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Stanisław Piasecki

ORGANIZATION OF TRANSPORT OF PARCEL CARGOES

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Prof. dr hab. inż. Jerzy LESZCZYŃSKI
Dr hab. inż. Andrzej CHOJNACKI

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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.

2. FORMULATION OF THE PROBLEM OF INTER-DISTRICT TRANSPORT OF PARCEL CARGOES

2.1. The network

The graph is given, (I,R), of the marshalling network, in which I is the set of graph vertices (indexed i and j), that is – the marshalling stations, and R is the set of branches (i,j) – formally represented by the pairs of numbers of marshalling stations – corresponding to the fact of existence of a railway line linking vertices i and j. We have, of course, $R \subseteq I \times I$. For the thus defined graph the following functions are given: d_{ij}, τ_{ij} and μ_{ij}, $(i,j) \in R$. These functions define, respectively, distance d_{ij} between stations i and j (with, of course, $d_{ij} = d_{ji}$), the time τ_{ij} necessary for covering this distance (and it can happen that $\tau_{ij} \neq \tau_{ji}$) and the line capacity μ_{ij} expressed in the number of trains (train sets or compositions) per unit of time. Obviously, in place of function τ_{ij} we can have function v_{ij}, defining the average velocity on the way from i to j. Then

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

2.2. The route M_{kl} of a train set

The route M_{kl} of movement from station k to station l, with $k,l \in I$ is constituted by the following set:

$$M_{kl} = \{(i_1 j_1), (i_2 j_2), \ldots, (i_n j_n), \ldots, (i_N j_N)\}$$

such that:

1) $(i_n j_n) \in R$ for every $n=1,2,\ldots,N$

2) $i_1 = k, \quad j_N = l$

3) $j_n = i_{n+1}$ for every $n=1,2,\ldots,N-1$

4) pairs $(i_n j_n)$ do not form internal loops,

additionally, the number N is the function of the pair (k,l): $N=N(k,l)$. Sometime we shall treat the set M_{kl} as an unordered set which can be always ordered in such a way as to satisfy the four conditions given.

The length of the route shall be denoted by D_{kl} and defined by

$$D_{kl} = \sum_{(i,j)\in M_{kl}} d_{ij}$$

Routes are the decision variables. Let us therefore introduce the first kind of these decision variables, namely the ones which define the routes of train sets. Take namely

$$x_{ij}^{kl} = \begin{cases} 1, \text{ when relation } (i,j)\in M_{kl} \\ 0, \text{ in the opposite case} \end{cases} \tag{1}$$

These decision variables are subject to the following constraints:

a) formal

$$x_{ij}^{kl} \le a_{ij} \text{ where } a_{ij} = \begin{cases} 1, \text{ when } (i,j)\in R \\ 0, \text{ when } (i,j)\notin R \end{cases} \tag{2}$$

$$x_{ij}^{kl} = 0 \text{ if } \lambda_{kl} = 0 \tag{3}$$

for all $(i,j)\in I\times I$ and $(k,l)\in I\times I$,

b) substantial

$$\sum_i x_{ih}^{kl} - \sum_j x_{hj}^{kl} = \begin{cases} 0, \text{ if } h\neq k,l \\ 1, \text{ if } h=l \\ -1, \text{ if } h=k \end{cases} \tag{4}$$

for every $h\in I$ and (k,l)

$$\sum_{k,l} \sum_{k,l} x_{ij}^{kl}\cdot d_{ij} \le D \tag{5}$$

where D is the parameter of the problem.

This latter value is determined from the solution to the problem (1),(2),(3),(4) with the minimized objective function:

$$\sum_{k,l} \sum_{k,l} x_{ij}^{kl} d_{ij} \to \min \tag{5a}$$

The optimum values of x_{ij}^{kl} determined from this problem define the shortest transport routes between the marshalling stations.

Thus, constraint (5) allows for routes which are not the shortest ones.

Constraint (4) and (5a), as can be easily noticed, is meant to guarantee satisfaction of conditions defining the feasible form of the sets M_{kl}.

2.3. Transport

Irrespective of the given matrix of transport intensities, λ_{ij}, expressed in car numbers per unit of time, there exists the necessity of transporting empty cars, if the difference

$$\Delta\lambda_i = \sum_k \lambda_{ki} - \sum_l \lambda_{il}$$

is not equal zero for all $i \in I$.

If $\Delta\lambda_i$ are not equal zero then we have to determine the demand for transport of empty cars.

Denote by y_{kl} the decision variable of the second kind, meant to represent the number of empty cars which have to be sent from station k to station l. Variable values should be chosen in such a way as to minimize the transport work.

In this manner we have obtained the formulation of the problem of determination of the values of y_{kl}, namely:

$$y_{kl} > 0, \quad (kl) \in I \times I \tag{6}$$

(To be precise, quantity y_{kl} should be a non-negative integer number.)

$$\sum_k y_{ki} - \sum_l y_{il} = \Delta\lambda_i, \qquad i \in I \tag{7}$$

and the following objective function is being minimized

$$\sum_{k,l} y_{kl} \sum_{i,j} x_{ij}^{kl} d_{ij} \rightarrow \min \tag{8}$$

From the solution to the problem (6), (7), (8) obtained for definite values of x_{ij}^{kl} we can get the optimal demand for the transport of empty cars, y_{ij}. Consequently, therefore, we will be able to determine the demand for full and empty cars, namely

$$\Lambda_{ij} = \lambda_{ij} + y_{ij} \tag{9}$$

2.4. The intensity of train composition movements

The intensity of movements of the train sets on the way from i to j should be chosen in such a way as to make the length of the composition correspond to the locomotives available. This length should not be too small, for then we will need a large number of locomotives and a greater line capacity (expressed in numbers of trains per time unit, and not in numbers of cars). On the other hand, this length cannot be too big, for then it could not be pulled by the locomotives available.

If, therefore, we denote by Z_{ij} the number of train sets per unit of time moving from station i to station j, with $(i,j)\in R$, then this variable is subject to the following constraints:

$$Z_{ij} = 0,1,2,\ldots \tag{10}$$

$$-\Delta N_{ij}\, Z_{ij} \le \sum_{k,l} X_{ij}^{kl}\, \Lambda_{kl} - N_{ij} Z_{ij} \le \Delta N_{ij}\, Z_{ij} \tag{11}$$

for all $(i,j)\in R$.

Quantities N_{ij} and ΔN_{ij} are given and they denote the desired length of the composition N_{ij} and the admissible tolerance on this length $\mp\Delta N_{ij}$, over the line connecting station i with station j.

In place of inequalities (11) one can apply the equality yielding an "approximate" solution, namely

$$Z_{ij} = \frac{\sum_{k,l} X_{ij}\Lambda_{kl}}{N_{ij}}, \qquad (i,j)\in R \tag{10a}$$

Quantity Z_{ij} should yet satisfy an additional constraint on the capacity of the railway line, that is

$$Z_{ij} < \mu_{ij}, \qquad (i,j)\in R \tag{12}$$

Note, in this, that the load on the line (i,j), as calculated in cars per unit of time, would be equal the value of the expression

$$\sum_{k,l} X_{ij}^{kl}\, \Lambda_{kl}$$

2.5. The magnitude of the marshalling work

Stations from where train compositions come to the station h form the set

$$V_h = \{i : \sum_{k,l} X_{ih}^{kl} > 0\}$$

Then, stations to which train compositions are directed from h form the set

$$V^h = \{j: \sum_{k,l} x_{hj}^{kl} > 0\}$$

The number of compositions entering station h is defined by the value of the expression

$$\sum_{i \in V_h} Z_{ih}$$

while the number of compositions outgoing from h is equal

$$\sum_{j \in V^h} Z_{hj}$$

so that the overall number of trains on which work is being done is equal

$$\sum_{i \in I} (Z_{ih} + Z_{hi})$$

The latter number should satisfy the constraints

$$\sum_{i \in I} (Z_{ih} + Z_{hi}) \le P_h \tag{13}$$

where P_h is the upper bound on the number of trains which arrive at or depart from the station h.

Note that the structure of these trains is defined as follows:

First, among the trains coming to station h from the direction $i \in V_h$ there are

$\dfrac{x_{ih}^{kl} \cdot \Lambda_{kl}}{Z_{ih}}$ cars travelling from k to l, forming a single group, including

$\dfrac{x_{ih}^{kl} \cdot \lambda_{kl}}{Z_{ih}}$ full cars, and

$\dfrac{x_{ih}^{kl} \cdot y_{kl}}{Z_{ih}}$ empty cars.

Compositions of trains going out from the station h in the direction $j \in V^h$ include

$\dfrac{x_{hj}^{kl} \cdot \Lambda_{kl}}{Z_{hj}}$ cars on the way from k to l forming a single group, and in that number

$$\frac{x_{hj}^{kl}\cdot\lambda_{kl}}{Z_{hj}}$$ of full cars and

$$\frac{x_{hj}^{kl}\cdot y_{kl}}{Z_{hj}}$$ of empty cars.

2.6. The solution evaluation criterion

The time of travel of cars through railway lines over the route (kl) is defined by the value of the expression

$$\sum_{(ij)} \tau_{ij} x_{ij}^{kl}$$

The average time of transfer of cars through stations h of the route (kl) is defined by the value of the expression

$$\frac{1}{2} \sum_{h\neq k,l} \sum_{i,j} \frac{x_{ih}^{kl}\cdot x_{hj}^{kl}\cdot\tau_h}{\min\{Z_{ih},Z_{hj}\}}$$

Thus, the total magnitude of "frozen" car assets over the route (kl) is equal the value of the expression

$$\Lambda_{kl}\{\sum_{i,j}(\tau_{ij}x_{ij}^{kl} + \frac{1}{2}\cdot\sum_{h\neq k,l}\frac{x_{ih}^{kl}x_{hj}^{kl}\tau_h}{\min\{Z_{ih},Z_{hj}\}})\}$$

Thus, admitting that the optimality criterion be the total accumulation ("freezing" of the assets) of cars in the network, we obtain the expression for this criterion in the form

$$\sum_{k,l} \Lambda_{kl}\{\sum_{i,j}(\tau_{ij}x_{ij}^{kl} + \frac{1}{2}\cdot\sum_{h\neq k,l}\frac{x_{ih}^{kl}x_{hj}^{kl}\tau_h}{\min\{Z_{ih},Z_{hj}\}})\} \Rightarrow \min \qquad (14)$$

where, as before, $\Lambda_{kl} = \lambda_{kl} + y_{kl}$.

If we accept as criterion the overall time of transporting the shipments we obtain its expression in the form of

$$\sum_{k,l} \{\sum_{i,j\in R}(\tau_{ij}x_{ij}^{kl} + \frac{1}{2}\cdot\sum_{h\neq k,l}\frac{x_{ih}^{kl}x_{hj}^{kl}\tau_h}{\min\{Z_{ih},Z_{hj}\}})\} \Rightarrow \min \qquad (14a)$$

2.7. The simplified formulation of the problem

In this simplified formulation we have:

$$X_{ij}^{kl} = \begin{cases} 1, \\ 0, \end{cases} \quad \text{as before,} \qquad X_{ij}^{kl} \le a_{ij}$$

$$\sum_i X_{ih}^{kl} - \sum_j X_{hj}^{kl} = \begin{cases} 1, & \text{if } h \neq k,l \\ 0, & \text{if } h = l \\ -1, & \text{if } h = k \end{cases}$$

$$\sum_{k,l} \sum_{i,j} X_{ij}^{kl} \cdot d_{ij} \le D$$

$$\sum_k Y_{ki} - \sum_i Y_{il} = \Delta\lambda_i$$

$$Y_{kl} \ge 0$$

$$F = \sum_{k,l} (\lambda_{kl} + Y_{kl}) \sum_{i,j \in R} (\tau_{ij} X_{ij}^{kl} + \frac{1}{2} \cdot \sum_{h \neq k,l} X_{ih}^{kl} X_{hj}^{kl} \tau_h \cdot \max\{\frac{N_{ih}}{\sum_{u,v} X_{ih}^{uv} (\lambda_{uv} + Y_{uv})}, \frac{N_{hj}}{\sum_{u,v} X_{ih}^{uv} (\lambda_{uv} + Y_{uv})}\}) \Rightarrow \min$$

where, for simplification, the following was used:

$$Z_{ij} = \frac{\sum_{k,l} X_{ij}^{kl} (\lambda_{kl} + Y_{kl})}{N_{ij}}$$

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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prosimy o konntakt z Instytutem Badań Systemowych PAN,
ul. Newelska 6, 01-447 Warszawa
tel. 37-68-22 e-mail: kotuszew@ibspan.waw.pl