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# ORGANIZATION OF TRANSPORT OF PARCEL CARGOES

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## INTRODUCTION

One of the most difficult problems in organization of transport is the question of transporting of parcel cargoes. In order to explain this question we shall first have to define what we mean by the notion of "parcel cargoes".

In order to do this we first introduce the notion of "one-time cargo". It shall be assumed that this notion denotes a cargo which cannot be divided into smaller parts and which is determined through one and only one couple of names: the name of the sender and the name of the recipient. Such a "one-time cargo" is sometimes called consignment or shipment. It is obvious, for instance, that the notion of one-time cargo cannot be applied to dry loose goods. It can be applied, on the other hand, to commodities transported in packages: parcels, pallets, cases, containers, barrels, sacks etc. One-time cargo has, obviously, its volume, mass, dimensions etc., hence it is defined also by its magnitude, similarly as transport units have their proper carrying capacity, defined by their lifting capacity, draught, volume capacity and so on.

Parcel cargo is the cargo whose magnitude is much smaller than the carrying capacity of a transport unit, which is to carry this cargo. This definition is, however, insufficient. We must, namely, exclude here mass transport of parcel cargoes from the same sender to the same recipient. Thus, for instance, the question of transporting of thousands of parcels between two partners, with the carrying capacity of the transport means of the order of several or tens of parcels shall not be treated as the problem of transport of parcel cargoes, but as the problem of transport of mass cargoes.

The following questions can be treated as the ones contained in the definition of transport of parcel cargoes:

- the problem of mail transport (letters, parcels, sacks etc.) with cars, wagons, airplanes etc.,
- the problem of railway transport of small cargoes (i.e. the ones which take only a small portion of a train),
- the problem of sea transport of small cargoes,
- the problem of sea transport of container cargoes,
- the question of dispatching consumption goods to retail trade

shops,

- the question of collecting of packages, mail etc.

and a number of other problems, similar in their nature.

It is characteristic for the technology of transporting of parcel cargoes to perform the operation of grouping of loads so as to form greater "portions", equal to the capacity of a transport unit. This operation is called differently for various branches of transport.

Thus, for instance, in railway transport, in case of loads which do not fill whole trains the operation of marshalling the train sets (compositions) is performed, consisting in grouping of cars having the same destination direction to form the train compositions. These compositions (train sets) are being changed in marshalling stations, which are special kinds of stations, distinct from loading stations, in which sending and receiving of loads takes place.

In car transport of parcel cargoes the operation of completion of shipments in warehauses and change of loads in special facilities takes place. Analogous problem appears in air transport.

This problem appears much more distinctly in sea transport of small freight. The operation of grouping of loads takes place in the port. In doing this of special importance is the question of adequate spatial location of loads in the hold (the problem of stowing), so that the necessity would not arise of pulling the loads from under the other ones when they have to be unloaded.

A similar problem is "completion" of the load of newspapers for cars dispatching the press to newsstands. Depending upon the choice of these loads the transport of the newspapers (to all newsstands by all cars) will cost less or more.

The attentive Reader shall certainly notice that the latter problem can be reversed, namely: to determine the car routes from which, simultaneously, the principles of load completion shall result.

In transporting of mail we are dealing with the problem of "sorting" of posted mail shipments. This is also the operation of grouping of loads.

It is not difficult to notice that the grouping operation occurs also in an entirely different kind of transport, and namely in the telecommunication systems for transmission of messages. This can best be seen in the case of organization of sending of cables.

We shall be interested in the problem of transporting the parcel cargoes from the point of view of organization of shipment, that is - the manner of putting together and moving of transport units (trains, cars, ships etc.) under given transport needs (demands, for we do not take into account the market side of the problem). In further considerations we shall therefore not be dealing with the details of transport technology, but shall limit ourselves to moving of the given transport means, in such a way as to satisfy the demands put on transport with a possibly low cost. Similarly, we shall not be interested by the road network, assuming that it is given, together with the adequate warehouse infrastructure, loading/unloading capacities and the like.

In order, however, for a Reader to better grasp the essence of the problem of grouping of loads we shall describe it through the example of transporting of parcel cargoes through railway transport.

Assume, therefore, that the railroad network is given. The vertices (nodes) of the network are railway stations (marshalling or loading stations), while edges - railway lines connecting the edges. Every marshalling station has its ascribed "region" - set of "subordinate" loading stations.

Within the "region" or "district" the so called "collect trains" are being organized, which bring down from the loading stations the cars which are loaded or empty to the marshalling stations or bring from the marshalling station to the loading stations loaded or empty cars.

Between the marshalling stations only trains of definite length are moving, composed of, say, several tens of cars.

In the marshalling stations train compositions are being changed. Incoming compositions are divided and new ones are being put together out of car groups.

Such an organization of transport is the result of many years of experience in the practice of solving the following problem:

We are given a definite road network (railway, car, airplane, sea etc.) and definite transport units of predefined capacity. Likewise, we are given periodical transport demand defined for instance for daily periods. These demands, or needs, are defined as the magnitudes of loads which have to be brought from given vertices to other vertices. Load magnitudes are many times smaller than the capacity of transport units.

In such a situation two extreme kinds of solutions to this problem appear.

The first one would consist in putting in every vertex the number of transport units equal to the number of potential addressees of the loads. In the extreme case, when transport needs account for shipments between all pairs of vertices, then there would have to be in every vertex the number of transport units equal to the number of all vertices minus one. Then, transport units (each labeled with its destination) should be left in their vertices of origin until they are filled completely with shipments. Then, these transport units would bring the loads in accordance with their vertex labels, along the shortest routes, of course.

The second extreme solution would consist in sending a shipment from a vertex immediately after this shipment appears in the vertex, irrespective of the fact that the transport units may be dispatched even almost empty.

A Reader will notice with ease that both these extreme solutions are not satisfactory.

In the first case we need an enormous amount of transport means, although we spare a lot in travelling. In the second case we lose a lot out on travelling, forcing transportation of empty units.

Practice, therefore, dictated a compromise solution, such as we observe, for instance, in the described organization of railway transport of small freight. This solution is the result of recognition of the fact that both keeping of a too great number of transport units costs ("frozen assets") and too much travelling of these units costs as well (in fuel and road use).

Still, the compromise solution described has a certain disadvantage. A new, additional operation of load grouping appears, which costs as well, for it is related, generally speaking, with loading, and in the case of the railroad example described - with the marshalling activities (division of the train sets, rolling and coupling). In this case, therefore, the summary translocation of loads in time and space is the result of addition of consecutive stages of translocation, of which every one is caused by moving of another transport unit.

Thus, in transport of parcel cargoes there is a separation of the movements of loads and the movements of transport units. The movement of loads should comply with the requirements set by the transport demands (vertices of sending and receipt), but it results from the movements of transport units. The movement of transport units, together with definition of loading (regrouping, marshalling) locations constitutes the decision variable. This decision variable is constrained by the direct limitations related to capacities of tansport units and to road network, and by the indirect limitations, concerning the load transport requirements.

Summing up, we can say that we are looking for the schedule of movement of transport units together with the schedule of loadings (marshalling - in the case of railway transport), and the criterion of evaluation of the quality of the schedule is the total cost of carrying out the transport task.

It should be emphasized here that in many transport systems two kinds of transport units appear: the active and the passive ones. Passive transport units fulfill the role of freight packaging, their only characteristic is load capacity. These are, for instance, freight cars, trailers, barges, containers etc.

The active transport units are, for instance: locomotives, tractors, tugboats etc.

Consequently, the time and space schedule of the movement of transport units shall be composed in such a case of the schedule for the passive units and the schedule for the active units. The first of these schedules is bound to satisfy the transport requirements, while the second - to provide for satisfaction of the first schedule.

Thus, for instance, for the railway transport of containers we would have the following three schedules:

- of the movement and loading of containers (full and empty),
- of the movement of cars (loaded and empty) and marshalling of the train sets, and
- of the movement of locomotives.

For the complete description of organization of transport one would have yet to include the schedules of work of train teams, engine-drivers and marshalling yard employees.

In further course of the book we shall limit ourselves to the case of determination of the schedules of movement of active and passive units. We shall be analysing this problem further on on the example of railway transport, turning attention especially to the schedules of freight cars and train sets.

For the sake of simplicity of problem consideration we shall be looking for the schedules of regular shipments, i.e. those which provide for satisfaction of cyclically recurring transport needs. Besides this, transport needs may be divided into fixed-time and open-time ones.

Let us explain: the fixed-time shipments are those, for which the instance of sending or the instance of receiving, or both, are precisely determined. In contradistinction, the open-time shipments should take place within a given time period, usually within the period of repetition of transport needs (in regular shipments).

Another simplification shall therefore consist in consideration of uniquely open-time shipments.

## 1.THE DECOMPOSITION OF THE PROBLEM OF THE PARCEL CARGO TRANSPORT

We shall present the decomposition of the problem on the example of railway shipments' transport.

Within a given railroad network there are definite stations in which cars can be loaded and unloaded. Then, within a subset of these stations train sets can be divided and formed again, to constitute complete trains together with the locomotive. These latter stations shall be called marshalling yards. We shall be interested in the train sets (compositions) and their routes, leaving locomotives and their movements aside, assuming that locomotives are added automatically when the train sets are complete.

In fact, it is easy to notice that the problem of determination of movements of locomotives is a secondary one. Thus, namely, when we consider the ready train sets then the problem of movement of locomotives can be formulated as a separate, secondary one.

In our case the cars ready to go, loaded or not, constitute the demand for transport. Each such car is labeled with a "relation" - a pair of addresses - of the stations of sending and receiving.

The first problem we encounter in transporting of a car is determination of the route, over which it would be transported together with other cars from the same locality (these other cars having usually different destination station addresses) and from other localities, to the closest marshalling yard.

Thus, it is the problem of collection of cars from the localities belonging to the region served by the given marshalling yard. Then, a separate problem is constituted by determination of the collection regions for each marshalling yard.

If we assume, consequently, that the railway cars are located in the marshalling yard, but have different destination stations then they should be sorted in such a way as to make the cars whose destination stations belong to the region served by definite marshalling yards constitute separate groups. Each such group can be assigned a collective transport relation from the marshalling yard of sending to the marshalling yard of destination. The third problem, to which we shall refer as to the marshalling problem, is formation of train sets out of the car groups and determination of their routes.

When passing through a marshalling yard a group, whose destination station is just the given marshalling yard, is disconnected there and may eventually be replaced by some other group.

If the marshalling problem is solved then there remains yet the fourth problem, namely dispatching of the cars coming to a marshalling yard towards their destination stations located in this yard's dispatching district.

Finally, the fifth problem is determination of the dispatching districts for each marshalling yard. Note that the second and fifth problems are the problems of division of the network into as many subnetworks as there are marshalling yards. These two divisions may be different and besides this some subnetworks may be empty.

Note that the problem being solved belongs to the class of typical organizational problems basing upon the existing technological network structure - so that it does not refer to investment outlays. On the other hand, it can easily be seen that the minimum cost of transport shall depend upon the number and location of marshalling yards. Still, the problem of choice of marshalling yards is connected with modification of the technological network structure and is outside of our scope of interest.

One of the most important technological realities which one has to account for when solving the problem are the limited capacities of marshalling yards and of the railway segments, as well as the limited number and capacities of locomotives.

Thus, the description presented suggests that the problem in question is to be decomposed into five problems, which can be partly solved independently.

If we assume that the collection and dispatching districts are given and we cannot, because of many reasons, change them, then three independent problems remain to be solved: collection, marshalling and dispatching, of which the first and the last one are connected and in a way complementary.

Let us make the decomposition presented more precise by formulating in a strict manner the problem of parcel cargo transport on the example of railway transport.

We are given the set of points of sending and destination of shipments, numbered with the index $s$, $s=1,2,...,S$. For every point a non-negative vector (including the indirect ones)

$$b_s=\langle b_s^1, b_s^2, \ldots, b_s^r, \ldots, b_s^S\rangle$$

is defined, with components $b_s^r \geq 0$ corresponding to given intensities of transporting from $s$ to $r$, $r=1,2,\ldots,S$, expressed in the number of cars (containers, parcels etc.) per unit of time - most often week or day. Values of $b_s^r$ for $r=s$ are equal zero.

Thus, for the whole set of points a matrix is defined having rows $b_s \geq 0$ and the diagonal $b_s^s=0$.

Out of the set thus characterized we choose the subset of marshalling points. This subset is indexed with the variable $i=1,2,\ldots,I$, in such a way that the points, other than the marshalling ones, are indexed $i=I+1, I+2, I+3,\ldots,S$. If we denote by **I** the set of numbers of marshalling points and by **S** the set of numbers of all the points then there is, of course, $\mathbf{I} \subseteq \mathbf{S}$.

The set **E** of direct road connections (railway routes) is defined over **S**, with $\mathbf{E} \subseteq \mathbf{S} \times \mathbf{S}$. Obviously, the set **R** of road connections between the marshalling yards.

Further, we have the following functions defined over **E** and **R**: $d_{ij}>0$, expressing distance between points, and $\tau_{ij}>0$, expressing time of passage between points. Quantities (values of functions) $d_{ij}$ and $\tau_{ij}$ are related through velocity of transport $v_{ij}$ from $i$ to $j$. There is, of course,

$$\tau_{ij} = \frac{d_{ij}}{v_{ij}}$$

Since transport between marshalling points may have somewhat different nature than transport between other points, we can distinguish two velocities: $v_{ij}^r$ for transport between the marshalling points and $v_{ij}^0$ for transport between other points.

Shipments are being transported between points in the following manner:

In the first phase shipments are collected in points, then sent to the "closest" marshalling point. From there, through a corresponding another marshalling point, shipments are transported to destination point.

For every marshalling point the following two districts (point subsets) are defined: district $S_i \subseteq \mathbf{S}$ from which loads are sent to marshalling point $i \in I$, and district $S^i \subseteq S$, to whose points loads are sent from the marshalling point $i \in I$.

Certainly, districts $(S_i, S^i)$ satisfy conditions of partition, that is: $S^i \cap S^j = \emptyset$, $S_i \cap S_j = \emptyset$ for each pair $(i,j) \in I \times I$ such that $i \neq j$.

In a particular case there may be: $S_i = S^i$.

Thus, for every marshalling point we can define the quantity

$$\beta_i^r = \sum_{s \in S_i} b_s^r$$

i.e. the intensity of transporting of shipments from the marshalling point $i$ to a point $r \in S$. If we sum the quantities $\beta_i^r$ for $r \in S^j$ then we obtain the intensities

$$\lambda_{ij} = \sum_{r \in S^j} \sum_{s \in S_i} b_s^r, \qquad (i,j) \in I \times I$$

of transporting of shipments from the marshalling point $i$ to marshalling point $j$. There is, of course, $\lambda_{ij} \geq 0$.

It is obvious that quantities $\lambda_{ii}$, $i \in I$, define the magnitudes of transportation within the districts. Some shipments do not necessarily have to go through the marshalling point $i$. We can therefore separate the problem of intra-district transport of loads determined as $b_s^r$ for $s \in S_i$, $r \in S^i$ with $i=1,2,\ldots,I$. The matrix of values of $\lambda_{ij}$, in which it was assumed that $\lambda_{ii}=0$ for $i=1,2,\ldots,I$, defines the problem of transporting shipments between marshalling points. Finally, the quantities

$$b_{si} = \sum_{r \in S^i} b_s^r$$

and

$$b_{ir} = \sum_{s \in S_i} b_s^r$$

define the contents of the problem of collection and dispatching in and from the marshalling point $i$.

Thereby, the problem of transporting parcel cargoes is decomposed into three problems (assuming that districts are given):

* the problem of transport between the marshalling points;
* the problem of collection in - and dispatching from - the marshalling points;
* the problem of intra-district transport.

The latter problem may turn out invalid if we maintain the principle that intra-district transport proceeds through collection in one point and dispatching from this same point. Such a method of transport is, though, uneconomic. The problem of marshalling shall be considered solved when the cost of transport between the marshalling stations shall be minimal for the determined structures of all the trains "circulating" between stations and for the defined routes of their journey. In this we understand that the train composition structure is the magnitude of each car group and the number of these groups entering the train (composition).

Note that if we know the number of incoming and outgoing train compositions for every marshalling yard and their structures we can define the magnitude of marshalling work which has to be done at each station. Knowing, then, the routes of these compositions we can determine the load of each railway line, and knowing the lengths of compositions as well as their numbers we can obtain the necessary number of locomotives.

It is easy to notice that the problem thus formulated does not encompass the whole of the problem subject matter. This formulation represents namely the "static" part of the problem, in which the intensity of "flow" of transport units carrying various sorts of loads is determined. In terms of theory of flows in networks this part of the whole problem concerns determination of coloured flows possibly strongly concentrated on some branches of the network with such a condition as to make the "marshalling work" possibly small.

The second part of the problem formulation for parcel cargo transport shall concern determination of the timetables of movements of train compositions and of the timetables of work in marshalling stations. This is a dynamic problem. Solution to this problem - timetable of transport movements - should comply with constraints on the average values of flows (in time), which should be equal the intensities of flows determined in the first part of the parcel cargo transport problem.

We shall first take up the static part of the problem and its solution.

This static part of the overall problem is divided into two consecutively solved subproblems.

First of these two is the subproblem of concentration of inter-district shipments connected with the choice of routes (paths in the network) over which loads should be transported from a given sender to the final destination indicated.

The second of the two subproblems is the one of grouping of loads into transport compositions (train sets) with, possibly, the choice of locations of grouping.

## 6. CONCLUDING REMARKS

The present publication contains the first integrated formulation of problems of organization of parcel cargo transport. This problem area encompasses all the questions of regular transport, with application both to cargoes and to information as well. Depending upon the nature of technical means of transport the whole problem takes on one of a variety of forms and particular cases, although the essence of the main questions remains the same. In view of limited volume of the present publication the variety mentioned could not be described systematically in full detail. This concerns especially these cases which are connected with transmission of information in telecommunication networks, in which the time needed for transmission on the way connecting nodes can be neglected, while the whole essence of the problem is concentrated in the nodes having limited capacity and effectiveness.

As stated, the subject of this publication is limited to regular transport (of cargoes and information).

Regular transport assumes cyclical repetitiveness of motion situations and, first of all, of transport demands. In such a case, by making use of knowledge of future transport needs, we can prepare earlier the whole transport plan. How to put together such a plan - was the subject of this publication.

It remains to explain relations between regular and irregular transport from the point of view of transport organization.

In irregular transport we are dealing with transport demands appearing in an irregular manner, difficult or simply impossible to predict.

Consequently, in irregular transport we are typically dealing with the situation in which a definite load should be moved immediately from one node of the network to another - given definite knowledge of transport situation in a given time instance. If this knowledge is complete, then this problem consists in determination of the schedule of transporting one shipment under conditions of given occupancy of roads and nodes and known movements of all compositions. Thus, an additional composition is to be constructed or the shipment is to be linked with the existing compositions.

In order to solve this problem we can make use of the algorithms described in this publication, proper for regular transport, with the difference that in this case the algorithms would concern singular load (and not the complete set of shipments appearing in the whole cycle of scheduling).

Certainly, in large transport systems assumption of complete knowledge of transport situation in the whole network is not realistic.

An example for that is provided by the computer network of information transmission or by the international telecommunication network.

Let us consider in a bit more detail this latter case of irregular "transport" of data in the telecommunication network.

Thus, namely, in case of appearance in a node of shipment meant to be sent to some other node, the first problem which appears is to decide to which neighbouring node the shipment should be sent (assuming that none of the neighbouring nodes, i.e. directly connected with the initial one, is the ultimate one).

It must therefore be established in the initial node what should be the priciples of proceeding with the shipments - defining the "direction" of sending for various shipments.

Besides this, if these shipments are parcel cargoes then priciples must be determined as to the time during which cargoes shall be gathered for a given direction to be then sent as a package - e.g. "data package".

For the thus organized work in the node no information on the motion situation in the network is necessary. A further improvement of organization of motion in the network would consist in additional dependence of choice of direction of shipment upon the current intensity of traffic in given direction. If, for instance, shipment meant for a given addressee would normally be directed to a definite node, then, in the situation of heavy traffic on the direction towards this node, the shipment would have to wait a very long time in the line until it is sent. In such a situation it may be better to have the shipment sent to some other neighbouring node, a less charged one. In just such a manner the "roundabout" connections (shipment routes) are being put together.

These, or very similar, are the methods of organizing "shipments" not only in telecommunication networks, but also in transport, whose classical example is provided by railroad transport in its part concerning irregular shipments.

At a first glance it would seem that organization of irregular transport in conditions of incomplete information on traffic situation has nothing to do with the methods of organization of regular transport, and in particular with the methods of construction of transport schedules.

Nothing more erroneous. Let us namely apply these procedures of organization of irregular transport to the case of shipments entirely predictable for a given period of time.

In order to do this, in accordance with the predicted transport demand, we hand over the shipments in the chronological order of their appearance to our system of organization of irregular transport.

Our system of organization of irregular transport - in accordance with the priciples of proceeding accepted for the system - shall determine the manner of sending of particular shipments. If we note down, independently, the directions and time instances of sending of the shipments, as well as the structure of compositions into which they will be included, then we shall obtain, as the ultimate result, the contents of the realized schedule for all the shipments. Thus, in regular transport we had been forming schedules through application of appropriate algorithms <u>before</u> the actual transport took place, while in irregular transport, through application of appropriate principles, we obtain schedules <u>after</u> the actual transport has occurred. This is the only difference. Note, that insofar as we have two schedules - one formed before realization and the second written down after transport took place, we are able of comparing their quality.

This is not difficult, since in regular transport schedules are put together considering mutual dependence of transport of all the shipments, while in irregular transport we do take care only of having the currently considered shipment transported optimally. This results from the fact that we do not have current information as to what shall be the subsequent shipments.

We have demonstrated thereby that the schedule of shipments in irregular transport cannot be better than that in regular transport, so that with probability one the effectiveness of functioning of irregular transport is better than in regular transport.

This is an obvious conclusion resulting directly from assumption that in regular transport we know future transport demand and that we make use of this information.

There is, however, certain similarity of methods of transport organization in regular and irregular transport.

Note, namely, that methods of organization of irregular transport could serve to construct the schedules of regular transport before their realization, just as it was presented in the example with noting down of the course of future transport. The thus prepared schedule (with a simulation method) could then be made use of for controlling future transports in a network.

What is therefore the difference between the principles of controlling transports in irregular transport and the principles of elaboration of schedules in regular transport?

The answer could be that there is no essential difference as to the fundamental principles, for the principles of control define *implicite* certain algorithm, and conversely, within the algorithm of determination of schedules one can identify definite priciples of elaboration of schedules. The main difference resides in the fact that the principles in the case of putting together a schedule could be better due to consideration of future situations (e.g. - the information that in the next period heavy traffic is expected to occur over a given direction). On the other hand, algorithms of control of individual shipments can take into account only current situation.

Thus, it can be stated that the algorithms elaborated for regular transport may also have application, once they are adequately simplified, in regular transport. Besides that it can also be stated that construction of algorithms for regular transport is much more difficult than construction of principles of control in irregular transport.

Concluding, I would like to emphasize that the present publication is meant mainly to attract attention to the whole range of interesting problems from the domain of theory of organization of transport.

Algorithms described, computer programs and examples are just an illustration of the real problems and their significance is primarily experimental.

One of the goals which were to be attained through publication of this work was demonstration of the possibility of application of mathematical methods and computerized algorithms in solving of problems traditionally held to be not solvable with the help of computers, and for which adequate mathematical formulations were nonexistent.

I think that I have attained the goal of demonstrating the potential capacities of modern methods of applied mathematics and the available computer software in solving of all the most difficult problems of transport organization.

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**STANISŁAW PIASECKI**

**ORGANIZATION OF TRANSPORT OF PARCEL CARGOES**

Procesy przemieszczania zarówno ładunków jak i wiadomości mają coraz większe znaczenie w gospodarce światowej. Wynika to z rosnącej, międzynarodowej kooperacji przemysłowej i wymiany handlowej.

Jednocześnie pojawienie się nowych technologii transportu (kontenerowego, ro-ro itp.) oraz przesyłania wiadomości (sieci komputerowe, łączność satelitarna itp.) wymagają nowego, ogólnego spojrzenia na organizację przemieszczania ładunków i informacji w sieciach. Książka jest próbą takiego spojrzenia, chociaż jej treścią jest teoria optymalizacji – procesu przemieszczania ładunków drobnych – „transportu cząstkowego".

Tak jak drobne ładunki muszą być grupowane w większe „zestawy" dopasowane do ładowności środka transportu, tak wiadomości są grupowane w większe „pakiety" zmniejszające zajętość sieci.

Ze względów dydaktycznych, zagadnienia optymalizacji są omawiane w większości na przykładach transportu kolejowego.

Podane metody rozwiązywania zadań optymalizacyjnych mogą być wykorzystane do optymalizacji działalności przedsiębiorstw transportowych, chociaż, niestety, pracochłonne obliczenia wymagają zastosowania techniki komputerowej.

Książka, w zasadzie przeznaczona jest dla pracowników naukowych, szczególnie wyższych uczelni.

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