**MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE**
**NATIONAL AVIATION UNIVERSITY**

**Air Transportation Management Department**

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Head of the Department
____________________D. O. Shevchuk
“______”_____________________2020

# MASTER THESIS
## (EXPLANATORY NOTES)

**Theme:** “Method of informational flows automation at transport enterprise”

**Done by:** Petruk Artem, FTML 202Ma

**Supervisor:** Shevchuk D.O. Doctor of Technical Sciences, Professor

**Standards Inspector:** Yulia V. Shevchenko

**Kyiv 2020**

**МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ**
**НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ**

**Кафедра організації авіаційних перевезень**

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
________________Шевчук Д. О.
“_____”______________2020 р.

# ДИПЛОМНА РОБОТА
## (ПОЯСНЮВАЛЬНА ЗАПИСКА)

**ВИПУСКНИКА ОСВІТНЬОГО РІВНЯ**
**“МАГІСТР”**

**Тема:** “ Метод автоматизації інформаційних потоків на транспортному підприємстві”

**Виконавець:** Петрук Артем, ФТМЛ 202Ма

**Керівник:** Доктор технічних наук, професор кафедри організації авіаційних перевезень Шевчук Дмитро Олегович

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**Київ 2020**

**NATIONAL AVIATION UNIVERSITY**

Faculty of Transport Management and Logistics

Air Transportation Management Department

Major(specialty): 275 "Transport Technologies (by transport modes)"

APPROVED BY
Head of the Department
____________________D. O. Shevchuk
"______" _____________________2020

**TASK**

**for completion the Master thesis**

Petruk Artem Viktorovich

1. Theme of the Master thesis entitled "Method of informational flows automation at transport enterprise" was approved by a decree of the Rector's order № 2026/art. of October 16, 2020.
2. Terms of thesis performance: from 05.10.2020 to 31.12.2020
3. Initial data required for writing the master thesis: production and results of a company "Robert Bosch", analysis of all competitors in the market.
4. Content of the explanatory notes: Analysis of the existing automated resource management system showed non-compliance with modern requirements for the operation of the transport enterprise. Its main disadvantage is the lack of automation of ordering processes, which significantly affects the efficiency of the enterprise. A method of automation of resource management, which differs from the existing ones by automatic generation of registration customs number and automation of goods placement processes in the warehouse of Robert Bosch, was developed, which allowed to increase the efficiency of the transport enterprise. The structural and functional scheme of the automated resource management system of the transport enterprise has been improved due to the ordering processes, which has allowed to reduce the time of delivery of goods to the customer. The developed method of automation

of resource management is software implemented on the basis of the software product BD-Soft and implemented in the company Bosch, which allowed to increase the number of orders, track the location of goods in the delivery process and reduce ordering time.

5. List of the mandatory graphic materials: different schemes of ordering processes, diagrams of automated processes, table which shows improvements after implementation new algorithm.

6. Planning calendar

| № | Assignment | Deadline for completion | Mark on completion |
|---|---|---|---|
| 1. | Collection and processing of statistical data | 10.10.20-19.10.20 | done |
| 2. | Writing of the theoretical part | 20.10.20-28.10.11 | done |
| 2. | Writing of the analytical part | 29.10.20-09.11.20 | done |
| 3. | Writing of the design part | 10.11.20-18.11.20 | done |
| 4. | Writing of the introduction and summary | 18.11.20-19.11.20 | done |
| 5. | Execution of the explanatory note, graphic materials and presentation | 20.11.20-25.11.20 | done |

7. Given date of the task: October 05, 2020

Supervisor of the bachelor thesis: Shevchuk Dmytro Olegovich
Task was accepted for completion: Petruk Artem Viktorovich

## REPORT

Explanatory note to the diploma project “” consists of 83 pages, 15 figures, 2 tables, 36 sources used.

KEY WORDS: BOSCH, ROBERT BOSCH, ORDERING, CUSTOMS, ORDERING PROCESS.

*Object of study*: the process of automation of MTE resource management in conditions of uncertainty.

*Subject of study:* **-** the system of automated management of energy resources in conditions of uncertainty.

*Purpose of thesis: increase the efficiency of MTE in conditions of uncertainty by automating the process of managing its resources.*

*Methods of analysis includes* comparative analysis, analysis of relevant literature, mathematical method.

During the completion of the master thesis it was established that implementation of new ordering process could improve all turnaround process time. Such an innovation will help improve the punctuality of the delivery and also have a positive financial result.

## LIST OF ABBREVIATION

HAN - Human Area Network;

LAN - Local Area Network;

LP - Linear Programming

PAN - Personal Area Network;

RB - Robert Bosch;

AW - Automated workplace;

AIMS - automated inventory management system;

MTE - motor transport enterprise;

GCN - global computer network;

EMF - electromagnetic field;

LS - logistics system;

LSEC - logistics system operating in emergency conditions;

DTM - data transmission multiplexer;

MR - material resources;

# CONTENTS

# *INTRODUCTION*

| Air Transportation Management Department | | | | NAU 20.09.57. 001 EN | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Done by: | Petruk A.V. | | | INTRODUCTION | Letter | | | Sheet | Sheets |
| Supervisor | Shevchuk D.O. | | | | | | D | 9 | 3 |
| Standards Inspector | Shevchenko Yu.V. | | | | FTML 275 ОП-202Ма | | | | |
| Head of the Department | Shevchuk D.O. | | | | | | | | |

The current trend of transition to digital methods of creating, transmitting, processing and storing information leads to the widespread introduction of static and dynamic databases, the organization of telecommunications for access to information through terrestrial and satellite information channels. Accordingly, in logistics systems there is a transition to digital technology in all areas of document management, including the replacement of paper transport documents with electronic ones. The integration of information flows and communication support in the transportation of goods has received a general name - telematics.

The introduction of information technologies and their integration on the basis of telematics are implemented in transport in several main areas. First of all, it is the active implementation and use of automated control systems of the transport company. Management of any enterprise requires a high level of information and analysis of the information obtained to form a management decision, so companies implement automated control systems (ACS) of different levels for quality collection and processing of information about the enterprise. ACS is based on the integrated use of technical, mathematical, informational and organizational tools.

The basis of ACS enterprises is a database - electronic files, which allow detailed structured accounting of all components of the enterprise. Using database management system it is possible to deeply analyze the content of information, make samples, reports, statistical and mathematical calculations. To access the company's employees to the database, a localized computer network of the company is created, through which each specialist can receive the necessary information, process it with appropriate professional software (warehousing, accounting, financial transactions, personnel accounting, payroll and billing, etc.). To protect and save information, access to the database is ranked - each of the network's clients has clearly defined rights to use certain information, change or copy it. The database information is stored on a special dedicated computer - a server that has the appropriate software to work with customer requests. On the working computers of the company's specialists, in addition to the main DBMS, additional programs necessary for the work of the specialist can be installed, for example, an accounting program or a car dispatching system in flight. These programs can interact with the DBMS, and can work autonomously. Automation of management on the basis of local computer networks and databases due to the availability of Internet access implements information integration with all participants in the logistics chain. Additional programs required for the specialist's work may be installed, such as an accounting program or a flight control system on the flight. These programs can interact with the database, and can work autonomously. Automation of management on the basis of local computer networks and databases due to the availability of Internet access implements information integration with all participants in the logistics chain. Additional programs required for the specialist's work may be installed, such as an accounting program or a flight control system on the flight. These programs can interact with the database, and can work autonomously. Automation of management on the basis of local computer networks and databases due to the availability of Internet access implements information integration with all participants in the logistics chain.

The main consequences of the introduction of ACS are to improve the quality, speed and reliability of accounting and analysis of the enterprise and structural units, individual employees; introduction of electronic document management, which also increases quality indicators; access to electronic interaction with other enterprises, customers, suppliers through Internet technologies. As a result, it gives an increase in the level of use of the rolling stock of the transport enterprise, optimization of its loading, reduction of costs for fuels and lubricants due to the introduction of route optimization programs, increasing competitiveness and profitability.

Ukraine has a powerful transport system, which includes rail, sea, river, road, air and pipeline transport. Each of these modes of transport is a set of means and ways of communication, as well as various technical devices and structures that ensure the operation of all sectors of the economy.

The main requirements for consumers to transport services are: reliability of transportation, minimum and guaranteed delivery times, regular delivery, well-established system of information and documentation, reasonable cost of transportation.

World experience shows that one of the effective ways to develop transport systems that ensure the delivery of goods in accordance with the basic requirements of consumers for transport services, is the widespread use of automation technologies in the organization of the transportation process.

Recently, increased attention to the organization and efficient operation of systems delivery of goods due to the reduction of the duration of trade cycles, increasing the cost of storage and the need to accelerate the response to consumer demand. One of the main approaches aimed at improving the efficiency of cargo delivery is the development of scientifically sound provisions for the automation of the processes of order formation, processing and delivery of goods to the consumer in a minimum time.

# 1. THEORETICAL PART

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| Done by: | Petruk A.V. | | | THEORETICAL PART | Letter | | | Sheet | Sheets |
| Supervisor | Shevchuk D.O. | | | | | | D | 13 | 21 |
| Standards Inspector | Shevchenko Yu.V. | | | | FTML 275 ОП-202Ма | | | | |
| Head of the Department | Shevchuk D.O. | | | | | | | | |

## 1.1. Comparative analysis of the principles of automation of the transport enterprise

Management of a modern enterprise in a market economy is a complex process that includes the selection and implementation of a set of managerial influences in the current time intervals in order to solve the strategic task of ensuring its sustainable financial and socio-economic development. Information technology greatly expands the possibilities of effective management, as it provides managers of all ranks with the latest methods of processing and analysis of economic information needed for decision-making. Information technology in management is a set of methods for processing disparate source data into reliable and operational information of the decision-making mechanism with the help of hardware and software in order to achieve optimal market parameters of the control object.

The motor transport enterprise can be considered as a complex system consisting of various elements that function and interact with each other and with the external environment. Possibilities of management of development of the motor transport enterprise (MTE) in the conditions of uncertainty of the environment are constructed on the basis of studying and systematization of information flows. The structuring of the organization's environment, the grouping of factors influencing the activities of the MTE, types of information and information flows create a basis for determining the most important accents of future development, formation and modeling of the MTE strategy.

The need and value of material resources are obvious, it is difficult to determine the value of information. However, information is the main source (or resource) of eliminating the uncertainty of the environment in which the company operates.

Effective work of MTE in market conditions, formation and modeling of the future or current strategy of its development is impossible without knowledge of structure, features, specificity, movement of the information environment and consequences of influence of its changes on activity of the enterprise.

Factors (elements) that exist within the enterprise itself are called factors of the internal environment. They are wholly or mainly owned by the company that manages them, can influence them. The company has real opportunities to influence the movement and formation of information flows about the availability and condition of property, staff and more.

The objects of the internal environment of the enterprise are managers, specialists, employees of departments and services, i.e. those who make decisions about the formation of information flows and manage them. Information flows reflect the hierarchical organization of the control and managed systems. The highest organization of the movement of information flows to the management level - the organization of the movement of the middle level and the organization of the movement of information flows in the external information flows at the lower level - in the environment, the average level of control - the internal environment.

On a temporary basis, we highlight the flow of current, retrospective, forecast information. The flow of forecast information contains data on the possible future state of the object, which can only act as a more or less accurate guide to future developments. All three streams of information are closely interdependent. First, current and forecast information eventually cease to be so and replenish the flow of retrospective information. Second, the flows of retrospective and current information are the basis for obtaining the flow of forecast information. Third, current information serves as a criterion for the accuracy of the forecast made to date. The tasks in connection with which different flows of information are formed, are as follows:

– retrospective information - identification of trends in the development of the object, the creation of a database for forecasts, the creation of a database of case studies;

– current information - knowledge of the current state of the object, assessment of the accuracy of previously made forecasts, reporting for regulatory authorities;

– forecast information - development of strategic directions of development of the organization of object.

The flow of retrospective information contains both current and forecast data that have lost their relevance and will be archived. Current and forecast information streams can contain both single and reusable information. According to the purpose it is expedient to allocate streams of universal and special information. The first flows in the enterprise include information of interest to several employees or departments. For example, it can be information about the mode of operation of the enterprise on holidays, the schedule of employees, about important events in the life of the organization. The second streams of information include those that are intended for an individual employee or one department of the enterprise. Streams of both universal and special information may contain mandatory information,

Over time, we distinguish the flow of conditionally constant and variable information. The first stream includes information that does not change over a long period of time. To conditionally constant it is possible to carry the information on contractual prices for raw materials, about a mode of a working day of the enterprise, about norms of labor costs and expenses of materials. The lifetime of variable information is limited to a short period. Obviously, the formation of flows of both constant-constant and conditionally-constant and variable information requires special diligence.

The allocation of discrete and monitoring information flows is essential. The flow of discrete information contains information that is directly related to any problem; the flow of monitoring information is focused on tracking on a long-term basis of existing trends in the development of the object. For example, the market is beginning to be actively introduced

a strong competitor that previously worked in other markets. Its appearance creates a problematic situation for a long-running company in this market. The latter has a need for information about the competitor In connection with the problem, the company forms a flow of discrete information about the competitor. In the future, it may be considered necessary to organize the flow of monitoring information about this competitor, taking into account its validity and intentions. Monitoring information implies systematic monitoring of the development of any object and identification of trends in this development. Collection of monitoring information is organized on a single methodological basis.

In the structures of MTE departments administrative, planning and economic, accounting, engineering and technical, supply, maintenance and repair form their own flows of information and can change the state and direction of incoming flows, obtaining the necessary data and information.

The information circulating in the system can be classified according to functional and pragmatic (by use) features.

Functional information:

– managerial, organizational, production, accounting and control, economic, marketing. Pragmatic information about:

– personnel, financial resources, material resources, information resources, results of activity.

Factors that exist outside the enterprise, form the external environment of the organization. The external environment, depending on the degree of connection with the activities of the enterprise, and the ability to influence these factors, it is advisable to divide into meso- and macro-environment.

## 1.2. Comparative analysis of the equipment of the automated transport enterprise

### 1.2.1. General information about computer networks.

A computer network is a collection of computers connected by means of data transmission.

You've probably heard of computer networks. These are interconnected computers that are equipped with the appropriate software. The simplest network can be created at home by connecting two computers. Today, dozens or even hundreds of computers are installed at large enterprises, banks, educational institutions and other institutions. Each computer has access to its own resources: RAM, file system on disks and external devices - additional drives, printers, modems and more. For optimal use of these resources and, in particular, for the exchange of information, computers are combined into local networks. Several interconnected local area networks form a global network. In fact, the Internet is the most popular public network, which is rightly considered (and this is reflected in its name) a network of networks. Connecting computers into a network has great advantages, completely unknown possibilities.

Everyone has their own needs for communication and access to sources of information, as well as ideas about the ways and prospects of using the Internet. For some, the Internet is associated with an exciting journey through the colorful web-pages of hockey, basketball, football leagues or the virtual world. For many, it is a means of communication for sending messages, copies of business documents, exchanging views on interesting issues. For some, it's an opportunity to buy a car or book tickets without leaving home. For professionals, it is a means of learning, mastering and applying new technologies in education, technology, business or everyday life.

The Internet is a country of computers that is constantly changing and evolving. Nobody controls the Internet. There is no president or king in this country. The Internet country has its own rules, which are called protocols. The protocols set out the basic laws under which a country lives, according to which computers can understand each other and live in harmony. A single computer is not a citizen of the Internet. To grant a computer citizenship, you must connect it to the Internet by installing the appropriate software and hardware. Since then, its information capabilities have become virtually unlimited. In the information society, it is considered that if some information is not available on the Internet, it is nowhere to be found.

### 1.2.2. Classifications of networks.

To classify computer networks, various features are used, the choice of which is to distinguish from the existing variety of those that would provide this classification scheme with the following mandatory qualities:

– possibility of classification of all, both existing, and perspective, computer networks;

– differentiation of essentially different networks;

– unambiguous classification of any computer network;

– clarity, simplicity and practical expediency of the classification scheme.

Some inconsistency of these requirements with each other makes the task of choosing a rational classification scheme of a computer network quite complex and such that there is still no unambiguous solution. Basically, computer networks are classified on the basis of structural and functional organization.

**1.2.3. Classification by size of the area covered.**

Human Area Network (HAN). Human Area Network - a computer network where the human body is used as a data transmission medium. A weak electric field on the surface of the human body is used as an information carrier. The transmitter in a certain place slightly changes it, the receiver registers these changes on the surface of the body.

Personal Area Network (PAN). Personal Area Network is a network built "around" a person. These networks are designed to combine all the user's personal electronic devices (personal desktops, laptops, phones, PDAs, smartphones, headsets, etc.). An example of such networks is to sit down on the basis of Bluetooth technology. PAN parameters:

– small number of subscribers;
– uncritical attitude to failure time;
– all devices included in the PAN network can be controlled;
– narrow range (30 meters);
– the network must support up to 8 participants.

There is no arbitration of the environment, i.e. who and how can work with this network is not controlled, there is no centralized management of such a network.

Local area network (LAN, Local Area Network) A local area network (LAN) is a computer network that usually covers a relatively small area or a small group of buildings (home, office, company, institute). There are also local area networks, the nodes of which are geographically spaced at a distance of more than 12,500 km (space stations and orbital centers). Despite such distances, such networks are still classified as local.

Home PNA (Home Phoneline Networking Alliance, HPNA) can also be included in this category of networks. HPNA is a joint association of non-profit industrial companies that promote and standardize home networking technologies using in-house coaxial cables and telephone lines. Among the sponsoring companies of HPNA, which set the course of the organization, we can highlight AT&T, 2Wire, Motorola, Cooper Gate, Scientific Atlanta and K - Micro. HPNA creates industry specifications, which are then standardized by the International Telecommunication Union (ITU), the world's leading standardization organization in the field of television and radio communications. HPNA also promotes technology, tests and certifies membership products as approved by Home PNA. Home PNA 3.1 is one of the new generation home networking standards.

This type of technology provides additional features such as Quality of Service QoS and is used by most providers (organizations that provide access to and maintain such networks) to provide a commercial triple play service (video, audio, and information). Home PNA 3.1 uses frequencies higher than those used by ADSL, ISDN (telephone line data technologies) and telephone calls on the line and lower than those used for DVB-S telecast and satellite telecast via coaxial (television) cable, so Home PNA 3.1 can coexist with these services in the same wires. Home PNA 3.1 was designed to both increase functionality in coaxial wires and expand their networking capabilities,

Requirements for Home PNA 3.1:

– Standard telephone or coaxial cable.

– Home PNA certified equipment.

Advantages of Home PNA 3.1:

– No new cables are required in the house.

– The operation of existing services - telephone, fax, DSL, satellite TV will not be disrupted, due to the fact that Home PNA works with different frequencies on one coaxial or telephone cable.

– The latest products offer data rates up to 320 MBs, providing the ability to support high-definition TV signal (High Definition TV HDTV) and standard television signal (Standard Definition TV SDTV).

– Guaranteed quality of QoS service, eliminates network "collisions". This allows real-time information streams, such as IPTV, to be delivered to the client without interruption.

– The maximum number of devices to connect is 64.

– The devices can be located at a distance of 300m. from each other on a telephone line and at a distance of more than a kilometer from each other on a coaxial cable. This is more than enough for homes.

– Standard Ethernet drivers are used, which allows you to easily add any product with an Ethernet port without touching the operating system.

– The necessary equipment has a low cost.

– New technologies, such as 802.11 Wi - Fi, are being developed to create mixed wired / wireless home networks.

– Providers can provide telephone, Internet, and digital television services in one package, using Home PNA-certified equipment.

– The hotel industry views Home PNA as an effective expensive option.

– The technology works in apartment buildings, providing a "triple play" service in the apartment.

Global computing Wide Area Network (WAN) is a computer network that covers large areas and includes tens and hundreds of thousands of computers. GOMs are used to connect disparate networks so that users and computers, wherever they are, can interact with all other members of the global network. Some GOMs are built exclusively for private organizations, others are a means of communication for corporate LANs with the global Internet or through the Internet with remote networks that are part of corporate. Most often, the GOM relies on dedicated lines, at one end of which the router connects to the LAN, and at the other the hub connects to other parts of the GOM.

Global networks differ from local ones in that they are designed for an unlimited number of subscribers and use, as a rule, not very high-quality communication channels and relatively low transmission speed, and the exchange control mechanism, they in principle can not be guaranteed fast connection. In global networks, the quality of communication is not much more important than the fact of its existence. However, it is no longer possible to draw a clear and unambiguous line between local and global networks. Most local networks have access to the global network, but the nature of the transmitted information, the principles of organization of exchange, modes of access to resources within the local network, as a rule, are very different from those accepted in the global network. And although all computers on the LAN in this case are also included in the WAN, the specifics of the local network it does not cancel. The ability to access the World Wide Web remains just one of the resources shared by LAN users.

### 1.2.4. Classification by type of functional interaction.

Terminal - host computer architecture (terminal - host computer architecture) - is the concept of an information network in which all data processing is carried out by one or a group of hosts.

This architecture involves two types of equipment:

– The main computer where network management, storage and data processing is carried out.

– Terminals designed to send commands to the host computer to organize sessions and perform tasks, enter data to perform tasks and get results.

The host computer communicates with the terminals through data multiplexers (data multiplexer (MPD) - a device that represents one physical channel in the form of several independent logical channels).

Peer architecture (peer-to-peer architecture) is a concept of an information network in which its resources are scattered across all systems. This architecture is characterized by the fact that all systems are equal.

Peer-to-peer networks are small networks where any workstation can perform both file server and workstation functions.
station. In peer-to-peer LANs, disk space and files on any computer can be shared. For a resource to be shared, it must be shared using remote peer-to-peer operating system remote access services. Depending on how data protection is installed, other users will be able to use the files as soon as they are created. Peer-to-peer LANs are good only for small workgroups.

Peer-to-peer LANs are the easiest and cheapest type of network to install. On a computer, they require only an operating system (such as Windows XP) in addition to the network card and network media. When computers are connected, users can share resources and information.

The problem with peer-to-peer architecture is when computers are disconnected from the network. In these cases, the types of service they provided disappear from the network. Network security can only be applied to one resource at a time, and the user must remember as many passwords as network resources. When you gain access to a shared resource, you experience a drop in computer performance. A significant disadvantage of peer-to-peer networks is the lack of centralized administration.

The use of peer-to-peer architecture does not preclude the use in the same network as the architecture "terminal - host computer" or architecture "client - server".

Client-server architecture is a concept of an information network in which the main part of its resources is concentrated in servers serving their clients (Fig. 1.1). This architecture defines two types of components: servers and clients.

**Server** is an object that provides service to other network objects upon their requests. Service is a process of customer service.

The server works on the tasks of clients and manages the execution of their tasks. After completing each task, the server sends the results to the client who sent the task.

The service function in the client-server architecture is described by a set of applications, according to which various application processes are performed.

A process that calls a service function through certain operations is called a client. They can be a program or a user. Clients can be workstations that use server resources and provide user-friendly interfaces. User interfaces are procedures for user interaction with a system or network.

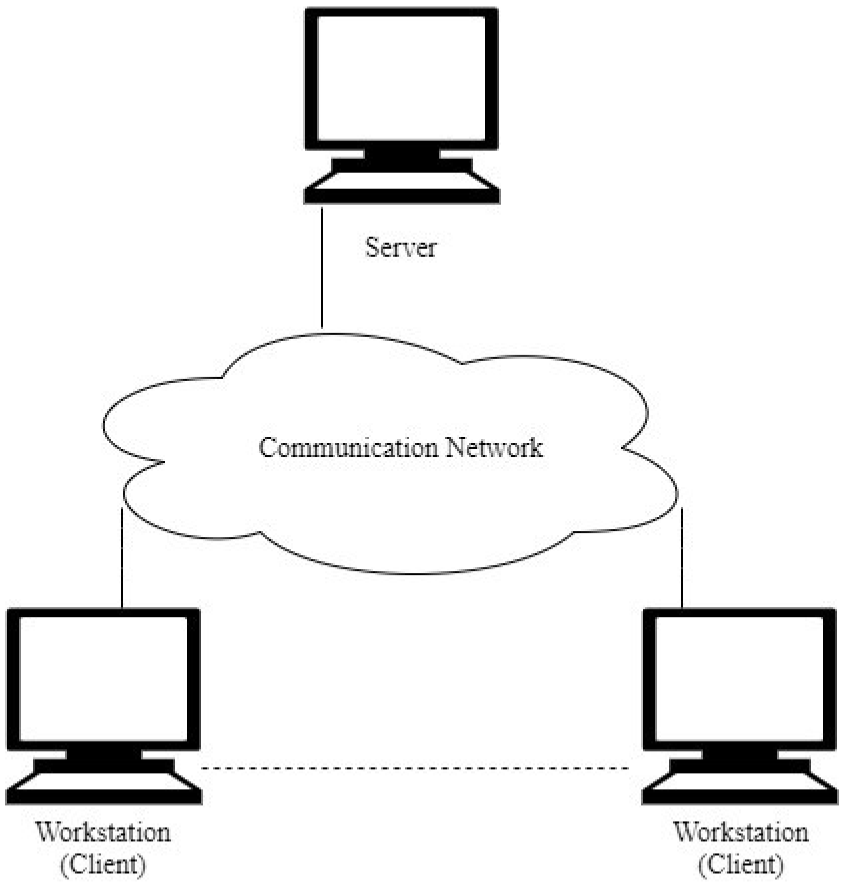


Fig. 1.1. Client - server architecture

The client is the initiator and uses e-mail or other server services. In this process, the client invites the type of service, sets up a session, gets the results he needs and notifies about the end of work.

In networks with a dedicated file server (Fig. 1.2) on a dedicated computer is installed server network operating system. This PC becomes a server. The software (software) installed on the workstation allows it to communicate with the server. Example of network operating systems: Windows Server family operating systems.

In addition to the network operating system, you need network applications that implement the benefits of the network.

Server-based networks have better performance and increased reliability. The server has the main network resources accessed by other workstations.

In the modern client - server architecture there are four groups of objects: clients, servers, these and network services. Customers are housed in systems at users' workplaces. The data is mostly stored on servers. Network services are shared servers and data. In addition, services manage data processing procedures.

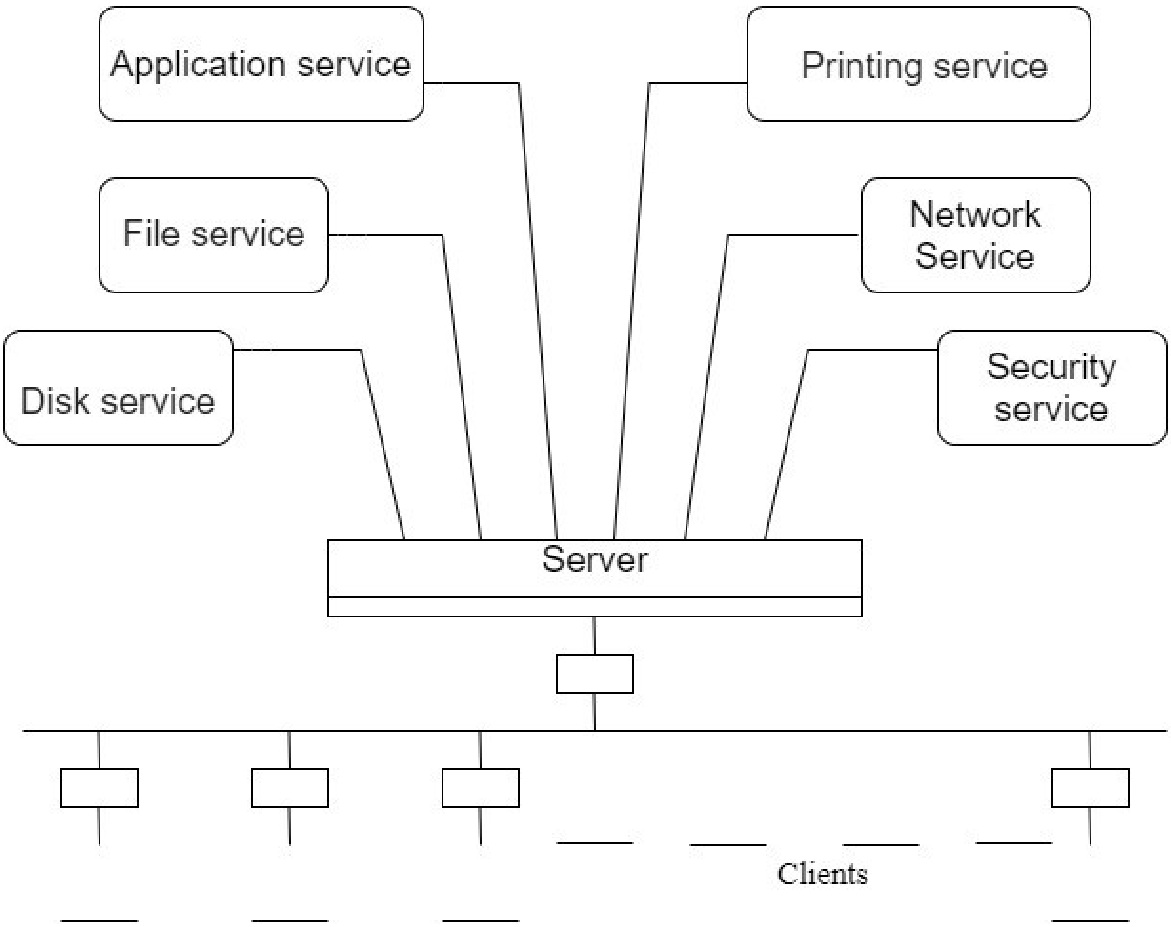


Fig. 1.2. Client-server model

As the functions entrusted to servers become more complex and the number of clients they serve, increases, so does the server's specialization. There are many types of servers.

### 1.2.5. Classification by type of network topology

Under the network topology is a description of its physical location, ie how computers are connected to each other in the network and with which devices are included in the physical topology.

There are four main topologies:

– bus;

– ring;

– star;

– mesh (cell).

## 1.3. Automation of the processes of operation of the company Robert Bosch

The Bosch Group has been operating in the Ukrainian market since 1993 and is the largest supplier of solutions for the automotive and secondary spare parts markets, as well as industrial and household appliances. Since 2008, a Bosch service center for maintenance and repair of power tools has been operating in Kyiv. In 2009, the Bosch Training Center was opened for car service staff. There are three Bosch Academies in higher educational institutions of Ukraine: on the basis of Odessa National Polytechnic University, Lviv Polytechnic National University and Kharkiv National Automobile and Road University.

Bosch operates in all regions of Ukraine through regional branches in Odessa, Lviv and Dnipro. Also in Ukraine there is a Bosch representative office in Kramatorsk and a plant for the restoration of starters and generators in the Krakovets, Lviv region. The turnover of the Bosch Group in the 2015 financial year amounted to 61 million euros. The company employs 360 people.

The Bosch Group is the world's leading provider of technology and services. In 2015, about 375,000 employees (as of December 31, 2015) provided sales of more than 70.6 billion euros. The Bosch Group operates in four main business areas: Mobility Solutions, Industrial Technology, Consumer Goods, Construction Technology and Energy. The Bosch Group includes Robert Bosch GmbH and more than 440 subsidiaries and regional companies in approximately 60 countries.

Together with its sales and service partners, Bosch is represented in almost 150 countries. The innovative power of the company is the basis of its prosperity in the future. The research and development sector employs 55,800 people in approximately 118 cities around the world. The strategic goal of the Bosch Group is to create products and services in the field of the Internet of Things. Bosch improves the quality of life with innovative technologies with a wide range of possibilities and inspiring solutions designed for life.

The company was founded by Robert Bosch (1861-1942) in Stuttgart in 1886 as a "Workshop on precision mechanics and electrical engineering." The special ownership structure of Robert Bosch GmbH guarantees the Bosch Group entrepreneurial freedom, which allows it to carry out long-term planning and use a significant share of investment funds, ensuring a secure future. Ninety-two percent of the share capital of Robert Bosch GmbH belongs to the Robert Bosch Stiftung GmbH. The controlling stake is owned by Robert Bosch KG and acts as the owner on the basis of trust management. The rest of the shares belong to the Bosch family and Robert Bosch GmbH.

## 1.4. Block diagram of the automated process of information exchange

### 1.4.1. Exchange of resources in the company of Robert Bosch

One of the main aspects of successful trade in the company are the means of implementing automation elements for the exchange of resources.

For appropriate turnover it is necessary to have a well-built network, where the information flow of data exchange and its interaction with automated workplaces will take place. To do this, we present a block diagram of the automated process of exchanging information resources of Robert Bosch (Fig. 1.3), and consider it in more detail.

Like all network hardware concepts, it is based on building a storage server. It consists of a physical database server and

virtually, the flow of information occurs according to the above scheme through the bus (network connection). The working server must function in the mode of constant online access, i.e. to be working 24 hours a day, 365 days a year. The server is used to store, transport and process data. It also exchanges data with other networks, such as the registration service, which issues a product registration code that is required to legally cross the border of the imported product.

Fig. 1.3. Block diagram of the automated process of information exchange of Robert Bosch

Accordingly, the company is equipped with workstations (workstations) that work on computers in software environments such as: BD-Soft, PARUS, DeloPro, MeDoc and others. For the normal functioning of the entire large mechanism, it is necessary to provide automatic interaction between data exchange programs. And also have an IT specialist to monitor the processes that will take place in the network space.

The company sells goods and, accordingly, the question arises in the rapid turnover, starting from the stage of purchase, transportation, import abroad, warehousing and sending the customer his order.

One of the tools for exchanging information flows in the company of Robert Bosch is the BD-Soft program.

The BD-Soft program is a system of sales automation and logistics. At the level of regional representation (RG - ROBERT BOSCH LTD.) Is a continuation of the logistics system of the central sales departments for which it has developed means of integration (export / import) with these systems (Level I). Operational maintenance of warehouses is performed by an external contractor (warehouse operator and carrier, usually represented in one person) who, through clearly defined interfaces, is integrated into BD-Soft by the warehouse (Level III). Accounting for settlements with suppliers and customers is logically taken from BD-Soft and assigned to an external program (Fig. 1.4).

BD-Soft operates with the following (documentation) information flows:

- transit, import invoices;
- sales reports, warehouse status;

– confirmation of posting the goods to the warehouse, confirmation of commissioning, condition of the warehouse;

– consignment notes;

It consists of the following main functional blocks:

– work with orders of suppliers and clients;

– work with contractors (target, dashing, management - blocking, limits, etc.);

– work with goods (calculation, tariffs, discounts, statistical groups, replacements).

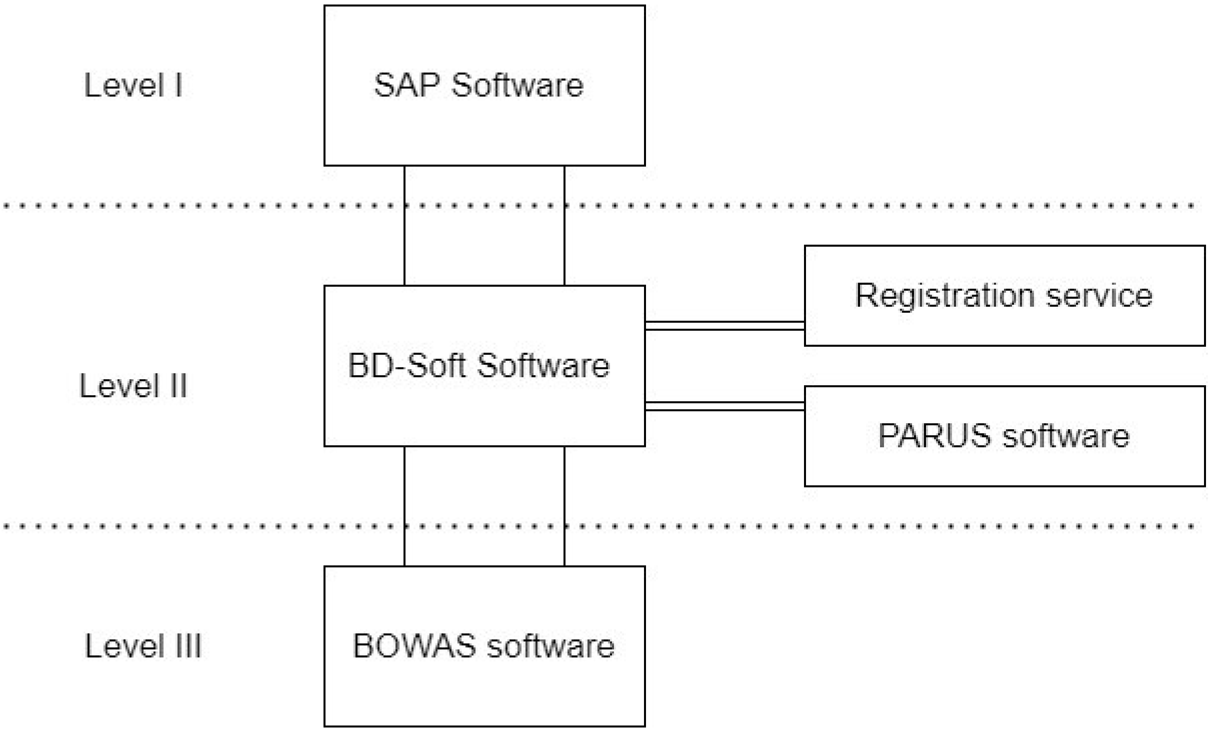


Fig. 1.4. The orientation scheme of the BD-Soft program

The supplier transfers a consignment of goods to its warehouse in Ukraine (consignment), accompanied by a transit invoice (TINV). Import of the electronic version of the transit invoice leads to the appearance in the section "Supplier orders" of the document with the status KIT - goods in transit. Posting of goods to the warehouse by the operator is accompanied by the generation of confirmations, the import of which in BD-Soft causes the transformation of KIT into KLS - a profitable invoice and the formation of a report on arrival of goods in the warehouse for the

supplier (BR). The sales order is made in the section "Sales orders" by creating a document with the status of JSC. After confirmation
the customer's order and in the presence of the corresponding positive balance or the issued commodity credit for the amount of the order in BD-Soft the order on the warehouse on commissioning (LR-) is formed is exported to a file and transferred to a warehouse for processing. After processing the order, the operator generates a file-report indicating the numbers of orders, their nomenclature and numbers of profitable invoices from which the goods are written off (LSB). The import of the report file in BD-Soft leads to the write-off of the goods from the profitable invoices and the generation of report files to the supplier on the nomenclature withdrawn from the warehouse and the corresponding invoice numbers from which the write-off was made. The received reports are transformed by the supplier into invoices (* .iif) are exposed to payment of Robert Bosch Ltd. The received invoices are the basis for import operations. After the customs clearance, the expendable consignment note is printed.

The process described above is an approximate description of the subject, a conscious simplification for better understanding. In addition to the above, there are also special mechanisms for moving goods between warehouses, returns, exchange rate adjustments, reporting, etc.

### 1.4.2. Algorithm for ordering goods and its delivery process to Ukraine

In order to understand the whole life cycle of goods entering the territory of Ukraine, we will describe how the process takes place in general.

It all starts with the ordering process, the moment when Ukraine decided to order a certain product from the head office in Germany. The logistician will place an order, send a request and receive an invoice in format, which contains information about specific products, their quantity and price. After receiving this file, enter the invoice into the system, start processing data, then check the completeness of the file, if the file is incomplete, you need to re-apply to the main office in Germany, if the file is complete, its processing begins. After entering all the necessary data, a request is made to the registration service to obtain a code, which is sent to the driver of the car to safely cross the border with the assigned number. Upon arrival of the car in a warehouse unloading of the goods, and its decomposition on places begins. The algorithm of the order of the goods is presented in fig. 1.5.).

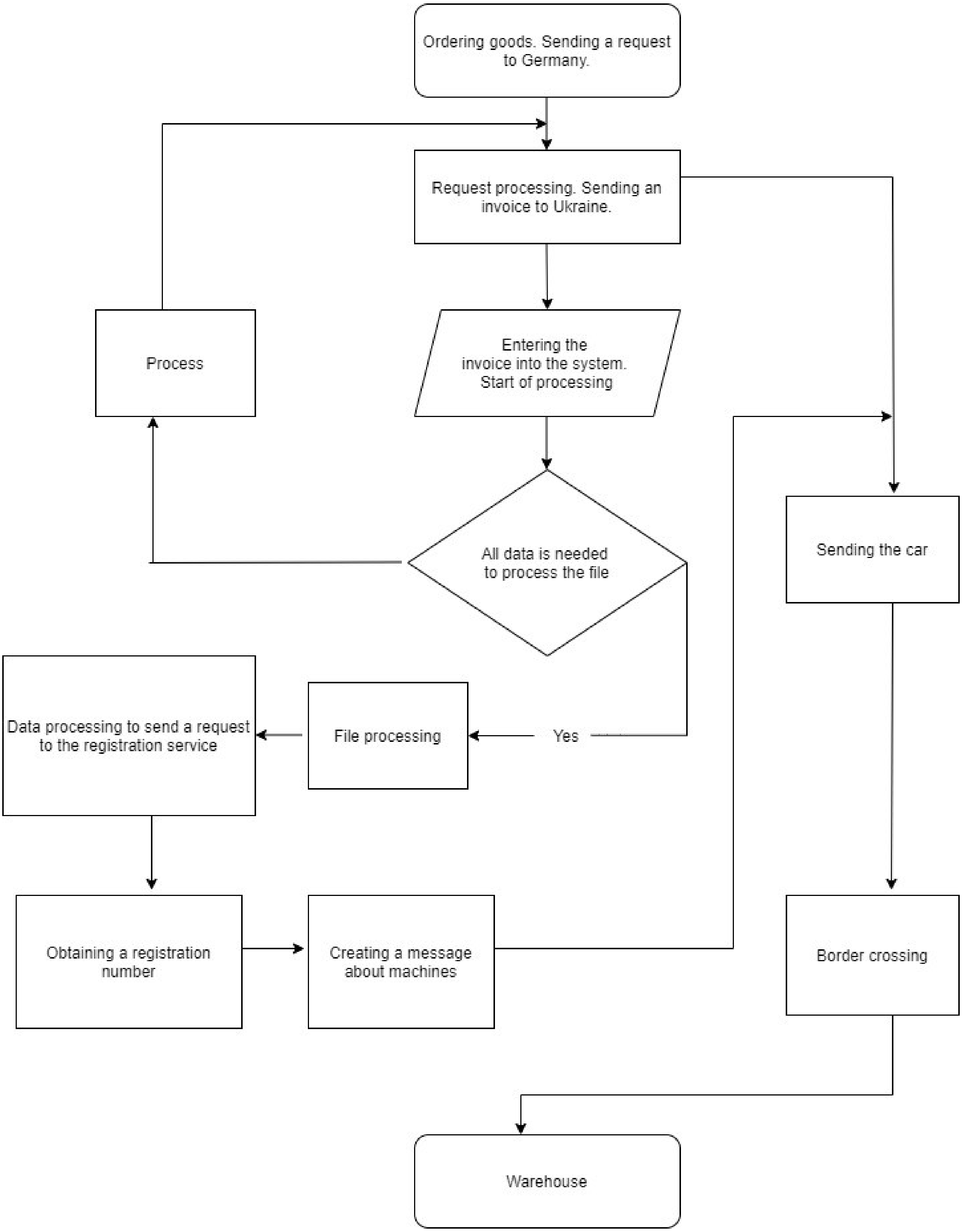

Fig. 1.5 Block diagram of the algorithm for automating the order of goods from the head office from Germany to Ukraine.

To increase the efficiency of the level of delivery of goods to the customer, we will form additional tasks to automate the process of ordering goods. First, the operator generates an order in the tab "Order of goods", it sends it manually via data channels. The reverse party receives the file and begins to process the received data, and forms the invoice which contains the necessary information on goods. This file is registered in the Bosch database and sent to the service. The registration service sends the code, which must be entered into the program manually and only after receiving the code, you must inform the driver (Fig. 1.6.).

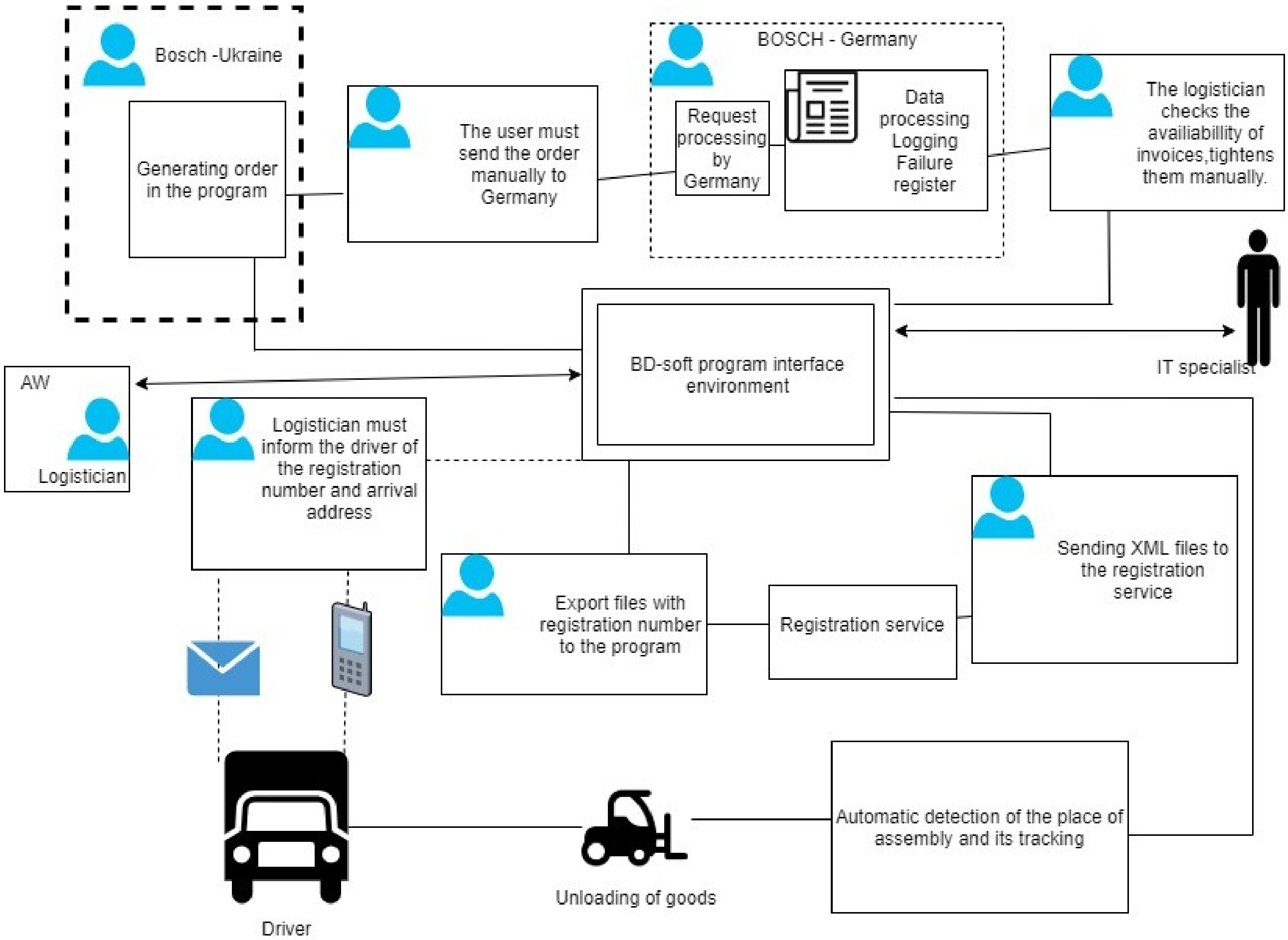


Fig. 1.6. Functional diagram of automation of the ordering process at the computer-technical level

After crossing the border, the car goes to a certain place of unloading. To increase the speed of unloading of goods, it is necessary to develop an automatic system that would allow to quickly determine the place of storage of goods. Control over the location of the product will give the whole mechanism more flexibility, because the customer always wants to know where his product is. Also, this information will allow the Bosch representative to optimally plan the actions of the purchase and sale process.

Thus, the analysis of the company's transport system by Robert Bosch showed that reducing the time of ordering and arrival of goods at the regional office in Ukraine, it is necessary to improve the structural and functional scheme by developing additional automation algorithms and implement them as a software product.

**Conclusions:** In this section of the thesis was a comparative analysis of the principles and equipment of automation of the transport company, considered general information about the principles of construction and types of computer networks, as well as the algorithm for ordering goods and the process of delivery to Ukraine by Bosch. Deficiencies were identified and solutions were proposed to improve the ordering process, as well as to introduce an algorithm that will significantly speed up the process of forming a registration number for customs control and an algorithm for automatic selection of the place of storage of goods.

# *2. ANALYTICAL PART*

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| Air Transportation Management Department | | | | NAU 20.09.57. 200 EN | | | | | | |
| Done by: | Petruk.A.V. | | | ANALYTICAL PART | Letter | | | *Sheet* | Sheets |
| Supervisor | Shevchuk D.O. | | | | | | D | 35 | 21 |
| Standards Inspector | Shevchenko Yu.V. | | | | FTML 275 ОП-202Ма | | | | |
| Head of the Department | Shevchuk D.O. | | | | | | | | |

# DEVELOPMENT OF THE METHOD OF AUTOMATED RESOURCE MANAGEMENT AT THE ENTERPRISE OF TRANSPORT PROFILE

## 2.1. Comparative analysis of decision-making methods

Under the theory of decision making is the study of operations in complex systems. Thus, decision theory is a set of mathematical methods and models designed to justify decisions made at the stages of analysis, development and operation of complex systems of different nature: organizational and economic, production, technical, information and others.

The most significant areas of decision theory are:

– decision making in terms of certainty - mathematical programming (linear, nonlinear, dynamic);

– decision making in conditions of uncertainty - stochastic programming, game theory and statistical decisions;

– making multi-purpose decisions;

– Markov processes in decision making.

Mathematical programming is one of the main tools for the study of operations - a science that optimizes the structure and functioning of large organizational and management systems, regardless of their social purpose. The content of mathematical programming consists of the theory and methods of solving problems on finding the extrema of a function on sets, which are determined by linear and nonlinear constraints (equalities and inequalities).

Decision theory includes all stages of the study of complex systems, from identifying the purpose of the system and the purpose of the study and ending with the establishment of working procedures to bring the system to a state of optimal functioning. Every large system works to achieve a certain goal. In the bottom diploma as the purpose the finding of the optimum decision of a so-called "transport problem", i.e. reduction of time of delivery of the goods at the expense of additional automation of this process acts.

So, at the transport enterprise in our case there are quantitative characteristics for example loading capacity of motor transport, a way between the supplier and the customer of the goods and other, we will mark them $c_k = (k = 1, 2, ..., l)$ are immutable, constant. These are the so-called task parameters or constant factors. Others have the character of variables, independent and dependent, deterministic or random.

Independent variables are divided into two groups:

$x_j = (j = 1, 2, ..., n)$ - endogenous variables (controlled variables or dependent factors), the values of which can be changed in some interval (for example: time of order processing, time of formation of the necessary documentation, etc.);

$\alpha_i (i = 1, 2, ..., n)$ - exogenous variables (uncontrolled variables), the value of which does not depend on the will of people and is determined by a set of external conditions or system parameters; they can be considered as variable parameters of the task (for example: disconnection, breakdown of motor transport, etc.).

Under these conditions, as a rule, it is possible to establish a functional relationship between the value of z, which measures the degree of achievement of the goal of the transport system, and independent variables and parameters of the system.

$$z = f(c_k, \alpha_i, x_j) \quad (2.1)$$

This function is called the objective function, or efficiency function, or optimizing form, because its value is a measure of the efficiency of the system to achieve a certain goal.

The task is to find the following values of controlled variables $x_j$, which would provide efficiency functions of extreme value (maximum or minimum), i.e.:

$$z^{*} = \max_{x_i} (c_k, a_i, x_j) \text{ or } z^{*} = \min_{x_i} (c_k, a_i, x_j) \quad (2.2)$$

where: $z^*$ - maximum or minimum value of the functional.

However, in practice, the ability to choose the values of controlled variables is almost always limited. These limitations depend primarily on the external conditions of the system, as well as on the parameters of the system itself. All these limitations can ideally also be described by a system of mathematical equations and inequalities:

$$g_r(c_k, \alpha_i, x_j) \leq=\geq 0, \quad (r = 1, 2, ..., m) \tag{2.2}$$

System (2.2) is called a system of constraints, or a system of conditions of the problem.

Any set of variables $(i = 1, 2, ..., n)$ that satisfies the system of constraints (2.2) is called an admissible solution or an admissible plan of a mathematical programming problem. Obviously, each such plan determines a certain way, strategy, program of actions for its implementation, a certain decision regarding the operation of the system.

The set of all solutions of system (2.2), i.e. the set of admissible plans, forms the area of admissible values, or the area of definition of the problem of mathematical programming.

The problem of optimization of the objective function (2.1) under conditions (2.2) superimposed on independent variables, and is a general problem of mathematical programming. This problem is the object of mathematical programming, and finding the optimum of the objective function - its purpose. Thus, the general problem of mathematical programming is the problem of finding the conditional extremum of the objective function (2.1) under conditions (2.2).

A valid plan that gives the objective function an optimal value is called optimal. The optimal plan is the solution of the problem of mathematical programming (2.1) - (2.2).

Under the decision-making in the studied operations understand a complex process in which we can distinguish the following four stages:

**1st stage.** Building a qualitative model of the problem under consideration, ie identifying the factors that are most important and establishing the patterns to which they are subject.

**2nd stage.** Construction of a mathematical model of the problem under consideration, i.e. recording in mathematical terms of a qualitative model. Thus, a mathematical model is an abstraction of a real phenomenon written in mathematical symbols, so constructed that its analysis makes it possible to penetrate into the essence of the phenomenon.

This stage includes the construction of the objective function (2.1) and the system of constraints (2.2).

As a result of these two stages the corresponding mathematical problem is formed.

**3rd stage.** Investigation of the influence of variables on the value of the objective function.

This stage involves the possession of a mathematical apparatus for solving mathematical problems that arise in the second stage of the decision-making process. The theory and methods of solving these problems are the content of mathematical programming.

**4th stage.** Comparison of the results of calculations obtained in the 3rd stage with the object that was modeled, i.e. expert verification of the results (criterion of practice).

Thus, at this stage the degree of adequacy of the model and the object is established within the accuracy of the source information.

2.1.1. Linear programming method.

Linear Programming or Linear Programming (LP) is a method of achieving the best yield (such as the highest profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships. Linear programming is a special case of mathematical programming (mathematical optimization).

The standard form of linear programming is attached as follows:

$$\begin{aligned}
&z = c_1x_1 + c_2x_2 + \ldots + c_nx_n \to \text{opt} : \max/\min,\\
&a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n = b_1,\\
&a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n = b_2,\\
&\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\\
&a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n = b_m,\\
&x_j \ge 0 \; (j = 1, 2, \ldots, n).
\end{aligned} \tag{2.3}$$

Or in a short note:

$$z = \sum_{j=1}^{n} c_j x_j \rightarrow \text{opt} : \max / \min,$$

$$\sum_{j=1}^{n} a_{ij} x_j = b_j \quad (i = 1, 2, ..., m). \qquad (2.4)$$

More formally, linear programming is a technique for optimizing a linear objective function that is bounded by linear equations and linear inequalities. The linear programming algorithm finds the point where this function z acquires the largest or smallest value if such a point exists.

### 2.1.2. Dynamic programming

Dynamic programming is a special method of decision optimization, specially adapted to the so-called "multi-step" (or "multi-stage") operations. Dynamic programming provides a very effective method of sequential decision-making on optimizing the system by solving one-step problems. Then they talk about a multi-step process of decision-making or problem solving. Unlike linear programming, in which the simplex method is a universal method of solving, in dynamic programming such a universal method does not exist. One of the main methods of dynamic programming is the method of recurrent relations, which is based on the use of the principle of optimality, which was developed by the American mathematician R. Bellman.

Thus, dynamic programming determines the optimal solution of the problem by decomposing it into stages, each of which is a one-step subtask.

Suppose that the efficiency of the entire operation of delivery of goods to the customer consists of performance indicators of individual steps:

$$Z = \sum_{i=1}^{n} z_i, \qquad (2.5)$$

where $z_i$ - efficiency indicator of the i-th step.

If Z has such a property, then it is called an additive objective function.

The set of all step-by-step controls is the management of the delivery of goods to the customer as a whole. Denote it by the letter x, step controls - letters $x_1, x_2, ..., x_m$ then:

$$x = (x_1, x_2, ..., x_m).$$

It is necessary to find the following control x, in which Z rotates to the maximum:

$$Z = \sum_{i=1}^{n} z_i \to \max.$$

The control x * at which this maximum is reached is called optimal control. It consists of a set of optimal step controls:

$$x^* = (x_1^*, x_2^*, ..., x_m^*)$$

The maximum that is achieved with this control is denoted by Z *:

$$Z^* = \max\{Z(x)\}.$$

### 2.1.3. Stochastic programming method

Stochastic programming is a set of planning methods for solving optimization problems, taking into account the possible (stochastic) processes. Thus under possible (stochastic) or casual processes understand processes of change in time of a condition of any element of system according to probable laws.

Such tasks include problems of optimal distribution
resources, transport task, inventory management task, etc. When solving problems in stochastic formulation usually use two approaches.

The first approach, as simpler, is to find the average value of all these random parameters and is reduced to the tasks of the corresponding previously discussed linear programming. This allows you to greatly simplify the task and in most cases get a plan that can be considered optimal with sufficient probability. We write the problem of this type in the following form:

$$z = f(\vec{X}, \vec{\Theta}) \to \text{opt} \tag{2.6}$$

under the conditions

$g(\vec{X},\vec{\Theta}) \leq 0, i = 1, 2, \ldots, m,$ (2.7)

where $\vec{X}$ - vector of unknown (controlled) variables;

$\vec{\Theta}$ - vector of random parameters.

Obviously, with an arbitrary plan $\vec{X}'$ (including the optimal) value of z will be random, and since random parameters are included in the system of constraints, the boundaries of the set of plans will also be indeterminate. Thus, the very concept of the optimal plan for a stochastic problem is ambiguous and needs some specification. One of the common concretizations of the concept of the optimal plan is its definition as the optimal plan of the problem obtained from (2.6), (2.7) by replacing random variables. $f(\vec{X},\vec{\Theta})$ and $g(\vec{X},\vec{\Theta})$, their mathematical expectations, i.e.:

$$z = Mf(\vec{X},\vec{\Theta}) \rightarrow \text{opt}; \quad (2.8)$$

$$Mg(\vec{X},\vec{\Theta}) \leq 0, \quad i = 1, 2, ..., m. \quad (2.9)$$

However, if the variance $Dg(\vec{X},\vec{\Theta})$, large, then with the optimal plan of the problem (2.8), (2.9) the real value of z may accidentally be too far from the optimal value of z * or may lead to complications (even absence) of the desired solution of the problem. Therefore, this approach, of course, may not always be effective.

The essence of the second approach is a multi-stage, step-by-step approach to the desired result. For example, at the first stage, a preliminary optimal plan is established when solving a deterministic problem based on maximizing or minimizing the objective function. Then at the second stage this plan is adjusted according to actually established statistical indicators and parameters.

### 2.1.4. Methods of nonlinear programming

The task of finding the optimal plan for delivery of goods to the customer, based on the assumptions about the linearity of the relationship between the cost of delivery of goods and the volume of delivered goods, is considered in detail in the sections devoted to linear programming. If such connections are nonlinear, then it is expedient to formulate more adequate mathematical models in terms of nonlinear programming.

The mathematical model of the nonlinear programming problem in general is formulated as follows to find the vector $\vec{X}=(x_1,x_2,...,x_n)$ which satisfies the system of restrictions:

$$\begin{aligned} &g_i(x_1,x_2,...,x_n)=b_i,\ i=1,2,...,m_1,\\ &g_i(x_1,x_2,...,x_n)\geq b_i,\ i=m_1+1,m_2+2,...,m_2,\\ &g_i(x_1,x_2,...,x_n)\leq b_i,\ i=m_2+1,m_2+2,...,m, \end{aligned} \tag{2.10}$$

and at which the extremum (largest or smallest value) reaches the objective function

$$z=f(x_1,x_2,...,x_n)\rightarrow \text{extr}, \tag{2.11}$$

where $x_j$ - variables, $j=1,2,...,n$;

$f$, $g_i$ - given functions from n variables;

$b_i$ - fixed values.

Depending on the type of objective function and the system of constraints, special methods of solving are developed, which include methods of Lagrange multipliers, gradient methods, convex and quadratic programming, approximate methods, graphical method.

Of the nonlinear programming, the most developed problems are those in which the system of constraints is linear and the objective function is nonlinear. However, even for such problems, the optimal solution can be found for a certain class of objective functions. It should be noted that in contrast to linear programming problems, where the extremum points are the vertices of the solution polyhedron, in problems with nonlinear objective function the extremum points can be inside the polyhedron, on its edge or at the vertex.

When solving nonlinear programming problems for the objective function, it is necessary to determine the global maximum or global minimum. The presence of local extrema complicates the solution of problems, as most existing methods of nonlinear programming do not allow to determine whether the extremum found is local or global. Therefore, it is possible to take the local extremum as the optimal solution, which can differ significantly from the global one.

### 2.1.5. Game theory and decision making

In practice, we often have to deal with problems in which it is necessary to make decisions in conditions of uncertainty, when the parameters on which the success of the operation depends are unknown, and there is no data to judge which values are greater and which are less likely.

Therefore, the optimality of the chosen solution depends on the quality of the data used in the described situation in which the decision is made. From this point of view, the decision-making process can belong to one of three possible conditions:

1. Decision-making under conditions of certainty, when the data are known accurately.
2. Decision-making in conditions of risk (stochastic uncertainty), when the data can be described using probability distributions.
3. Decision-making in conditions of uncertainty, when the data can not be attributed to the relative weights that reflect their degree of significance in the decision-making process.

In fact, under conditions of certainty, the data are reliably defined, under conditions of uncertainty, they are not defined. This does not mean that under uncertainty there is no information about the task at all. The point is that these problems are difficult or impossible to classify according to the degree of their significance for decision-making and that for these data, which are considered as implementations of random variables or processes, the distribution function or other statistical characteristics are unknown or cannot be determined. Therefore, decision-making in conditions of risk is an intermediate case.

In game theory, there are several basic criteria that are used in choosing the optimal decision-making strategy: Wald's test, Hurwitz test, Savage test, Laplace test, Bayesian test and others.

Therefore, analyzing the advantages and disadvantages of the considered methods of optimal decision making, we can conclude that to solve this goal in the thesis there is a method of linear programming. Because the considered problem has a linear dependence of parameters and it is easy to implement it in practice.

## 2.2. Statement of the transport problem and features of its structure

Consider the formulation of a transport problem and finding its solution using the method of linear programming. The mathematical structure of this problem is characteristic of a large class of linear programming problems, called distribution.

The transport problem will mean the name of the classic transport problem, which deals with the most economically rational ways of transporting a certain homogeneous product from producer to consumer. The term "homogeneous product" means a product or product that has the same quality and purpose. For example, it can be a question of transportation of tools to consumers, or auto parts, etc.

It should be noted that the actual transport tasks in their content
are divided into several groups. As a rule, the criterion of division is the criterion of optimality of the objective function of the problem, namely: problems to minimize the cost of transportation, problems to minimize the time of transportation, problems to minimize the length of routes, and so on.

We present a transport problem to minimize the total cost of transportation. Suppose there are m starting points $A_1, A_2, ..., A_m$ (suppliers) in which stocks of some homogeneous cargo in quantity accordingly are concentrated $a_1, a_2, ..., a_m$ units. There are n destinations $B_1, B_2, ..., B_n$ (consumers) who place orders accordingly on $b_1, b_2, ..., b_n$ units of cargo.

*Table 2.1*

**Known transport costs per unit of cargo**

| Departure points | Consumption points | | | | | Stocks |
|---|---|---|---|---|---|---|
| | $B_1$ | … | $B_j$ | … | $B_n$ | |
| $A_1$ | $c_{11}$ | … | $c_{ij}$ | … | $c_{1n}$ | $a_1$ |
| … | … | … | … | … | … | … |
| $A_1$ | $c_{i1}$ | … | $c_{ij}$ | … | $c_{in}$ | $a_i$ |
| … | … | … | … | … | … | … |
| $A_m$ | $c_{m1}$ | … | $c_{mj}$ | … | $c_{mn}$ | $a_m$ |
| … | $b_1$ | … | $b_j$ | … | $b_n$ | … |

Known values $c_{ij}$ transportation of a unit of cargo from each point of departure $A_i$, $i=1,2,...,m$ to each destination $B_j$, $j=1,2,...,n$, which are given in table. 2.1.

All numbers $c_{ij}$ form a matrix, which is called the matrix of transportation costs $(c_{ij})_{m\times n}$:

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ c_{i1} & \cdots & c_{ij} & \cdots & c_{in} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ c_{m1} & \cdots & c_{mj} & \cdots & c_{mn} \end{pmatrix}$$

It is believed that the cost of transporting several units of cargo is proportional to their number.

It is necessary to make such plan of transportations (from where, where and how many units to carry) that all orders were as much as possible fulfilled (full execution is possible only at total quantity of stocks more or equal to total number of orders), and the general cost of all transportations was minimum.

Let's mark $x_{ij}$ - the number of units of cargo sent from the i-th point of departure $A_i$ to the j-th destination $B_j$. Integral variables $x_{ij}$ can also be written as a matrix

$$\begin{pmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{pmatrix},$$

which is called the transport matrix $(x_{ij})_{m\times n}$.

Sizes $x_{ij}$, which are to be determined, are called transportation; $\vec{a} = (a_1, a_2, ..., a_m)$ - stock vector; $\vec{b} = (b_1, b_2, ..., b_n)$ - vector of needs.

Depending on the ratio between the stocks of cargo and the total needs in it, transport tasks can be closed and open.

If

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j ,$$

then the task is called a closed or transport task with the correct balance. If

$$\sum_{i=1}^{m} a_i \neq \sum_{j=1}^{n} b_j ,$$

then an open or transport task with the wrong balance.

The thesis considers a closed transport problem, i.e. the total amount of cargo sent from each point of departure to all destinations must be equal to the stock of cargo at this point. This will give m conditions-equations:

$$x_{11} + x_{12} + \ldots + x_{1n} = a_1 ,$$

$$x_{21} + x_{22} + \ldots + x_{2n} = a_2 ,$$

$$\ldots\ldots\ldots\ldots\ldots\ldots ,$$

$$x_{m1} + x_{m2} + \ldots + x_{mn} = a_m .$$

The total cost of all transportation must be minimal:

$$z = c_{11}x_{11} + c_{12}x_{12} + \ldots + c_{1n}x_{1n} + \ldots + c_{mn}x_{mn} \rightarrow \min .$$

Thus, the mathematical model of a closed transport problem can be briefly written in the form

$$z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \rightarrow \min ,$$

with restrictions:

$$\sum_{j=1}^{n} x_{ij} = a_i ,$$

$$\sum_{i=1}^{m} x_{ij} = b_j ,$$

$$x_{ij} \geq 0 , \ (i = 1,2,\ldots,m; \ j = 1,2,\ldots,n).$$

### 2.3. Transport task by time criterion

The problem according to the criterion of time arises when optimizing the time of delivery of goods to the customer. As in a normal transport problem, there are m suppliers with stocks $a_1, a_2, ..., a_m$ and n consumers to whom the goods are to be delivered in bulk $b_1, b_2, ..., b_n$. Known time intervals $t_{ij}$ ($i = 1, 2, ..., m$ ; $j = 1, 2, ..., n$), for which the cargo is delivered from each i-th supplier to each j-th consumer. It is necessary to make such plan of transportations of freight at which stocks of all suppliers are taken out completely, demand of all consumers is satisfied completely and the greatest time of delivery of all freights is minimum.

Let's make a mathematical model of this problem. Let's mark $x_{ij}$ - the volume of cargo transported from the i-th supplier to the j-th consumer.

Let $X = (x_{ij})$ ($i = 1, 2, ..., m$ ; $j = 1, 2, ..., n$) - some basic solution of the problem. We write down the objective function of the problem. Denote by $T(X)$ the largest value of the elements of the matrix $T(X) = (t_{ij})$ that correspond to the base cells of the table: $T(X) = \max(t_{ij})$. So, in an hour $T(X)$ the transportation plan will be fulfilled in full.

The mathematical model of the transport problem by the criterion of time has the following form:

$$T(X) = \max(t_{ij}) \to \min,$$

$$\sum_{j=1}^{n} x_{ij} = a_i,$$

$$\sum_{i=1}^{m} x_{ij} = b_j,$$

$$x_{ij} \geq 0,$$

$$i = 1, 2, \ldots, m; \; j = 1, 2, \ldots, n.$$

The problem is solved in the following order. There is an initial reference solution $X_1$. The value of the objective function is determined $T(X_1) = \max(t_{ij}) = t_{l_1 k_1}$. All free cells to which the value corresponds $t_{ij} > X_1$, are excluded from consideration (crossed out) (Table 2.1). It is impractical to occupy these cells, as the value of the objective function will increase. To reduce its value, you must release the cell $A_{lj}B_{kj}$ , In which $t_{ij}$ reaches a maximum.

To do this, build the so-called unloading cycles, which may include several free cells. In each unloading cycle, starting with the unloading cell $A_{lj}B_{kj}$, the signs “-” and “+” are placed and the value is shifted $\Theta = \min_{-}(x_{ij})$.

If this cell can be unloaded, it is excluded from consideration (crossed out). A new reference solution is obtained $X_2$ , on which the value of the objective function is less than on $X_1$. Then again try to unload the cell that responds $T(X_2) = \max(t_{ij}) = t_{l_2 k_2}$.

The process continues as long as the possibility of unloading the corresponding cell still exists.

## 2.4. Organization of placement of goods in the warehouse

Warehousing and processing of goods are important components of logistics. The costs of their implementation absorb from 12 to 40% of the company's logistics costs.

Modern large warehouse is a complex technical structure, which consists of numerous interconnected elements, has a certain structure and performs a number of functions for the conversion of material flows, as well as the accumulation, processing and distribution of goods among consumers.

The transformation of material flows in the warehouse is associated with a change in the parameters of received and issued consignments (by size, composition, physical characteristics of incoming cargo, time of departure of transport consignments, etc.). Existing warehousing systems differ in size and complexity, types of stored products, costs associated with their work, the nature of the random processes occurring in them and the nature of the information received by decision makers.

Product movement management in the warehouse consists of a number
performed logistics functions, such as: acceptance of goods from carriers; acceptance of goods for storage: preparation of goods for storage; warehousing of goods: storage of goods; preparation of goods for vacation; preparation of goods for transportation; release of goods to consumers; service services; accounting for the movement of goods. Each function includes certain procedures, and a separate procedure includes the corresponding logistics operations. With end-to-end material flow management in the warehouse, IT provides invaluable assistance, as it allows you to track all processes in the warehouse in real time. A function such as "Accounting for the movement of goods" is greatly simplified. This function includes procedures: operational accounting and analytical accounting.

The procedure of "operational accounting" in modern information warehousing systems involves accounting for the receipt of products in the warehouse, the movement of products within the warehouse, the release of products to consumers. Due to the operation of the information system in the warehouse, which includes software and hardware, it becomes possible to determine the presence or absence of goods in the warehouse for individual items at any time. This task is greatly facilitated by the use of product identification technologies: bar coding and radio frequency identification (RFID).

The procedure of "analytical accounting" is to create an information base on the movement of products in the warehouse for quite long planning periods and in the constant replenishment of this database with quantitative indicators in subsequent periods.

The basis of modern high-tech warehouse is an automated warehouse management system. The generalized (typical) process of warehousing with the information component (database, product identification, document flow) is presented in the figure.

The technology of placement and accounting of goods with the use of specialized software and hardware has the following order. Each storage location in the warehouse has a label with a barcode containing three coordinates: row number, cell number and tier. When accepting cargo, the system reserves storage space for newly arrived pallets and produces a label for newly arrived cargo. The pallet number, product name, quantity, expiration date and batch number are applied to the label.

The driver of the stacker reads the barcode on the label with a scanner and receives the address of the cargo placement on the rack at his terminal. Approaching the specified place, the warehouse worker places the cargo in the cell and scans the control code of the storage place. If the load is not placed correctly, the system blocks further operations until the load is placed correctly.

At delivery of cargo the driver of the stacker moves to the cargo specified on its radio terminal, removes a package from a rack and scans a bar code. If the load is selected correctly, the system gives the area of the warehouse to which the load should be moved.

Technical capabilities of the warehouse information system allow you to produce in the warehouse commissioning. that is, a selection of individual items from different pallets to fulfill customer orders.

Based on the above, we can conclude that the operation of large warehouses (especially class A and A +) is impossible without the use of information technology.

Used software allows not only to provide operational accounting of goods, but also to analyze the dynamics of sales to forecast turnover and capacity utilization.

We will describe the process of how the product will be tracked in our program. First there is a need - you need to know where the product is, the program is accessed, enter the product request into the system knowing its number, the run in the system begins on the specified parameters, the program analyzes the request gets the result and displays it on the interface (Fig. 2.1).

A necessary prerequisite for optimal storage of goods is the development of a certain system of their placement by varieties, sizes, places of storage, taking into account the frequency of demand and turnover of inventories. A clear order of placement of goods makes it possible to quickly find the necessary goods when selling them to wholesale buyers, as well as the necessary place to place a new batch of goods. It facilitates accounting, promotes the introduction of automation of warehouse management, facilitates warehousing.

The first stage in the development of the system of placement of goods is the grouping of goods by assortment and homogeneity of storage regimes. This involves the distribution of the entire commodity mass on the basis of mass and dimensions, the time of their sending to the customer.

When placing goods in the warehouse, the following requirements must be met:

– make maximum use of the area and capacity of the warehouse, the carrying capacity of equipment for storage of goods;

– most efficiently place and use storage equipment for the convenience of reloading, updating and checking goods that
stored;

– use the means of automation and mechanization to perform loading and unloading and transport and warehousing.

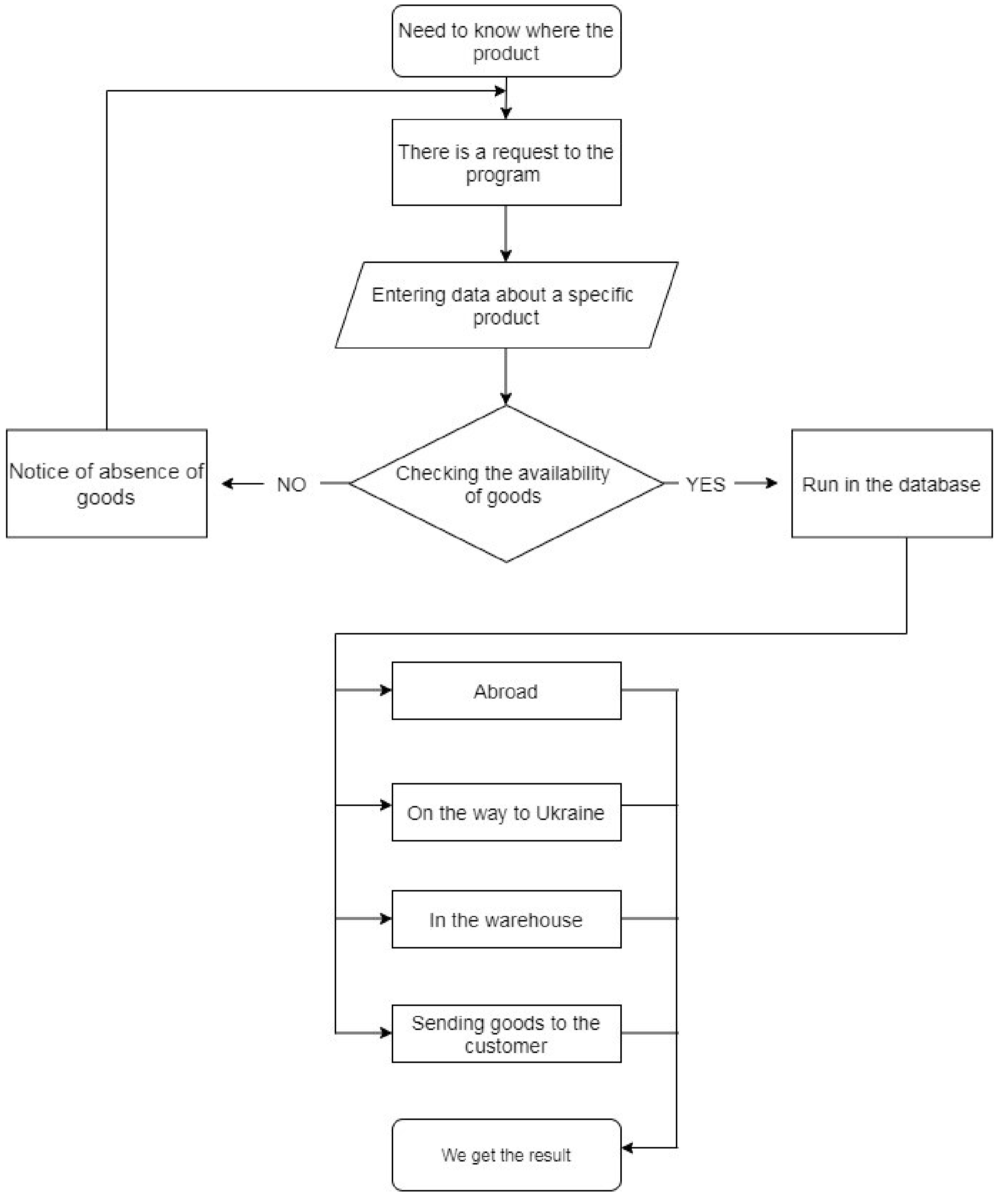


Fig. 2.1. Block diagram of the algorithm of the automated process of product tracking

In order to speed up the placement of goods on arrival and selection when picking and releasing the storage of goods in warehouses are coded (indexed), and for greater clarity, decisions are made in the form of schemes for placement of goods (in high-altitude warehouses - map plans). During their development, the specialization of storage sites should be taken into account and the maximum use of storage areas and capacities, as well as the possibility of mechanization of loading and unloading and warehousing operations should be ensured. Indexation of storage places is reflected in the cards of quantitative accounting and directly on the warehouse equipment. As a rule, a table with the number of the rack and the indication of the goods is attached to each rack from the side of the central passage.

The architecture of the automated information system of warehouse management is built on a three-level principle. The first component is a visible part for the user - a human-machine interface - a "client program" through which the user enters, modifies and deletes data, makes requests for operations and requests for data sampling (receiving reports); this component can be available on a computer, TSD, tablet, smartphone. The second component (part of the system hidden from users) is a database server that stores data. The user through the client program initiates the procedure of requesting to select, enter, change or delete data in the database (DB). The third component - business logic ("tasks" or "processes" - specialized processing programs) performs user-initiated data processing,

The territory of the warehouse is divided into zones by types of technological operations in order to automate procedures: reception, placement, storage, processing and shipment of goods, which allows you to streamline the work of staff in different areas and effectively distribute areas of responsibility.

At the stage of implementation, a description of the physical characteristics of the warehouse, trucks, parameters of all used equipment and rules of work with it is entered into the system.

All loads marked with barcodes. Carrying out technological warehousing operations under the control of the system is carried out on the basis of data of bar codes, a place of storage and cargo equipment. Loading and unloading works and warehouse workers are equipped with radio I / O data terminals, which are a portable computer that communicates with the main server of the system via radio. The system can use any of the existing types of codes or print labels with an internal barcode.

When conducting an inventory, experts use barcode terminals to read barcodes, which are automatically entered into the database of devices.

The system takes into account all the requirements for storage conditions when allocating storage space for entrants to the warehouse. For example, humidity, temperature, expiration dates, manufacturers, lead times, suppliers, compatibility rules and any other parameters can be taken into account. The warehouse management system automatically selects storage locations for received goods and creates tasks for warehouse workers. Tasks come to the screen of radio terminals in the form of basic step-by-step commands individually for each employee.

When forming teams, the system develops optimal routes for moving equipment on the territory of the warehouse complex, which allows to reduce the idle mileage of loading vehicles. To perform operations, the system assigns the truck, the use of which most fully meets the task. Tasks are confirmed by scanning the barcode. Thus, the system controls all the actions of the employee and allows you to almost completely eliminate the possibility of misplacement
cargo or incorrect completion of the order. The system instantly updates all information about the location of goods, the availability of goods in the warehouse, the actions of employees and operations. For convenience, it is possible to control the composition in the mode of two-dimensional graphical display. Based on the results of work or the state of the warehouse, the system allows you to generate reports that can be both printed and transmitted to the corporate system of the company.

Work in warehouses in production, distribution and distribution centers, for example, as automotive spare parts has a number of features that allow you to distinguish a warehouse management system of this type as an industry solution.

This type of warehouses is characterized by a wide variety of assortment, groups and subgroups of auto parts: repair kits, tools, equipment for service stations, the entire range of auto parts for cars, trucks and specials. appliances, tires, batteries, oils, paints, antifreeze, etc.

A wide range of auto parts requires special storage conditions for each subgroup of goods. Minor deviations from storage conditions can lead to a decrease in their quality and the impossibility of further delivery to the consumer.

In the thesis it is proposed to perform the placement of goods taking into account their parameters at 3 levels.

At the first level there is an analysis of goods into 3 types - auto parts, power tools, thermotechnics; at the second level the analysis of type of the goods is carried out; at the third level there is an analysis of the product on the basis of mass and dimensions. Taking into account the above parameters, a number is generated, which corresponds to the number of the shelf in the warehouse. This document automatically enters the database of the warehouse workstation (Fig. 2.2.).

Fig. 2.2. Block diagram of the algorithm for automatic determination of the place of goods in the warehouse

The Bosch warehouse uses the following automated process of placing goods in the warehouse, which allows:

– active warehouse management;

– increasing the speed of typing goods;

– obtaining accurate information about the location of the goods in the warehouse;

– effective management of goods that have a limited service life;

– obtaining a tool to increase the efficiency and development of processes for processing goods in the warehouse;

– optimization of the use of warehouse space.

**Conclusions:** In this section of the thesis a comparative analysis of decision-making methods and the method of linear programming is chosen. A method of automated resource management has been developed, which differs from the existing automation of the processes of forming a registration customs number and placing goods in the warehouse of Robert Bosch, which has increased the efficiency of the transport company.

# *3. DESIGN PART*

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# STRUCTURAL AND FUNCTIONAL SCHEMES OF THE ADVANCED SYSTEM OF AUTOMATION OF TRANSPORT OF THE ROBERT BOSCH ENTERPRISE

## 3.1. The structure of the decision support system for transport logistics

The result of solving any problem is of practical interest only if, firstly, it is based on sufficient quality information that provides a correct assessment of the state of the environment in which the system operates, and the state of the system itself, and secondly, obtained on the basis of adequate mathematical models using appropriate mathematical methods.

A typical modern trade and production complex has a complex, branched structure, which contains a set of information and materially related and interacting elements and works as follows.

In stores and other points of sale of the product of the production complex is retail and retail trade for cash, while, given the lack of storage space of large volumes, stocks of goods are often replenished (in practice, every day). Branches have their own warehouses, which allows you to store stocks for several days of trade and eliminates the need for daily replenishment. Information on the results of trade in stores and branches is sent to the Central Information System (CIS), where it is stored, processed and analyzed.

The delivery department works with large customers for non-cash and cash payments, provides a flexible system of discounts and the ability to pay in installments or on credit. Orders are accepted during the day and accumulated in the CIS, where they are available to the dispatch program of the organization of deliveries to consumers and the program of orders for control of the level of commodity balances.

The analytical department analyzes the market, solves the problem of estimating and forecasting demand, production planning, order optimization, as well as various marketing research. To do this, the department uses special analytical modules that solve the problem of managing a multi-item stock in conditions of uncertainty, taking into account the limitations.

With a sufficiently large volume of turnover, i.e. with a large number of suppliers and consumers, centralized freight management is implemented in order to improve the quality of service, as well as reduce transport costs by optimizing delivery routes. The solution of these tasks at the enterprise is performed by the control room, which controls the full delivery cycle, starting from the issuance of documents for loading the goods, ending with the receipt of reporting documents from drivers and freight forwarders. In the course of work dispatchers use the special program by means of which they receive access to the orders saved up for day, and on the basis of data on existence of free vehicles (TK), a location of buyers, desirable time of delivery, etc. Carry out the distribution of goods on the vehicle and the appointment of transportation routes.

The management of all this complex multi-element system of information processing and management decisions regarding the tasks of transport logistics should be carried out by a specialized decision support system (DSS). The following features of the following systems should be borne in mind:

1. Operating large amounts of heterogeneous information. In the decision-making process, information is processed, which is characterized by a variety of socio-economic indicators. The source is usually stored in local databases (DB), organized on different platforms or paper. The required data exchange does not ensure efficiency.

2. Procedures for data collection, transmission and processing are not formalized. The existing technology of integrated data preparation is inefficient.

3. Existing methods of solving problems of joint processing of demand data in order to obtain metadata are not effective enough.

4. Existing methods of solving the problem of finding the optimal transportation plan do not use a systematic approach.

Taking into account these features, we can identify the basic principles of creation and implementation of information technology in modern DSS:

- client-server architecture support;

- centralized data storage and processing;
- use of Internet / Intranet-technologies to organize access to corporate data;
- centralized administration of information resources
- protection against unauthorized access;
- the ability to add new or change existing components without changing other functional parts of the system;
- the ability to operate DSS components on different software and hardware platforms without additional development costs;
- ease of use, which is provided through the provision of user work without strict requirements for knowledge in the field of programming and system architecture.

### 3.2. Information technology of DSS software design

In the process of designing and implementing DSS, a number of typical tasks are traditionally solved:

- choice of software development life cycle model; analysis of the subject area of transport logistics system management (STL);

-analysis of a set of options for using the software management system STL and choosing the best; choice of system architecture; detailed design of a software solution corresponding to the designed architecture with a set of software components for the implementation of this solution and the specification of the interfaces of each component;

-reasonable choice of technology for implementing software solutions; implementation of software to support the management of STL.

At the first stage of realization of information technology of decision support of problems of transport logistics the problem of a choice of model of a life cycle of process of software development is solved.

The software development process consists of a set of stages and is determined by the life cycle model of the development process. The set of life cycle processes of the development process is defined in. It includes: requirements analysis and tasks, architectural and detailed design, software implementation and debugging, software integration and testing, software supply to the customer. When choosing a model of the life cycle of the software development process, the following options are considered: waterfall model, spiral model, model of incremental-iterative development.

The waterfall model describes a process in which the individual stages are arranged in a strict sequence: requirements analysis, design, coding, testing and integration. The disadvantages of this approach include low flexibility (it is impossible, in particular, to correctly take into account changes in requirements), low user involvement, poor adaptability to reuse solutions, difficulty in support.

The spiral model is implemented as a repetitive cycle of work on the entire software product. Deciding on the length of each cycle and the choice of life cycle processes at each iteration is controlled, for which cycle iterations include goal setting, evaluation of alternatives, prototyping, and scheduling of the next cycle.

Incremental-iterative model is a set of two processes: iterative and incremental development. Iterative development is implemented as a series of iterations of short temporal length. Each iteration of the process includes: stages of requirements analysis, architectural design and code implementation. The initial iteration usually includes requirements analysis, system architecture development, and implementation of its basic functions. In the future, the time spent working with the requirements and architecture of the system is reduced, while the time spent on the implementation of the final version of the system increases.

In the process of incremental development instead of releasing one final version of the software is the development of individual small increments. Each increment is considered as an intermediate result of the software development process, which expands the functionality of the system. The most common implementation of this approach is the Rational Unified Process (RUP).

This paper uses an incremental-iterative version of software development, the advantages of which include:

1. The ability to obtain some version of the software system in the early stages of the software development process.

2. Implementation of more important functionality at earlier stages of the software development process compared to less important functionality.

3. The possibility of the appearance of working versions of the software system at earlier stages of the project.

The content of iterations of the chosen approach is as follows.

On iteration 1 the analysis of requirements and development of the first prototype of system is realized. As a result of the iteration, an intermediate result is obtained, which includes a conceptual model of the subject area, a set of uses and the first prototype of the system.

In iteration 2, the detailed design and development of the second prototype of the system is performed. As a result of this iteration, an intermediate result is obtained, which includes the general architecture of the system, the result of detailed design of the system in the form of a set of its components and their interface, and the second prototype of the system.

In iteration 3, the final version of the system is developed. As a result of this iteration, a result is obtained that includes the final version of the system.

### 3.3. Analysis of the subject area of transportation management and options for using the decision support system

The analysis of the subject area is based on the study of literature sources that address issues related to it, and through interaction with stakeholders. As a result of such analysis the set of basic concepts is allocated, communications between these concepts and rules of their use are defined. An important component of the analysis of the subject area is the technology of structural organization of the selected information. The two most common approaches to such an organization are: the conceptual modeling approach and the ontological approach.

The conceptual model of information contains a set of concepts and connections between them, which describe the specification of the subject area for this task. In the ontological approach, the information is organized in the form of ontologies, which are developed with the expectation of more active and long-term reuse. Ontologies are described using special ontology languages, such as OWL. The approach of conceptual modeling is used in the work.

The conceptual scheme of the subject area has the form shown in Fig. 3.1. The diagram lists the concepts identified during the analysis and the relationship between them.

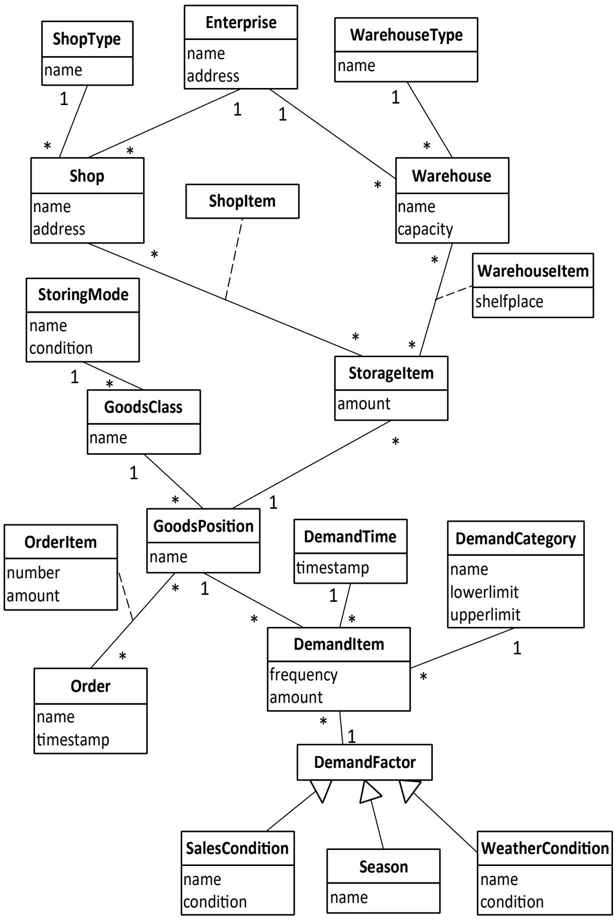



Fig. 3.1. Conceptual scheme of the subject area of management multicomponent stocks

1. Enterprise - the enterprise for which the problem is solved. The characteristics of the enterprise are used as attributes, in particular: name - the name of the enterprise, address - its legal address.

2. Shop Type - type of trading terminal. Is a classifier for the following concept, highlighting the categories of trading terminals.

3. Shop - a trading terminal owned by a specific company.

4. Warehouse Type - type of storage tanks.

5. Warehouse - a storage tank owned by a particular company. The characteristics of the repository are highlighted as attributes:

. As personifications allocate the stored volume - amount.

6. Storing Mode - is a characteristic of the following concept - categories of goods.

7. Goods Class - product category (classifier of stored nomenclature).

8. Goods Position - the position of the nomenclature (specific name of the product).

9. Storage Item - a unit of storage of goods. Corresponds to the position of the nomenclature

12. Order Item - order position (associative concept - a characteristic of the relationship between the order and the position of the nomenclature), is characterized by the following attributes: number - serial number in the order list, amount - the ordered volume.

13. Demand Time - time to collect information about demand.

14. Demand Category - a category of demand (from extremely low to excitement), each such category is characterized by lower and upper limits of the frequency range.

15. Weather Condition.

16. Season - what time of year.

17. Sales Condition - trading condition (discount, sale, etc.).

18. Demand Factor - a factor that affects demand. Represents a generalization of the three previous concepts.

19. Demand Item - a unit for collecting information about demand. It is characterized by connections with the position of the nomenclature, time of information collection, demand category and influencing factor. As attributes it is possible to allocate frequency - frequency of hit of demand in a range of a category and amount - the fixed size of demand.

10. Warehouse Item - a characteristic of the relationship between the unit of storage of goods and storage (associative concept). Corresponds to the unit of storage of goods in storage, as an attribute is allocated storage space – shelf place.

11. Order - an order to receive a consignment of goods. Among the attributes of this concept are the name of the product - timestamp, which determines the time of the order.

### 3.4. Architecture of multi-item inventory management support system

When choosing an architectural style for a support system for multi-item inventory management, the following alternatives were considered: monolithic architecture, layer-by-layer component architecture and service-oriented architecture.

1. Monolithic architecture. This architectural style defines the implementation of the system as a whole without a breakdown into logical parts. There are no restrictions on the relationship between the components. The use of such an architecture is appropriate only if the system is small, its development is not planned, the resulting solutions are not expected to be reused. Currently, such architecture is largely outdated.

2. Layered component architecture. In this case, the system is designed as a set of software components located on several logical levels so that the components of the lower levels do not depend on the implementation of the components located above, and never refer to them. As a result, the choice of such an architecture allows to achieve independence between the individual layers of the system. A three-tier component architecture is usually considered, in which the following levels are distinguished: level of data access, level of business logic and level of representation.

Components of the level of access to data are responsible for the peculiarities of access to information external to the system; components of the level of business logic are responsible for the implementation of the basic functionality of the system; the components of the presentation level are responsible for the implementation of interactive interaction with users. Data access layer components should not refer to business logic layer components, and access from data access layer and business logic layer components to representation layer components is prohibited.

3. Service-oriented architecture. In this case, the system is presented to its users as a set of external services, each of which is provided with independent access. Such services do not have a user interface, for the organization of end-user access it is necessary to implement the appropriate software separately. In most cases, this architecture is designed to develop software designed to create an infrastructure within which it is possible to develop specific software solutions.

In the course of this work, it was decided to focus on the layered component architecture as the architectural style chosen for the implementation of the system. This choice was dictated by the following factors: the presence of several actors with possible simultaneous access to the system, the need to separate the external interface of the system from its internal representation, the possibility of future reuse of business logic in combination with alternative implementations, no need to allocate some functionality systems for use in other systems.

According to the chosen architecture, the multi-item inventory management support system consists of a set of components, each of which is accessible through a specific interface. The components are located at the following levels: data access level, business logic level, and presentation level. The description of the components of the business logic level is given below. In this paper, we will not describe the components of the level of representation and level of access to data, because the implementation of these components depends on the specifics of the chosen architectural style (eg, model-representation-controller architecture) and is not related to the subject area.

Components required for system implementation. The set of components of the level of business logic required for the implementation of the system, and the interfaces provided by them are shown in the diagram of components in Fig. 3.2. and includes:

1. Enterprise Management - a component that is responsible for managing information about businesses and premises (warehouses and trading halls). Provides the following interfaces: Manage Enterprises (contains operations that allow you to

directly manage enterprise data), Provide Enterprise Data (contains operations that provide information about enterprises), Manage Places (contains operations that allow you to directly manage data about the premises) and Provide Place Data (contains operations that provide information about the premises). Does not depend on other components.

2. Goods Management - a component that is responsible for managing information about the range of goods. Provides the following interfaces: ManageGoods (contains operations that allow you to directly manage nomenclature data) and Provide Goods Data (contains operations that provide nomenclature information). Does not depend on other components.

3. Warehouse Management - a component responsible for managing inventory information. Provides the following interfaces: Manage Storage (contains operations that allow you to directly manage inventory data), Provide Storage (contains operations that provide inventory information), Manage Orders (contains operations that allow you to directly manage inventory data), Provide Orders (contains operations that providing information on orders for goods). Depends on the Provide Place Data interfaces of the Enterprise Management component and the Provide Goods Data component of the Goods Management component.

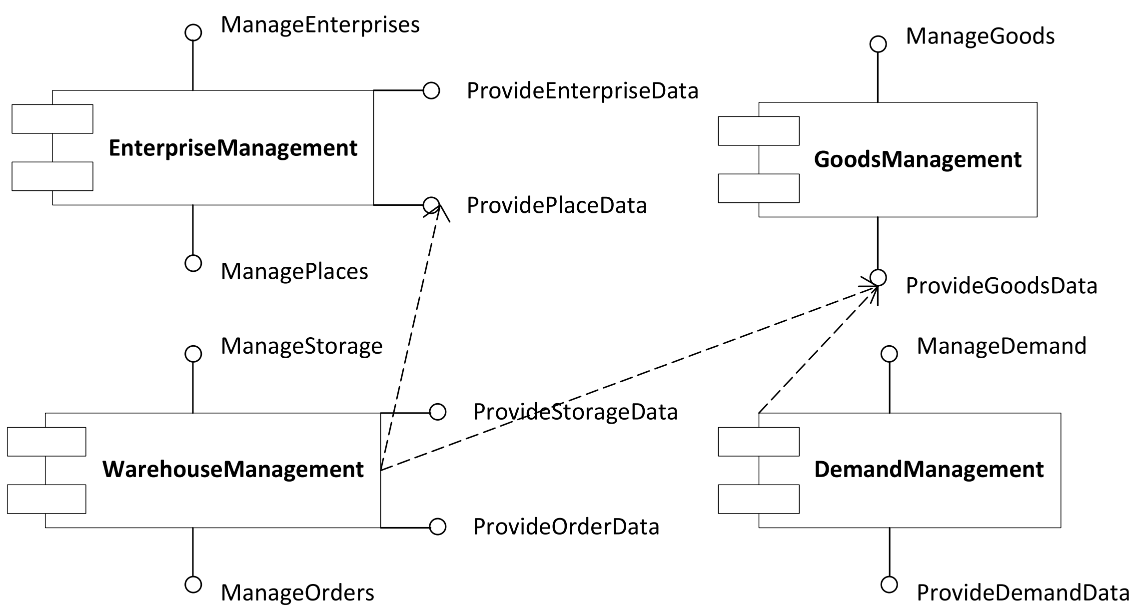



Fig. 3.2. Components of the implementation of the support system for the management of multi-item stocks

4. Demand Management - a component that is responsible for managing information about the demand for goods. Provides the following interfaces: Manage Demand (contains operations that allow you to directly manage data on demand for goods) and Provide Demand Data (contains operations that provide information on demand for goods). Depends on the Provide Place Data interface of the Enterprise Management component.

### 3.5. Setting automatic tasks at different stages of the ordering process

In the thesis to achieve this goal, minimizing the cost of resources for delivery of goods, it is necessary to optimize the process of ordering goods from the beginning of its formation and to the unloading of goods.

First you need to define a programming language, to achieve the goal all automatic tasks were programmed using a high-level, interpreted, dynamic general-purpose programming language - Perl. Perl was developed in 1987 year Larry Wall, a linguist and programmer by education, who worked at the time system administrator in NASA, as scripting language for Unix. Since then, many changes have been made to the language, and its concept and architecture have been revised, making it very popular with programmers. Larry Wall continues to work on the core of the language, and a new version is currently expected to be released, Pearl 6.

Perl borrows the capabilities of many other programming languages, such as C,, shell scripting,, AWK and sed. The language provides powerful word processing capabilities without arbitrary data length restrictions on many modern Unix tools, and makes it easier to process files and data.

The general structure of programs in Perl was borrowed from WITH. Perl is the default procedural language, with variables,, expressions, assignments, brackets-separators, blocks,, cycles and subroutines.

Perl has also borrowed some features from shell programming. The names of all variables begin with special characters, each of which characterizes a certain type of data (for example, scalars, arrays and hash tables). It is important to note that this allows you to correctly interpret the names of variables directly in the text of programs. Perl has many built-in features that provide the programmer with tools that are often used in shell programming (although many of these tools are implemented using external programs), such as sorting or calling external programs.

Perl borrowed lists from the language Lisp, associative arrays (hash) with AWK, and regular expressions with sed. This simplifies the process of parsing and processing large amounts of textual information.

Complex support has been added to Perl 5 data structures, functions of the first class and object-oriented programming model, which includes links, packages, etc. Among the biggest innovations in Perl 5 is the support of modules that allow you to reuse code. Larry Wall He later said: "The addition of Perl 5 support modules was made to stimulate the growth of Perl culture, not the language itself."

All versions of Perl perform automatic variable typing and memory management. The interpreter knows the type and methods of storing all data objects in the program.

Consider the developed scheme of automation of the ordering process at the computer-technical level (see Fig. 1.5.), which is programmed using the Perl language.

In the considered scheme it was offered to automate 5 actions which are carried out by the operator, for processing and formation of the order.

After generating the order, the program has the first task in sending a specific document to the first level of sales (see Fig. 1.3). To automate the process of resource management, we will form a script that processes documents with the order and sends the received file to the first level (Fig. 3.3.). You also need to create an environment where the files will flow, process, log and register errors. The corresponding script №1export_moi, given in Annex A.

The next step is to automatically read the sent invoices from the first level and enter them in the program. To do this, form a script - script №2 – import_iiv, given in Annex A.

Next, one of the important steps is to automate the process of obtaining a registration number for goods imported into the country. This significantly slowed down the process of delivery of goods, because the car can stand at the border until it receives the appropriate code. To solve this problem in the thesis developed a program that automatically sends a request to the registration service on the basis of a ready-made invoice. The corresponding script №3 - export_xml_for_rs is given in Annex A.

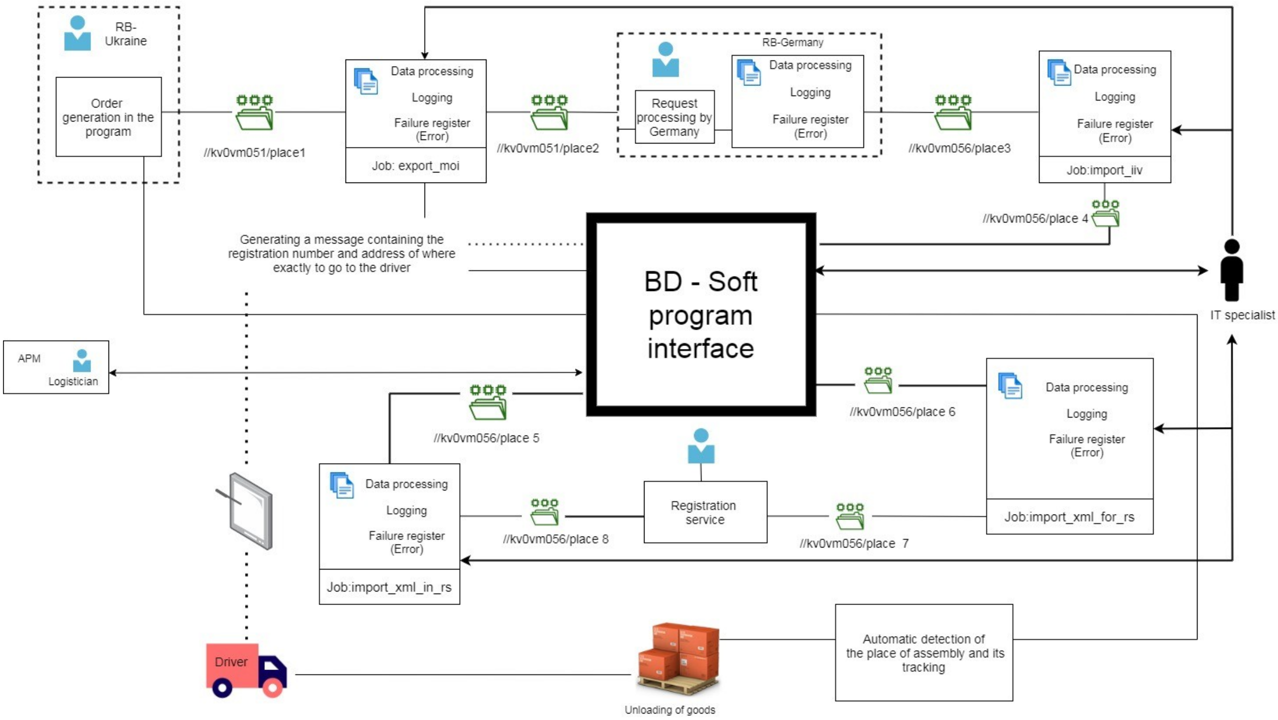



Fig. 3.3. Functional diagram of the automated process of ordering at the computer level after the introduction of completion

Accordingly, after the request, a response is received from the registration service, which enters the system script import4 import_xml_for_rs.

The last step in automating the ordering process, which will significantly speed up the process of delivery of goods, is to notify the driver of the car, the first - the registration code, and secondly, additionally provided to the driver coordinates of arrival. Previously, these operations took place with the help of human intervention, i.e. the driver called the logisticians and asked where to go, so it was necessary to develop a procedure for automatically notifying the driver of the necessary data. A procedure for automatic data import was developed, together with the coordinates of the car driver.

The scheme of the ordering process at the computer level, taking into account the entered automatic tasks is shown in Fig. 3.3.

In the previous section the basic principle of tracking of the goods and its automatic distribution is formed. This task must be implemented accordingly at the program level, it is as follows.

The workstation operator applies to the program in order to find out at what stage of delivery the cargo is. The process of tracking the cargo is as follows: when the cargo is at one of the stages of delivery, an additional function is triggered to enter a mark in the program. For example, when an order has just been generated in the program, the value LS ~ is assigned; when crossing the border - LS +; and accordingly, when the product enters the warehouse value LS. In fig. 3.4. the automation module, which is responsible for the distribution of goods in the warehouse, is also shown. Job: (generation_s_kod) gives the number of the storage location and accordingly fixes the position in the program, it significantly speeds up both the storage process and its subsequent search for use.

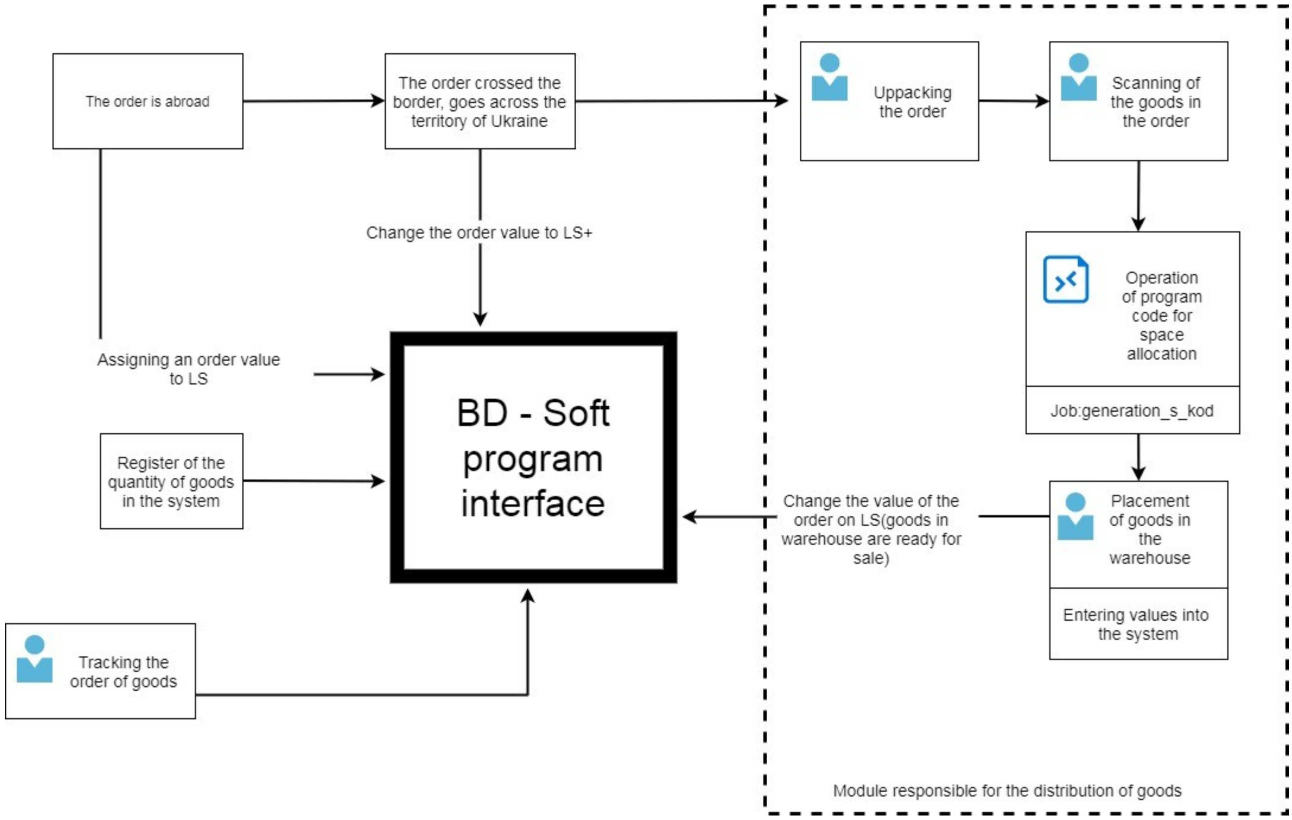


Fig. 3.4. Functional diagram of the automated process of tracking the order and its automated distribution in the warehouse at the computer level

## 3.6. Construction of a map of communication between automatic tasks and an example of execution of one of them

Automatic tasks work with files, i.e. for each task a file space was allocated, where data processing such as:

– // kv0vm051 / place1;

– // kv0vm051 / place2;

– // kv0vm056 / place3;

– // kv0vm056 / place4;

– // kv0vm056 / place5;

– // kv0vm056 / place6;

– // kv0vm056 / place7;

– // kv0vm056 / place8.

These are examples of the ways in which files "come".

But there is a question in tracking such places because when there is a failure in automatic tasks, the IT specialist must find exactly where the test script is and to solve the problem of restoring the functioning of automatic systems. To do this, a map was created that allows you to track such processes. The Free Mind program was taken as a basis.

Free Mind - a program to create thought cards. Free Mind written on Java and distributed in accordance with GNU General Public License.

The program has advanced export capabilities. Export XHTML allows you to create a map-scheme with a branched structure and links to external sources.

The main features of Free Mind are:

– folding of branches;

– the ability to use HTML to format nodes;

– export to HTML, XHTML;

– export 'fully opened image' to the following formats: PNG, JPEG,, SVG and PDF-format;

– export to Flash only from the 8th beta version 0.9.0.

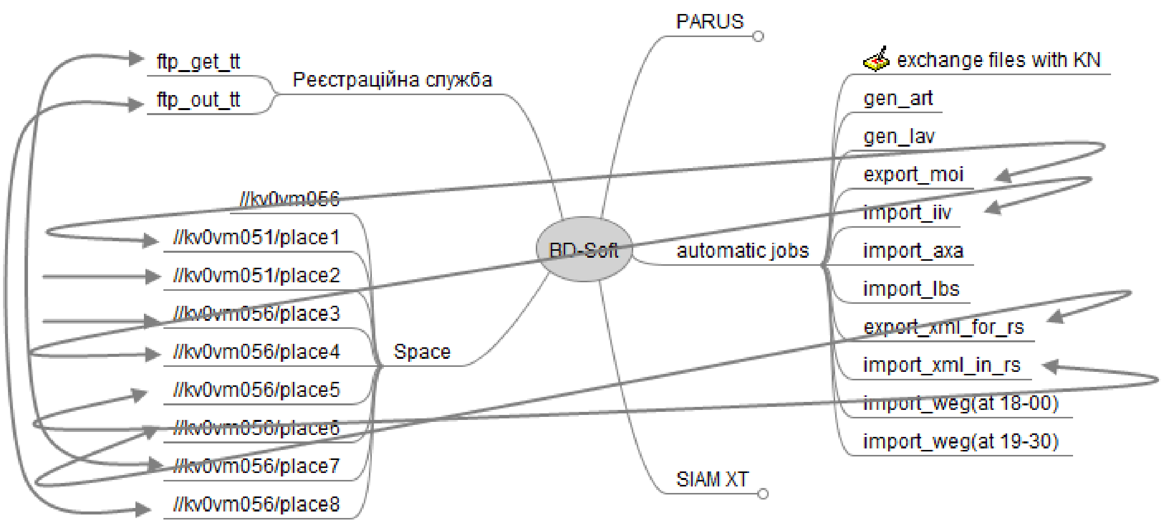



Fig. 3.5. Map of the relationship between the automatic tasks that were entered into the scheme

– Decorating knots and branches.

– Graphic binding of nodes.

– Links to other memory cards, web pages and external files.

– Search by individual branches.

– Import and export lists.

Thus, using the program Free Mind created automatic tasks, which are connected to the places of working files (Fig. 3.5.).

In addition to fig. 3.5. the interaction between additional programs was shown, such as: PARUS accounting module, registration service.

Let's show an example of operation of one script (Script №2):

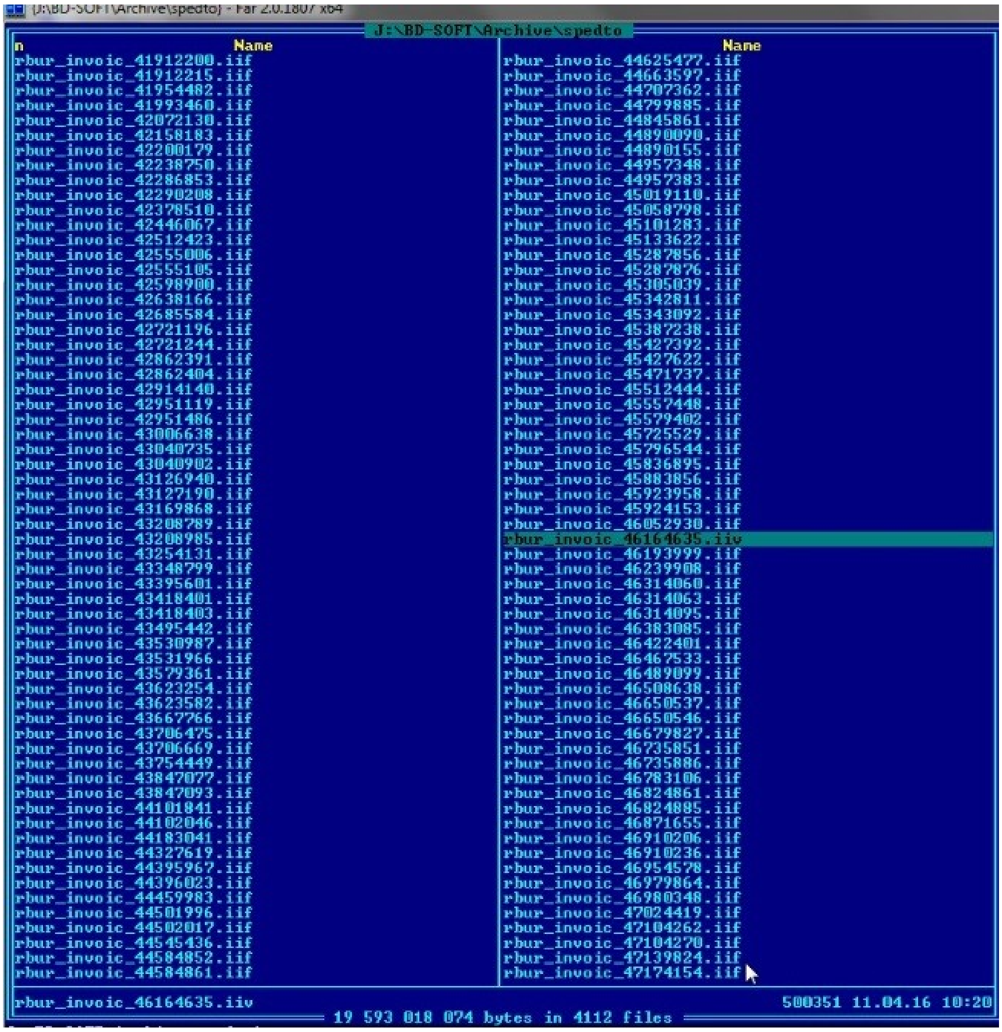
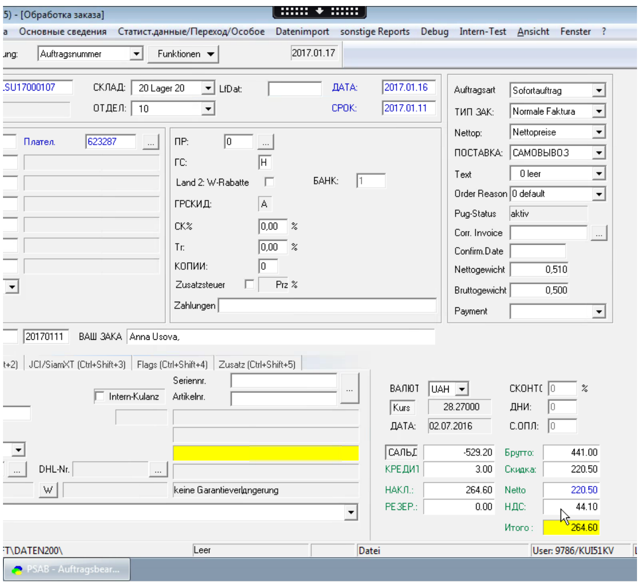



Fig. 3.6. Location of * .iiv files

Files of type * . iiv fall into the layer // kv0vm056 / place3 (Fig. 3.6). At the set time the script works, and as a result we have automatically entered data into the



program, in fact the interface of the BD-Soft software environment is shown (fig. 3.7).

Fig. 3.7. Example of working out an automatic task

Main fields: order number, order type, warehouse number, date of formation, term and more.

### 3.7. Calculation of the efficiency of a functionally implemented advanced automation system in the company of Robert Bosch

Calculation of the main indicators of efficiency of functioning of the enterprise of a transport profile after introduction of the improved system of automation of management of resources

The transport company performs such operations as sorting, selection, assembly, consolidation, division, packaging, warehousing, storage, cargo processing, packaging, supply and transportation of goods. As you know, the management of delivery times in order to reduce them is a priority.

The term delivery ($t_{del}$) means the time required to move the goods from the point of departure to the destination ($t_{transp}$), including the cost of time for loading and unloading ($t_{lu}$) and all additional operations ($t_{op}$):

$$t_{дост} = t_{пер} + t_{зв} + t_{опер} \; . \qquad (3.1)$$

In this case, the time of transportation of goods, taking into account the characteristics of means of transportation (transmission) depends on the speed of the truck (v), the distance between points of departure and destination (L), as well as various delays on the way. time for processing documents, obtaining a registration customs code, inspection of cargo, etc.). Loading and unloading time is determined by the amount of cargo (Q) and the intensity of cargo operations (M). In general, the above dependence is presented in the form of the following formula:

$$t = \frac{L}{v} + \frac{2Q}{M} + t. \qquad (3.2)$$

In the practice of transport calculations is also used an indicator of the commercial speed of delivery of goods:

$$V = \frac{L}{t}. \qquad (3.3)$$

Speed of delivery is the most important indicator of the quality of transport services. It comprehensively evaluates the work of various parts of the transport company on the final result for a particular recipient. Due to the great importance of this indicator, there is an urgent task to automate the processes of forming a customs registration number and determining the place of storage of goods in warehouses.

First, we will count all the indicators before the introduction of refinement:

We first introduce constant variables, they will be the speed of the truck v = 80 km / h, the distance between points L = 1547 km, the amount of cargo Q = 8000 kg and the intensity of cargo work M = 500 kg / h.

– Let's make calculations of delivery time tdost1 for this purpose we enter the following variables:

– time required to move the cargo from the point of departure to the destination tper1 = 126 (h);

– time spent on loading and unloading $t_{lu}1 = 24$ (h);

– additional operations $t_{op}1 = 5$ (h).

Therefore, $t_{del}1 = 126 + 24 + 5 = 155$ (year).

– Determine $t_{transp}1 = \frac{1547}{80} + \frac{2 \cdot 8000}{500} + 155 \approx 207$ (year).

– Let's define the indicator of commercial speed of delivery of cargo:

$$v_{com2} = \frac{1547}{206,338} = 7,49.$$

Accordingly, we will make calculations after the introduction of refinement

– Delivery time $t_{del}2$ for this we enter the following parameters:

– time required to move the cargo from the point of departure to the destination $t_{del}2 = 25$ (h);

– time spent on loading and unloading $t_{lu}2 = 5$ (h);

– additional operations $t_{op}2 = 1$ (h).

Therefore, $t_{del}2 = 25 + 5 + 1 = 31$ (year).

– Determine $t_{transp}2 = \frac{1547}{80} + \frac{2 \cdot 8000}{500} + 31 = 82{,}338$ (year).

– We also calculate the indicator of the commercial speed of delivery of goods:

$$v_{com2} = \frac{1547}{206{,}338} = 18{,}789.$$

As you can see, the introduced adjustments significantly affect the time of delivery of goods to the place of assignment, as well as increasing the rate of commercial speed.

The second important variable, which also depends on this development, are quantitative indicators. The following data are taken from statistical reports made by sales staff, for the period from 07.09.2014 the number of orders amounted to 573 orders per month, from 01.09.2016 to 30.09.2016 the number of orders amounted to 1134 orders per month. This also affected the financial indicators, we see an increase of 20% in profit due to increased speed of delivery of goods and, accordingly, an increase in the number of orders per month.

The calculated results are given in the table 3.1.

*Table 3.1*

**Temporal and quantitative indicators**

| **Operations** | **To improve the ACS** | **After improving the ACS** |
|---|---|---|
| I. Transportation of goods from the point of order to the destination | | |
| Time required to move the cargo from the point of departure to the destination $t_{del}$ | 126 hours | 25 years |
| The cost of time for loading and unloading so-called | 24 hours | 5 hours |
| Additional operations now | 5 years | 1 year |
| Total delivery time | 206,338 | 82,338 |
| II. Registration and shipment of the RBUR customer order | | |
| Formation of the order in the program before the moment of the invoice from Germany | 18 working hours (2 days) | 9 working hours (1 day) |
| Time for registration of the transport consignment note by bookkeeping | 13.5 working hours (1.5 days) | 9 working hours (1 day) |
| Shipment of the car to the customer | 13.5 working hours (1.5 days) | 9 working hours (1 day) |

Comparative analysis of calculations shows that after the improvement of the automated ordering system, the time required to move the goods from the point of order to the destination was reduced by 2.5 times; the number of orders doubled, which in turn increased profits by 20%.

**Conclusions:** In this section the structural and functional schemes of automation at the enterprise of a transport profile were improved. The formulation of automatic tasks at different stages of the ordering process is considered, as well as a map of the relationship between automatic tasks and an example of one of them, which significantly increased the efficiency of the transport company. The efficiency of the implemented advanced automation system in the company of Robert Bosch is calculated.

# SUMMARY

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Air Transportation Management Department | | | | NAU 20.09.57. 300 EN | | | | | | |
| Done by: | Petruk A.V. | | | *SUMMARY* | Letter | | | Sheet | Sheets |
| Supervisor | Shevchuk D.O. | | | | | | D | 79 | 1 |
| Normative Supervisor | Shevchenko Yu.V | | | | FTML 275 ОП-202Ма | | | | |
| Head of the Department | Shevchuk D.O. | | | | | | | | |

Analysis of the existing automated resource management system showed non-compliance with modern requirements for the operation of the transport enterprise. Its main disadvantage is the lack of automation of ordering processes, which significantly affects the efficiency of the enterprise.

A method of automation of resource management, which differs from the existing ones by automatic generation of registration customs number and automation of goods placement processes in the warehouse of Robert Bosch, was developed, which allowed to increase the efficiency of the transport enterprise.

The structural and functional scheme of the automated resource management system of the transport enterprise has been improved due to the ordering processes, which has allowed to reduce the time of delivery of goods to the customer.

The developed method of automation of resource management is software implemented on the basis of the software product BD-Soft and implemented in the company Bosch, which allowed to increase the number of orders, track the location of goods in the delivery process and reduce ordering time.

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