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THE APPROACH TO SOLVING THE PROBLEM OF OPTIMIZATION OF TRANSPORTATION

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Анотація. *Розглядається проблема оптимізації логістичних процесів для господарюючих суб'єктів агропромислового сектора. У статті розглядається повний цикл формування логістичного потоку. На основі аналізу інтегрованих показників діяльності національних агрохолдингів запропоновані модель процесу упорядкування транспортних перевезень та обчислювальна схема рішення задачі.*
Ключові слова: *логістичні потоки, модель ресурсів, неідентичні машини, послідовно-паралельне впорядкування.*

Аннотация. *Рассматривается проблема оптимизации логистических процессов для хозяйствующих субъектов агропромышленного сектора. В статье рассматривается полный цикл формирования логистического потока. На основе анализа интегрированных показателей деятельности национальных агрохолдингов предложены модель процесса упорядочения транспортных перевозок и вычислительная схема решения задачи.*
Ключевые слова: *логистические потоки, модель ресурсов, неидентичные машины, последовательно-параллельное упорядочение.*

Abstract. *There was discussed the problem of optimization of logistics processes for agri-industrial sector. The article discusses the complete cycle of development of logistics flow. Based on the analysis of the integrated indicators of the national agricultural holdings there were proposed model of the ordering process of transportation and the computational scheme for solving the problem.*
Keywords: *logistics flows, the resource model, non-identical machines, sequential-parallel ordering.*

1. Introduction to the topic of the study

Increased competition in domestic and global markets and the simultaneous aggravation of the problem of food security require a significant increase of the level of development of the agricultural sector in the GDP of Ukraine and the transition of the agricultural sector to more advanced control over the entire range of core and supporting processes. This leads, in turn, the need for new, previously unused control systems agricultural enterprises, which would give the opportunity to obtain a synergistic effect due to not only optimize their own objects of management, but also due to the interaction with related parties in the chain of promotion of agricultural raw materials and processed products. It is such an effective tool for the management of agricultural enterprises of Ukraine may be the concept of optimization of logistics in the direction of the Association of theoretical and methodological approaches, which uses modern world experience optimizing material flow in logistic units.

According to international studies, the use of scientifically-based methods of optimization of logistics processes to reduce costs by 20%, the cost of inventories by 30%–70%, reduce turnaround time of material flow by 20%–50%. It is obvious that the achievement of these indicators in real terms of the resourcing of the agricultural sector could be significant benefits.

However, due to various objective and subjective reasons, innovative methods of optimization of logistics and marketing we are used insufficiently.

You may notice that today agri-logistics – new applied direction of the logistics associated with the use of its provisions and methods in the field of agricultural production. In Ukraine agri-logistics is at an early stage of development. However, in developed countries – USA, Canada, Western Europe, Australia – long ago estimated the high efficiency of logistic approaches in agribusiness. Today in many countries of the European Union in the state structures assume a proactive role in the implementation of logistic approaches in the activities of agricultural enterprises. Formed agricultural logistics as a separate research area, in which are developed scientific principles, methods, mathematical models, algorithms, which provide the ability to plan, monitor and manage the transportation, warehousing and other tangible and intangible flows and operations that occur during the delivery of raw materials to agricultural production, the organization of the production process, delivery of agricultural products processing, to the final consumer according to its requirements.

2. Features of logistical approach

Study questions use of logistic approach in the management of material resources, it can be argued that its novelty consists in the change of priorities of economic activity, where the main role is played not just the product material, and the whole process in the form of logistics flow (financial, information, return) between suppliers and consumers. Therefore, it can be noted that for the optimization of logistic processes is to optimize the entire forming cycle logistics flow [1]:

- Supply logistics.
- Logistics inventory.
- Production logistics.
- Distribution logistics.
- Warehouse logistics.
- Transport logistics.

The activity of the enterprises of the agricultural sector makes use of concepts and tools logistics in the sphere of material support their core business through the optimization of procurement processes main capital goods and other materials in order to create or update the Park units of technological transport, equipment necessary to perform the production process in accordance with agronomic requirements, auxiliary equipment, means of production processing capacity of the agricultural holding. The use of instrumentation, and logistics planning and procurement of material resources involves decision-making based on reliable, sufficient and timely information, which should be the decision makers (DM). I.e., is becoming the actual process of creating in the agricultural holdings logistics information systems and the use of tools of information logistics. The creation of a logistics information system Corporation will enable the implementation of information exchanges, both within the boundaries of internal micrologistics systems and integrated supply chain (e.g. in the marketing of agricultural products).

3. Integrated indicators of the national agricultural holdings

Integrated the company's national agricultural sector can be characterized by the following indicators [2]:

- Highly diversified activities.
- Relatively low production cost and high value-added products.
- Developed logistics system.
- Integration of production subsequent processing of commercial products.
- Geographically distributed structure.
- Developed system infrastructure.
- The availability of innovative technologies in production.
- The concentration of capital.
- Complex multi-level control system.
- Effective use of available resources.
- High professional level managerial staff.
- The availability of investment attractiveness for foreign companies.

The largest number of agricultural holdings recorded in Kherson, Dnipropetrovsk, Donetsk regions. The amount of arable land in Ukraine is more than 32 million hectares, of which 40% is processed in small and medium enterprises.

Managing the logistics processes is a basic and one of the most important components of any enterprise information system. Today the use of existing commercial ERP systems allows you to work with one integrated software product instead of several disparate. Unified more optimally used to control the processing, logistics, distribution, supply, accounting, financial and tax accounting. It should be noted that the introduction of classical ERP systems belongs to the category of “heavy” custom software products – their selection, purchase, implementation and maintenance require very careful planning in the framework of a long process involving the partner supplier or a consultant. The use of ERP systems are usually closely linked to the creation and maintenance of a powerful database. Among the most well-known commercial software products that implement the concept of ERP, and are used in the management of large companies, can be called in the first place, SAP, Oracle, Microsoft Dynamics, 1C:Enterprise (module – logistics), Parus Corporation v.8:10, Galaxy – Logistics Management and others. In recent years, in a world of rapidly developing market "cloud" online versions of systems enterprise resource planning.

4. Components of task scheduling

Structural task scheduling consists of the following components [3]:

1. Objective (O). Many transport, educational and industrial events organized periodically by the way, repeating at the same time through the day, week, otherwise an integer number of days. Such an arrangement allows reducing the costs of planning, which is the main purpose of the task. Scheduling is the process of planning the collection of centralization and evaluation of the quality of the source information necessary and sufficient for the schedule.

2. The model of the object of research (M). The model of the object of research includes the original (X) and output (Y), and the conversion method in the original result (F).

3. The original set (X). The schedule is often characterized by three main characteristics of the event, place and time (What? Where? When?). In public transport, for example, such characteristics are: cargo, date of transport, travel time. Education is the start and end times of classes, audience, and subject. Production is the start time and end time of the transaction, the machine on which the operation is performed and so on

4. Result (Y). The result is a work plan that includes an ordered time series of activities, deadlines, the work required resources for the execution of works, responsible person.

5. Method of converting the original result (F).

Possible there is a wide range of private options, objectives and evaluation criteria of the causes of a wide range of approaches to the solution. Methods of construction schedules can be divided into three large groups [4]:

a) algorithms based on the decomposition of the task scheduling into subtasks (attachment tasks in the family of simpler tasks);

b) algorithms based on the method of branches and borders;

c) algorithms based on the correction current schedule (iterative algorithms).

Algorithms using the decomposition schedules may be based on:

– on dynamic programming;

– on greedy strategies.

6. The evaluation criterion of the result (C).

The paper presents a class of discrete optimization problems, described as a version of the fundamental problems of the theory of schedules. The resource model each problem class under consideration presents a system of m, $1+m$, $1+m+1$ machines, where m parallel non-identical machines are intended to perform n operations.

This model was chosen as the standard for describing and studying the processes in which some operations work assigned in parallel to existing objects, and others create the queue in front of the individual object. This class is a subclass of optimal ordering one- , two - and three-operational works that are assigned to the same identical machine.

The problem of optimal ordering works on identical machines are generalizations and variants of the task of compiling a pipelined schedules and fairly well understood.

The task scheduling for non-identical machines more complex and virtually unexplored. In statements of the problem the input data are set in a matrix of assignments that generate a significant increase in the number of feasible solutions and difficulty finding the optimum.

For the considered models series-parallel ordering and assigning work overall is a square matrix of assignments $[\beta_{ij}]_m$ with non-negative integers, permutation $\pi = (\pi(1), \pi(2), ..., \pi(i), ..., \pi(m))$ and diagonal, the corresponding permutation is π. As the basic design for building models used task assignments [5].

Objectives of the study form a class of tasks, which is a generalization of the assignment, and with other tasks series-parallel execution.

5. The model of the ordering process

The model of the ordering process, in terms of which the formulated research objectives, contains the following components:

1. System resources are $1+m$ machines, where m non-identical machines, t.i. machines with different performance and functionality, provide parallel execution of works. In the future this system will be called duplex in the sense that its input is the only machine, and the output of the m parallel identical machines.

2. Model jobs is described by a set G of n two-stage independent work g_j at the same time coming at the input of the system. The first stage of the work is done on the machine first level over time γ_j, and the second stage on – machine second level over time β_{ij}. Moreover $\beta_{ij} = \infty$, if any job j cannot be performed on machine i. Not simultaneously execution of works run more than one machine. On each machine at any point in time is assigned no more than one work. Interrupt stages of the operation is invalid. All works are ready to run at the time conventionally equal to 0.

3. As an indicator of effectiveness is the length of the schedule or the time of operation of the system.

The input data serial-to-parallel arrangement contain a matrix $\left[\beta_{ij}\right]_{m\times n}$, in which the element β_{ij} is equal to the execution time of the second phase of operation j on machine i, and the vector $[\gamma_1, ..., \gamma_2, ..., \gamma_n]$, that determines the duration of the first stages of the work. Overlay vector $[\gamma_1, ..., \gamma_2, ..., \gamma_n]$ for each row of the matrix $\left[\beta_{ij}\right]_{m\times n}$ obtained in the input task data spreadsheet $\left[(\gamma_i, \beta_{ij})\right]_{m\times n}$ and related combinatorial configurations.

In the most general case the problem of series-parallel two-step ordering of activities in a system of $1+m$ machines can be formulated as follows: you must select each column in the table $\left[(\gamma_i, \beta_{ij})\right]_{m\times n}$ one the column element $(\gamma_{i,} \beta_{ij})$ so that under given conditions the process of execution of works to be the schedule is optimal by implication of the selected criteria.

In the case where the first stages zero, get the model of parallel machines, and in the case when there are three stages that are executed sequentially on a single machine of the third level (or it could be the same machine the first level), we have the model of $1+m+1$ machines.

Each generalization of the task assignments is considered a square table $\left[g_{ij}\right]_m$, the elements of which can be the number $\beta_{ij} \square Z_0^+$ or ordered pairs $\left(\gamma_{i,}\ \beta_{ij}\right)$ or ordered triples $\left(\gamma_{i,}\ \beta_{ij}, \eta_j\right)$.

In the first case the resulting minimal task assignment and task search many solutions of the assignment.

In the second case, when $n=m$, we obtain a generalization of the assignment of a two-stage works in the system of non-identical machines, and, as a special case when a single early stages of work, the task of parallelization of a two-stage work.

And in the third case we get generalization of the task of editor.

It should be noted that in the case $n>m$, tasks belong to the class of NP-hard problems even in the case of identical machines of the second level.

All these problems are efficiently solvable using a unified computational scheme.

6. Computational scheme

The method of successive build local optimal solutions, which in its basis, is beyond the bounds of the way the solutions of the assignment and differs from the known algorithms for optimal distribution of works only acceptable increase in the volume calculations.

The methods consist in successive improvement of the valid solutions and build all optimal solutions. It consists of two sequentially performed procedures.

The first procedure creates *m-1*submatrix and a valid solution to the problems, which elements are the minimum values of the coefficients in submatrixes ordered by non-growth and, moreover, forms the initial matrix from the source task data. The second procedure consistently finds the optimal solution for each of the submatrixes and uses the solutions obtained in the previous step.

It is possible to allocate three ways to build optimal solutions.

1. The way (a) consists in addition to optimum sequence for submatrixBl-1corresponding components of the admissible decision for a submatrix B_l.

2. The way (b) consist in an exception of optimum sequence for a submatrix B_{l-1} components of the decision and addition of the elements of a submatrix B_l belonging to a line and a column on which crossing there is an excluded decision element.

3. The way (c) consists in replacement two component of the decision for a submatrix B_l with the components corresponding to them in the same submatrix not belonging to the decision and application to the received sequence of actions of a way (b).

The complexity of the proposed algorithm in the worst case estimated at $N_{\max} m^4$, where $N_{\max}$ is the maximum number of local optimal solutions in submatrixes.

Problems of series-parallel streamlining of transport works are solved also by means of a method of consecutive creation of local optimum decisions and are presented by the following tasks.

The problem of optimal assignment of n two-stage works in a system of $\left[1+m\right]$ non-identical machines for the case $n<m$, which follows from the above task organize a two-stage works and consists in finding of the minimum schedule length from the rectangular matrix $\left[\beta_{ij}\right]_{m\times n}$.

Task – a special case of the previous task – at zero first stages of works. In a task it is known that there are *n*- objects, each of which is intended for departure in any of points m and costs of transportations of objects are known. It is necessary to minimize the cost of transportations.

This task can be considered and as a problem of definition of a stream of the minimum cost in a transport network of a special look where each arch of a network has single capacity.

To solve these tasks may use the same method sequential build local optimum solutions by adapting it to the input data, represented as a rectangular matrix $\left[\beta_{ij}\right]_{m\times n}$.

Formation of aninitial matrix from initial statements of the problem consists in addition to the last bottom $m-n$ rows containing zeros.

The complexity of these tasks is estimated as $O\left(N_{\max} m^4 \log_2 m\right)$.

The next task is the problem of finding a schedule with the minimum total completion time one-step works in the system of non-identical machines in case $n>m$. For the adaptation of the developed method to the solution of this problem it is necessary to provide the raw data in the form of a matrix consisting of n rows and mncolumns that is to get the input matrix of task and forth to form the initial matrix of these data.

Further we will consider the problem of minimizing the average completion time one-step transport works, which are known to the ready time of each vehicle to perform n runs. To perform the steps of the algorithm for constructing all optimal solutions, it is first necessary to construct the matrix $[\tau_i]_{nxm}$ of moments of readiness cars to runs, to receive from it a matrix D of dimension $n\times nm$ and, finally, the matrix D+B, from which the admissible solution of a task is found and submatrixes are formed.

As the development of the above results, considerable interest is the following model of efficient organization of passenger transportation. It is necessary to minimize the total execution time for m-bus m pendular routes between two points 1 and 2. Transportation should provide the m_1 bus company 1 and m_2 bus company 2. From timetables for bus stations know the departure time for each run from P1 to P2 in the opposite direction. All buses after the run have to go back to his business. In the task you want to minimize the total time of buses in the outfits.

To solve this problem developed an approximate algorithm with acceptable in practice, deviations from the optimum. It consists of two main phases. During the first phase, initial matrix of objectives and the scheme of local optimal sequences are all optimal solutions of the assignment, and the second phase is the split that minimizes $T\left(\pi^*\right)=\min T^{'}\left(\pi\right)$, where π_1^*,π_2^* an optimal schedule for enterprises 1 and 2, respectively.

To perform the second phase of the algorithm had to solve an auxiliary task of minimizing the total execution time of all jobs *n* on *m* machines, if the number of machines is equal to 2 , which represent π_1^*,π_2^* the optimal blocks of the index works, intended respectively for the 1st and 2nd machine. The complexity of the algorithm is estimated as $O\left(N_{\max} m^4\right)$.

Further the use of the above result is of considerable practical importance in the optimization of logistics processes in the conditions of agricultural holdings.

7. Implemented modules

Under the theme includes several modules:

1. Automated information management system fleet in terms of a group with regard to the timing of technical inspections units of technological transport, with the possibility of accounting for and analysis of all cost items.

2. Automated information control system capacity in terms of agricultural holding, taking into account the dependency of the commercial properties stored agricultural products from the time of its storage.

3. Automated information control system of productive capacity in terms of a group with the structure of the total cost of seed material, taking into account the current state of the fertile layer, with the cost accounting for seasonal watering, fertilizing, etc.

4. Based on the use of so-called "ant algorithms" implemented a WEB application for the calculation of optimized routes units of technological transport.

5. Implemented software application for small transport companies (up to 25 vehicles) on the basis of the software using MS Excel.

8. Conclusions

Trends of development of modern economy testifies to the increasing role of logistics, which in the conditions of growing competition, reduce information barriers and globalization is one of the most important components of the strategic development of enterprises. The importance of strategic planning in logistics due to the possibility of elaboration of strategic development programs of companies that focus on the optimal organization of stream processes and improve their competitiveness. Methodological apparatus of logistics proved the versatility of their use in optimization of streaming processes in all sectors of the economy. Integrated logistics planning contributes to improving the economic sustainability of companies in the market due to logistic coordination, allowing you to find a compromise between the functional departments of the company and to ensure its integration with the external environment. In modern conditions one of the main problems of domestic enterprises is the lack of logistics strategies designed for integrated supply chain management to optimize resource companies. Analysis of the experience of Europe and the USA shows that the world's leading companies focus their activities on strategic logistics to be able to cover suppliers, logistics intermediaries and consumers. The process of developing logistics strategies should be based on careful study of all possible alternatives for the development of the company and consist in the choice of priorities, developing markets served needs, competitive practices, resources and logistics service level. The choice of strategic directions, companies must shift from competition on the basis of low costs and unique features of goods and services to the strategies based on proximity to consumers and the formation of logistics networks.

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