic chains or logistic processes, which are fragments of the logistic supply chain of goods, the installation of data and procedures integration is required.

2 Service-oriented integration

SOA is by far the most sophisticated approach to application integration. The goal of this paradigm is to break down the logical functionality of a software system into smaller logical units, also called services.

The central concepts of SOA integration are "service"and "process". A service is a function that is well-defined, self-contained, and independent of the context or state of other services. Services have the following characteristics:

- Reusable custom encapsulation of a recurring business task that hides implementation details from the service interface.

- They are the building blocks for business processes.

- Can be linked with other services to encapsulate more important business functions, working in the context of specific business needs.

A process (business process) is defined as the logic of their interaction, independent of the implementation of services.

Allocating services based on application functionality only makes sense if they can be used repeatedly and in different contexts. It is customary to distinguish a supplier, a service consumer, and a component that ensures interaction between the supplier and the consumer (the so-called broker). Business processes are encapsulated from the service virtualization layer through direct interaction with application functions. Business processes are connected by connecting services with varying granularity. Together they represent an end-to-end implementation. The flexibility of business processes is a consequence, since one service can be changed to a more suitable implementation, without any impact on the consumer of business processes [3].

In the SOA approach, the information system is divided into several nodes - services that can interact with each other. This is an SOA integration scenario, i.e. coordination of information and data transmission formats.

To solve such a problem, it is necessary first of all to determine how the services are connected. You can connect to each other directly, but then you get a large number of links that will be difficult to use when expanding the platform, and the conversion of the data format when moving from one service to another must be taken into account. Therefore, with such a problem, a BPEL server can be used, which acts as a service bus, it unifies the data format, as well as controls the exchange of data between services [4].

2.1 The basics of building software for a business process automation system based on BPEL

As part of the work, the model of service of goods is considered, which describes the main stages of receipt and shipment of goods. The block diagrams describing the algorithm are shown in Figure 1-2.

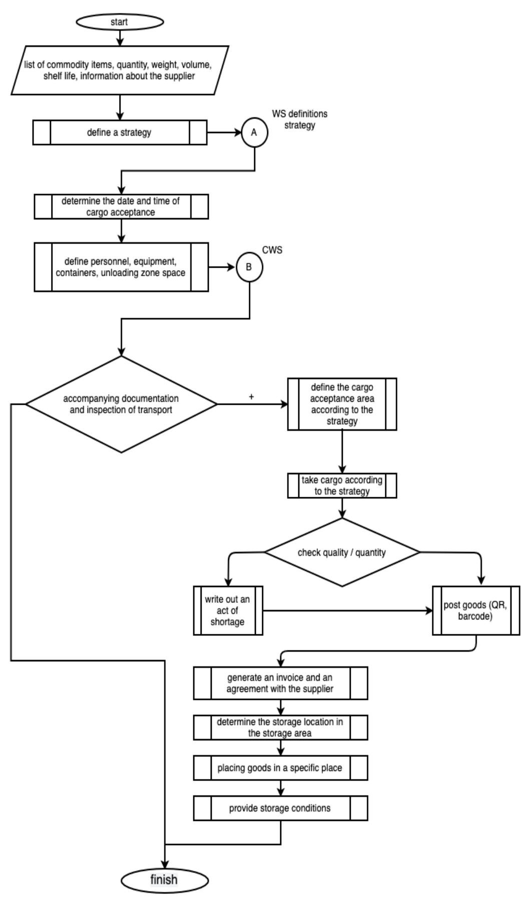

Figure 1: Algorithm for executing the cargo service model (goods receipt)

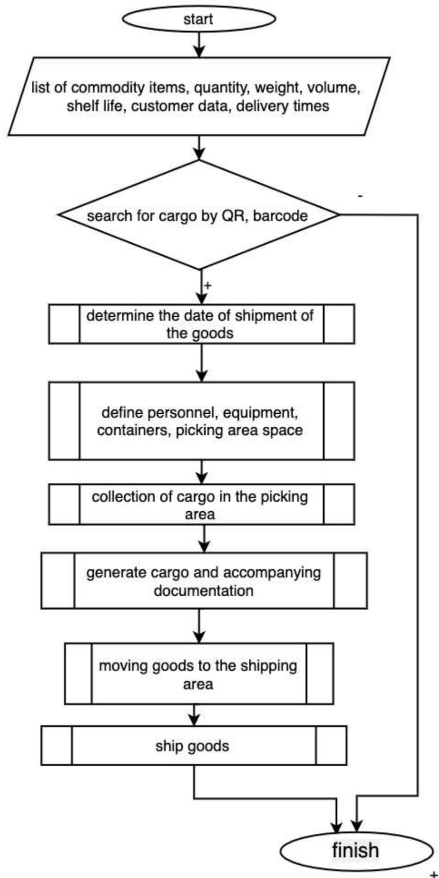

Figure 2: Algorithm for executing the cargo service model (packaging and shipment of goods)

Each task in the presented flowcharts is performed using the BPEL language:

- waiting for the arrival of a new application or the previous process (i.e. waiting for the result of the previous task). To accomplish this goal, BPEL must use Receive semantics;

- initialization of the passed variables to prepare for calling the web service. In this case, data type conversion is possible. BPEL supports Assign semantics to accomplish this goal;

- calling a web service, which is available as a WSDL, to perform a specific task, for example, "determine the date of receipt of the goods."BPEL supports Invoke semantics to accomplish this goal;

- getting the execution result of the called web service to prepare for returning or transferring the result to the next process. To accomplish this, you also need to use the Assign semantics in BPEL;

- return of the received data when the current task is performed next. To accomplish this, you need to use the Reply semantics in BPEL.

In addition to the semantics discussed above, the BPEL language supports a whole set of other semantics, the use of which allows you to build an information model of system management.

Let's model the workflow using BPEL. Here, a typical model of cargo acceptance is considered, in which there are main stages from the moment the application is submitted to the placement of the cargo at the storage address. Figure 3 shows the process for filing a storage claim.

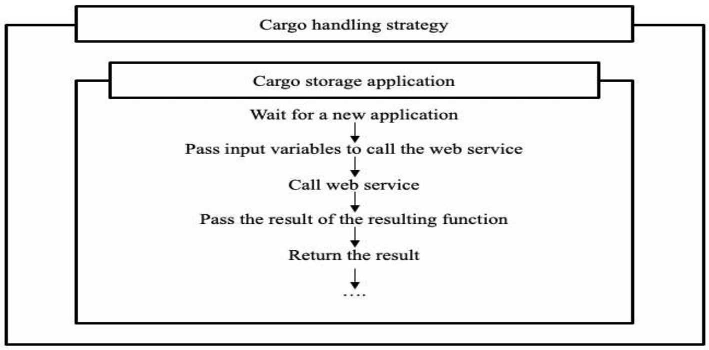

Figure 3: BPEL description of the cargo storage claim process)

Now we will give a description of the same BPEL process in code form:

<process name="Zayavka≫

The process element is followed by partnerLinks, which define other services or processes with which this process interacts. In this case, the only affiliate link automatically generated by the wizard is the link for the client interface of that BPEL process

<partnerLinks> //

<partnerLink name = "client"partnerLinkType = "tns: Client-Admin"
myRole = "Admin"/>

<partnerLink name = "reservation"partnerLinkType = "tns: Admin-reservation"
partnerRole = "zayavkaIssuer"/>

</partnerLinks>

PartnerLinks is followed by global variable definitions that are available throughout the BPEL process. The types of these variables are defined in the WSDL for the process itself.

<variables>
<variable name="purchaseRequest"messageType="tns:purchaseRequest"/>
<variable name="cost"type="xsd:double"/>
<variable name="items"type="tns:ItemSet"/>
<variable name="cancelRequest"messageType="tns:cancelRequest"/>
<variable name="cancelResponse"messageType="tns:cancelResponse"/>
<variable name="detailRequest"messageType="tns:detailRequest"/>
<variable name="detailResponse"messageType="tns:detailResponse"/>
<variable name="dateReached"type="xsd:boolean"/>
</variables>

1. The administrator receives data from the client using a web application;

2. The administrator sends the data to the service. As a result, a new request sends the entered data to the execution server of BPEL processes (which is visible from the outside as a set of web services) and thus generates a new instance of the "request for cargo acceptance"process;

3. The BPEL process calls an external web service that performs the "create a new ticket"task. The function of this service takes input from the request in step 2) and passes the result to the next process;

4. formation of a queue, which includes information about the cargo, the date of receipt, special processes of certain strategies (selection of mechanisms, personnel, etc.)

<bpel:sequence name="strategy≫
<bpel:sequence name="date≫
<bpel:receive name-="new request "partnerLink="client"/>
<bpel:assign name "variables≫
</bpel:assign>
<bpel:invoke name="Calling an external function with parameters≫
</bpel:invoke> <bpel:assign validate="no"name="Getting the result of a function ≫
</bpel:assign>
<bpel:reply name="Returning the result"/>
</bpel:sequence>
</bpel:sequence>
</bpel:process>

The process must also match requests to each other. For example, we can assign a unique ID to each quote and final proposal. BPEL documents these identifiers using the <correlationSet> tag:

A key part of the BPEL document defines the steps required to process a request. The <sequence> tag performs actions sequentially; the <flow> tag runs them in parallel; and the <receive>, <reply>, and <invoke> tags define the basic steps required to interact with web services using WSDL.

The sequence begins after receiving the buyer's request. The <flow> tag takes a parallel set of steps to contact each supplier for a quote. Each action refers to a specific WSDL operation and uses the available variables for input and output. After receiving responses from the supplier, the purchasing agent composes a message to respond to the buyer. An administrator can use the BPEL <assign> tag and W3C XPath to target portions of an XML document to take vendor containers and finalize a proposal back to the customer [5].

The last step is to manage the exceptions in the script. For example, if an error occurs while contacting a supplier, the agent might want to send a message to the customer. BPEL includes error handlers for these error conditions.

3 Material and methods

In this section, the relevance of the distribution of the execution of the operation on the cargo and the web service performing the operation for the subsequent automation of important decision-making processes will be considered.

In the developed platform, the method of decision-making under uncertainty was applied and an attempt was made to model a decision-making system based on common sense.

The problem of combining general consideration and logical reasoning was resolved with the advent of the theory of fuzzy sets, proposed by L. Zadeh, a professor at the University of Berkeley (California, USA) [6-7], in the 60s of the last century. The theory of fuzzy sets made it possible to operate with a mathematically fuzzy representation of concepts that have qualitative and subjective characteristics.

With the help of a fuzzy model, the problem of cargo distribution among web service operations was solved. Obviously, the decision-maker must distribute the load taking into account such characteristics of operations as the speed of the operation, reliability, flexibility of the operation, etc.

Given:

X=$(x_1, x_2, x_3, ..., x_n)$ is a set of loads arriving at a certain moment of time;

Y=$(y_1, y_2, y_3, ..., y_p)$ a set of features that characterize the operation;

Z=$(z_1, z_2, z_3, ..., z_m)$ a set of web services performing the operation.

It is required to distribute the load among web services in an optimal way, taking into account the properties of the operation for this particular load.

Of course, for each group of cargoes, it is advisable to select its own set of features, and here it is obvious that each cargo will have a feature to some extent.

In the work, the main features of the operation are considered, 4 features have been identified that are important for any type of cargo:

- quick response to the order;
- the reliability of the operation;
- the speed of the operation;
- flexibility of the operation;
- execution of the operation requiring special conditions.

All signs of the operation were assessed by experts of DRAGON SYSTEM LLP engaged in international logistics and experts of BK Logistics LLP engaged in warehousing and storage of non-food products. An expert assessment is necessary, since in many cases the decision maker does not have the full amount of data and acts in conditions of inaccurate information. The experts were asked to evaluate the cargo according to these characteristics, i.e. if, for example, we take the sign "speed of operation it is easy to determine which of the goods is perishable and requires quick execution of the operation, and which cargo can be processed in a longer time frame. This allows experts to give an expert assessment of the value of the membership function of a particular cargo to a set of perishable goods: if the cargo is obviously perishable, then the value of the membership function will be close to 1, if, on the contrary, the value of the membership function will be close to 0.

According to the criterion "speed of response to an order an order with high danger (toxicity) and food orders must be processed quickly, that is, if there is a cargo with such characteristics, the expert assigns the order a maximum value of 1;

According to the criterion "reliability of the operation the goods having the criterion of fragile, dangerous, toxic and other characteristics - the maximum value of the membership function 1;

According to the criterion "speed of operation"for perishable goods, the maximum value is 1;

According to the criterion "flexibility of the operation"if the operation when working with the cargo can be rebuilt, stopped without loss, etc. then the value is 0;

According to the criterion "execution of an operation requiring special conditions"goods with a large dimension, or large weight, or special conditions of transportation.

Thus, at the first stage, experts evaluated all 5 features and a formalized condition of the problem was obtained.

We have two sets R and S.

Let r: $X \times Y \rightarrow [0,1]$ be the membership function of the odd binary relation R, which is set by the experts. The physical meaning of this function is to what extent the attribute yj. corresponds to the load x_i.

As a result, we get a representation of the ratio R in matrix form:

$$R = \begin{matrix} x_1 \\ x_2 \\ \dots \\ x_n \end{matrix} \begin{bmatrix} r\left(x_1,y_1\right) & r\left(x_1,y_2\right) & \dots & r\left(x_1,y_p\right) \\ r\left(x_2,y_1\right) & r\left(x_2,y_2\right) & \dots & r\left(x_2,y_p\right) \\ \dots & \dots & \dots & \dots \\ r\left(x_n,y_1\right) & r\left(x_n,y_2\right) & \dots & r\left(x_n,y_p\right) \end{bmatrix}$$

Table 1: Fuzzy ratio R

	quick response to the order	the reliability of the operation	the speed of the operation	flexibility of the operation	execution of the operation requiring special conditions
Item 1: solid, light weight, small size, household, not hazardous. No special conditions	0,3	0,1	0,3	0,1	0,1
Item 2: solid, heavy weight, oversized, manufacturing, non-hazardous, special conditions	0,1	0,5	0,1	0,9	0,9
Commodity 3: solid, light weight, small size, food, not dangerous, No special conditions	0,9	0,1	0,9	0,5	0,9
Commodity 4: solid, regular, small size, manufacturing, hazardous, special conditions	0,5	0,9	0,5	0,4	0,8
Item 5: Liquid, Regular, Dimension, Household, Hazardous, Special Conditions	0,7	0,9	0,7	0,5	0,8
Item 6: liquid, regular, small size, food, not hazardous, No special conditions	0,9	0,3	0,9	0,5	0,3
Item 7: Liquid, Heavyweight, Oversized, Household, Hazardous, Special Conditions	0,7	0,5	0,7	0,8	0,8
Item 8: gas, light weight, large size, household, hazardous, special conditions	0,7	0,9	0,7	0,7	0,8
Item 9: gas, light weight, dimension, household, not dangerous, No special conditions	0,5	0,7	0,5	0,4	0,5
Item 10: Gas, Regular, Dimension, Household, Hazardous, Special Conditions	0,7	0,9	0,7	0,4	0,8

We carry out the same procedure with S fuzzy binary relation.

Let s: $Y \times \ Z \to [0,1]$ be the membership function of a fuzzy binary relation S. Is equal to the degree of importance from the attribute y_i for the web service z_j. In matrix form, this relationship is:

$$S = \begin{matrix} y_1 \\ y_2 \\ \dots \\ y_n \end{matrix} \begin{bmatrix} s(y_1, z_1) & s(y_1, z_2) & \dots & s(y_1, z_m) \\ s(y_2, z_1) & s(y_2, z_2) & \dots & s(y_2, z_m) \\ \dots & \dots & \dots & \dots \\ s(y_p, z_1) & s(y_p, z_2) & \dots & s(y_p, z_m) \end{bmatrix}$$

Table 2: Fuzzy ratio S

	WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9	WS10
quick response to the order	0,9	0,9	0,9	0,9	0,7	0,5	0,7	0,3	0,5	0,3
the reliability of the operation	0,9	0,7	0,5	0,3	0,9	0,9	0,9	0,7	0,3	0,5
the speed of the operation	0,7	0,9	0,3	0,5	0,9	0,7	0,5	0,9	0,9	0,3
flexibility of the operation	0,5	0,3	0,9	0,7	0,5	0,9	0,3	0,9	0,7	0,9
execution of the operation requiring special conditions	0,3	0,5	0,7	0,9	0,3	0,3	0,9	0,5	0,9	0,9

The matrix of fuzzy relations R:

$$R = \begin{bmatrix} 0,3 & 0,1 & 0,3 & 0,1 & 0,1 \\ 0,1 & 0,5 & 0,1 & 0,9 & 0,9 \\ 0,9 & 0,1 & 0,9 & 0,5 & 0,9 \\ 0,5 & 0,9 & 0,5 & 0,4 & 0,8 \\ 0,7 & 0,9 & 0,7 & 0,5 & 0,8 \\ 0,9 & 0,3 & 0,9 & 0,5 & 0,3 \\ 0,7 & 0,5 & 0,7 & 0,8 & 0,8 \\ 0,7 & 0,9 & 0,7 & 0,7 & 0,8 \\ 0,5 & 0,7 & 0,5 & 0,4 & 0,5 \\ 0,7 & 0,9 & 0,7 & 0,4 & 0,8 \end{bmatrix}$$

The matrix of fuzzy relations S:

$$S = \begin{bmatrix} 0,9 & 0,9 & 0,9 & 0,9 & 0,7 & 0,5 & 0,7 & 0,3 & 0,5 & 0,3 \\ 0,9 & 0,7 & 0,5 & 0,3 & 0,9 & 0,9 & 0,9 & 0,7 & 0,3 & 0,5 \\ 0,7 & 0,9 & 0,3 & 0,5 & 0,9 & 0,7 & 0,5 & 0,9 & 0,9 & 0,3 \\ 0,5 & 0,3 & 0,9 & 0,7 & 0,5 & 0,9 & 0,3 & 0,9 & 0,7 & 0,9 \\ 0,3 & 0,5 & 0,7 & 0,9 & 0,3 & 0,3 & 0,9 & 0,5 & 0,9 & 0,9 \end{bmatrix}$$

Further, from the matrices R and S, we obtain the matrix T

$$T=\begin{bmatrix} t(x_1,z_1) & t(x_1,z_2) & \dots & t(x_1,z_m) \\ t(x_2,z_1) & t(x_2,z_2) & \dots & t(x_2,z_m) \\ \dots & \dots & \dots & \dots \\ t(x_n,z_1) & t(x_n,z_2) & \dots & t(x_n,z_m) \end{bmatrix}$$

where each element of the matrix is calculated by the formula:

$$t(x,z_i)=\frac{\sum_y r(x,y)\bullet s(y,z_i)}{\sum_y r(x,y)}$$

thus the matrix T has the form:

$$T=\begin{bmatrix} 0,72 & 0,77 & 0,63 & 0,68 & 0,72 & 0,63 & 0,63 & 0,63 & 0,68 & 0,46 \\ 0,53 & 0,50 & 0,72 & 0,69 & 0,53 & 0,66 & 0,66 & 0,69 & 0,69 & 0,77 \\ 0,62 & 0,69 & 0,67 & 0,74 & 0,62 & 0,57 & 0,65 & 0,62 & 0,74 & 0,56 \\ 0,66 & 0,66 & 0,64 & 0,64 & 0,66 & 0,65 & 0,73 & 0,64 & 0,64 & 0,59 \\ 0,67 & 0,68 & 0,64 & 0,64 & 0,67 & 0,65 & 0,70 & 0,64 & 0,64 & 0,57 \\ 0,71 & 0,73 & 0,65 & 0,68 & 0,71 & 0,65 & 0,61 & 0,65 & 0,68 & 0,49 \\ 0,63 & 0,64 & 0,68 & 0,69 & 0,63 & 0,64 & 0,64 & 0,66 & 0,69 & 0,60 \\ 0,66 & 0,66 & 0,65 & 0,65 & 0,66 & 0,66 & 0,68 & 0,66 & 0,65 & 0,58 \\ 0,68 & 0,68 & 0,64 & 0,63 & 0,68 & 0,67 & 0,69 & 0,65 & 0,63 & 0,56 \\ 0,68 & 0,69 & 0,63 & 0,64 & 0,68 & 0,64 & 0,71 & 0,64 & 0,64 & 0,56 \end{bmatrix}$$

Next, you need to set a threshold number in order to determine the set of products, the operation of which can be performed using the web service, according to the formula:

$$l\ =\min_{(i,j)} \underset{x}{max}\ \min\left(t\left(x,\ z_i\right),\ t\left(x,\ z_j\right)\right)$$

The first step was to compose a matrix of pairwise minima:

$$Matrixofpairwiseminima=\begin{matrix} 0,722 & 0,633 & 0,633 & 0,678 & 0,633 & 0,633 & 0,633 & 0,633 & 0,456 \\ 0,500 & 0,500 & 0,692 & 0,532 & 0,532 & 0,660 & 0,660 & 0,692 & 0,692 \\ 0,621 & 0,670 & 0,670 & 0,621 & 0,573 & 0,573 & 0,621 & 0,621 & 0,561 \\ 0,661 & 0,635 & 0,635 & 0,635 & 0,648 & 0,648 & 0,642 & 0,635 & 0,590 \\ 0,672 & 0,639 & 0,639 & 0,644 & 0,650 & 0,650 & 0,644 & 0,644 & 0,567 \\ 0,707 & 0,652 & 0,652 & 0,679 & 0,652 & 0,610 & 0,610 & 0,652 & 0,486 \\ 0,631 & 0,639 & 0,677 & 0,631 & 0,631 & 0,643 & 0,643 & 0,660 & 0,603 \\ 0,658 & 0,653 & 0,647 & 0,647 & 0,663 & 0,663 & 0,658 & 0,647 & 0,584 \\ 0,677 & 0,638 & 0,631 & 0,631 & 0,669 & 0,669 & 0,654 & 0,631 & 0,562 \\ 0,677 & 0,631 & 0,631 & 0,643 & 0,643 & 0,643 & 0,637 & 0,637 & 0,557 \end{matrix}$$

We calculate the maximum element of each column: 0,722 0,670 0,692 0,679 0,669 0,669 0,660 0,692 0,692

Among the maximum elements, we find the minimum, equal to 0.66. In the matrix T we find a number slightly less than 0.66, it is equal to 0.658, which is a threshold number.

Next, we modify the matrix, and if the element $t\,(x_i,\ z_j)$ is greater than or equal to the threshold number, then the product xi is included in the set M_j.

As a result, we get a modified matrix T'.

$$T' = \begin{bmatrix} 0,722 & 0,767 & 0 & 0,678 & 0,722 & 0 & 0 & 0 & 0,678 & 0 \\ 0 & 0 & 0,724 & 0,692 & 0 & 0,66 & 0,66 & 0,692 & 0,692 & 0,772 \\ 0 & 0,694 & 0,67 & 0,742 & 0 & 0 & 0 & 0 & 0,742 & 0 \\ 0,661 & 0,661 & 0 & 0 & 0,661 & 0 & 0,726 & 0 & 0 & 0 \\ 0,672 & 0,678 & 0 & 0 & 0,672 & 0 & 0,70 & 0 & 0 & 0 \\ 0,707 & 0,734 & 0 & 0,679 & 0,707 & 0 & 0 & 0 & 0,679 & 0 \\ 0 & 0, & 0,677 & 0,689 & 0 & 0 & 0 & 0,66 & 0,689 & 0 \\ 0,663 & 0,658 & 0 & 0 & 0,663 & 0,663 & 0,679 & 0,658 & 0 & 0 \\ 0,685 & 0,677 & 0 & 0 & 0,685 & 0,669 & 0,692 & 0 & 0 & 0 \\ 0,677 & 0,689 & 0 & 0 & 0,677 & 0 & 0,711 & 0 & 0 & 0 \end{bmatrix}$$

4 Results and discussion

We represent matrix T' in the form of a table 3.

Table 3: Modified fuzzy ratio T'

Thus, the distribution of the operation execution for different categories of goods by web services was considered, which have the characteristics of the operations that they can perform.

As can be seen from matrix T', the distribution of product categories by web services was obtained, taking into account the priority of the product.

If a service is busy performing an operation of one product, another product with the same characteristics can implement another service. When evaluating the services, the "preferences"of the web service were taken into account. Therefore, each web service works only with the product that is present in its set of preferred products.

4.1 Integration solution for logistics system applications

Apache Camel, which implements Enterprise Integration Patterns, is used as a basis for integrating applications within the system. The advantages of using this framework are as follows:

1. Open source framework
2. Implemented EIPs
3. Ability to use different transport (TCP, UDP, HTTP, etc.) and API
4. Lightweight routing description language, based on Java DSL, and it is also possible to use Spring XML, Scala, PHP and other languages.

If you need to integrate with web services, the SOA architecture is used in conjunction with the Apache CXF framework, which also simplifies application development. At the moment, it has a huge number, 328, plug-in components for interacting with third-party systems

For a more detailed application, it is necessary to understand the architecture of the framework itself. The following figure shows the main components of the framework:

	WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9	WS10
Item 1: solid, light weight, small size, household, not hazardous. No special conditions	0,722	0,767	-	0,678	0,722	-	-	-	0,678	-
Item 2: solid, heavy weight, oversized, manufacturing, non-hazardous, special conditions	-	-	0,724	0,692	-	0,660	0,660	0,692	0,692	0,772
Commodity 3: solid, light weight, small size, food, not dangerous, No special conditions	-	0,694	0,670	0,742	-	-	-	-	0,742	-
Commodity 4: solid, regular, small size, manufacturing, hazardous, special conditions	0,661	0,661	-	-	0,661	-	0,726	-	-	-
Item 5: Liquid, Regular, Dimension, Household, Hazardous, Special Conditions	0,672	0,678	-	-	0,672	-	0,700	-	-	-
Item 6: liquid, regular, small size, food, not hazardous, No special conditions	0,707	0,734	-	0,679	0,707	-	-	-	0,679	-
Item 7: Liquid, Heavyweight, Oversized, Household, Hazardous, Special Conditions	-	-	0,677	0,689	-	-	-	0,660	0,689	-
Item 8: gas, light weight, large size, household, hazardous, special conditions	0,663	0,658	-	-	0,663	0,663	0,679	0,658	-	-
Item 9: gas, light weight, dimension, household, not dangerous, No special conditions	0,685	0,677	-	-	0,685	0,669	0,692	-	-	-
Item 10: Gas, Regular, Dimension, Household, Hazardous, Special Conditions	0,677	0,689	-	-	0,677	-	0,711	-	-	-
Lots of products to be distributed across web services	T1, T6, T9, T10, T5, T8, T4	T1, T6, T3, T10, T5, T9, T4, T8	T2, T7, T3	T3, T2, T7, T6, T1	T1, T6, T9, T10, T5, T8, T4	T9, T8, T2	T4, T10, T5, T9, T8, T2	T2, T7, T8	T3, T2, T7, T6, T2	T2

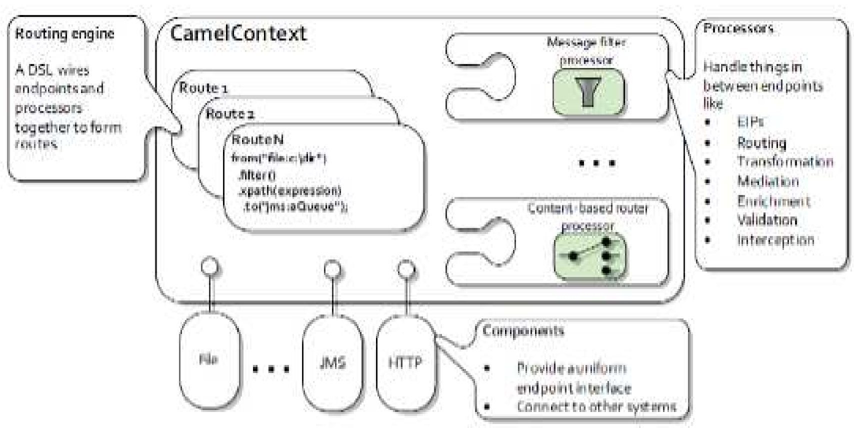

Figure 4: Components of the framework

1. CamelContext - context of code execution
2. Routing engine - message routing engine
3. Processors - message handlers

4. Components - components of interaction with third-party systems

The exchange of messages shown in Figure 5 is carried out between systems using "neutral"endpoints, described using a message endpoint (URI).

An example of an endpoint description (Figure 6):

1. Schema - determines the type of transport (in this case, the file will be read)

2. Context path - context address (data / inbox directory)

3. Options - additional option (delay of 5000 ms, update interval is determined)

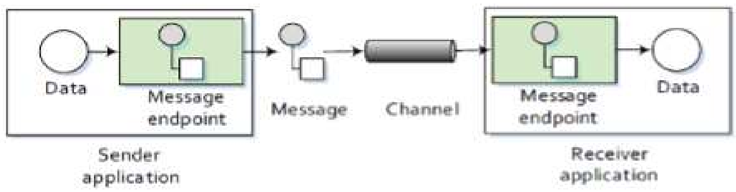

Figure 5: Messaging between applications

Figure 6: Endpoint description

5 Conclusion

To solve a common task - the task of automating logistics processes, it is required to perform various integration tasks. The need for integration arises both at the level of data and software modules (within models and intermodular relations) and at the level of the logistics system as a whole, i.e. to harmonize the robots of the logistics system with other systems, for example, ERP systems, CPM systems, enterprise PLM systems, etc. This factor requires that the system be integration-oriented or integration-adapted, i.e. adapted to integration processes.

Thus, the system should be designed on the basis of integration-oriented design technologies, and also, which is no less important, the operation of the system should be carried out on the basis of technology oriented to the integration process, while integrating data, software modules and applications [8-9].

Integration of data and software modules during design will occur in different cases and in different parts of the system. In other words, it can be argued that the integration process occurs when the logistics processes are performed in various places / tasks and subtasks or operations. To complete the integration process, it is required to build a system based on certain requirements, i.e. the system must have a number of conditions.

1. the system should be built on the basis of POSIX principles.

2. the system must be interoperable, i.e. interoperability, interfaces must be fully open, interact and function with other products or systems without any restrictions on access and implementation.

Various integration processes are carried out in places of origin in the procedural composition of the corresponding system, or by collecting a set of separate procedures that locally solve only one integration process as part of a single system, which we will call a system or a subsystem, or an integration bus [10].

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