THE TECHNOLOGICAL MODEL OF OPERATING AREA BY THE COMBINED TRANSPORT

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The contribution deals with design technology service model using the combined transport. It assesses the performance indicators in relation to price and quality of services provided and on this basis decides on the type of the transport. This is the decision-making processes, which should answer the question, whether used directly in road freight transport, direct rail freight transport or combined transport. In this contribution is the combined transport meant as a system between the conventional modes, which are transhipped goods from road vehicles to the rail cars or river boats.

Key words: hub location, heuristic and metaheuristic methods, combined transport

1 Introduction

The Technology Hub and Spoke is the sphere of logistics technology services. It consists in grouping of smaller shipments into larger units, which are then transported by capacity transport system to the destination where they are divided into destinations. These operations are performed in the centres of freight transport (e.g., logistic centres, transportation junctions, combined transport terminals, etc.) of logistics (transport, forwarding) services. The consolidated shipments are transported in containers, air containers, swap bodies and pallets extensions. The consolidation of shipments is advantageous for the carrier for the following reasons:

a) the long-distance transport capacity means of transport is less costly than the parallel transport of the consignment of several smaller means of transport;

b) the transport infrastructure improves throughput, reduces the intensity of transportation;

c) the customers are receiving benefits from volume discounts.

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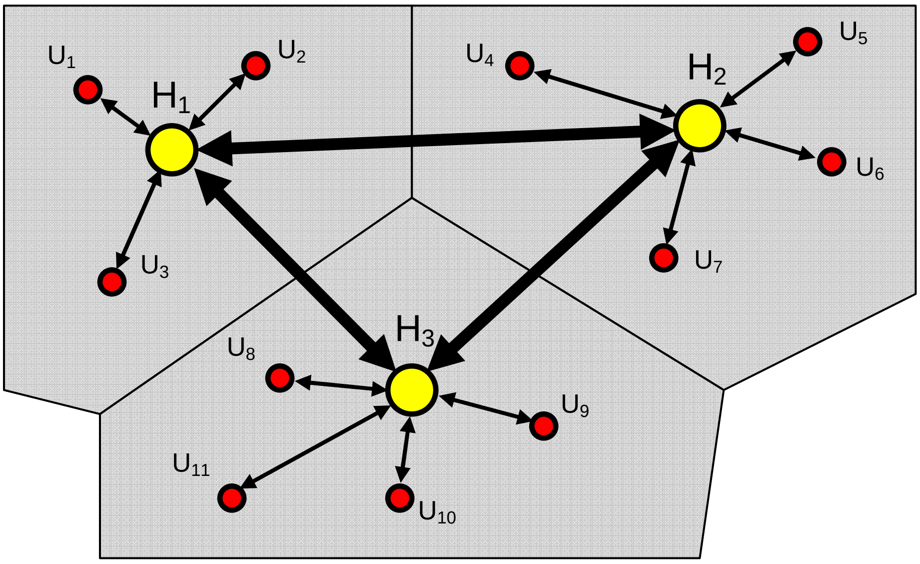
2 The Layout of technological Model by operated area

2.1 The Defining the Problem

The problem of technology service model is introduced to design the optimal number of centres Freight “Hub and Spoke” and their deployment is based on the assumption that the transport of goods between these centres will take the rail and using operated area is operated by road haulage. The model transport wagons load will therefore be as follows: The shipment is transported by rail departure station to the first Hub, then it is removed until the next Hub and then been transported to the final destination. In the event that the departure station and final station is located in the same operated area of Hub, the first shipment soon Hub transported to final destination and transport will therefore be implemented through a single hub. The Shipment realized through more than two hubs are in a certain model situation permitted, because any further processing and shipment of stay Hub is the emergence of delays. Each Hub will consist of direct trains to all other hubs. The diagram of such a system is shown in Picture 1-1. Any transport between the two hubs can be done only by using bidirectional edges shown by arrows, and can not be used more than 3 edges.



Picture 1-1: Illustration of the considered system Hub-and-Spoke
Source: Authors

Individual junctions can be assigned just to one up (the free allocation of a situation is illustrated in Figure 1-1), or may be included several hubs in the operated area (so-called multiple allocation). The advantage of multiple allocations is the partial elimination of the so-called “anti-flow direction” shipments and therefore reduce the value of objective function versus free allocation, the disadvantage is the complex organization (traffic is not underway or in a bun from nodal point only through a single hub, as in the case of free allocation, but the choice the two hubs depending on the particular session nodal points i and j) and the need for narration in general, more trains in ensuring the collection and distribution hub of hubs. The basic shape of the proposed model will therefore be a simple allocation, and for some sessions may be different in reality to introduce the organization of transport (i.e. through other than the mouth, which has operated departure station or district. Designation belongs to), if convenient.

The advantage of the above described organization of transport arises from the concentration of traffic flows to a hub, allowing the hubs to carry shipments economically (higher volumes of shipments) and reasonable period of time (higher frequency of shipments). As a result of mail processing hubs in a possible extension of the route is to extend delivery deadlines versus direct shipment, so it is best to organize the priority transport and transport to a session high volume of traffic flow as a direct transport (i.e. trains holistic).

2.2 Mathematical model of the role of distribution channels where the trains are starting

The lay-out of the ideal number of Freight Traffic Centers and their location, comes out of the presumption that goods transportation on railway lines is carried out on the basis of the “Hub-and-Spoke” arrangement. Model transportation of the full wagon load would proceed as follows:

1. The load is prepared for dispatch from the railway station to the first train formation yard, which serves as a hub.
2. It is transported to the next train formation yard (next “hub”)
3. It is transported to the final destination.

When the dispatch station and the destination station lie within the area of the same station (train formation yard), the load is transported from the first station (train formation yard) to the destination, through one “hub”. Transportations carried out by more than two train formation yards are not allowed in the model situation, because every other processing or halting of the load in the train formation yard means time delays. This implies that direct trains will be dispatched in every train formation yard to all other train formation yards. Situation diagram is described in Fig. 1. Any transportation between two points of junction can be carried out only by using railways demonstrated by two-way arrows, while it is not possible to use more than three railways.

Particular junction points can be assigned to just one”hub” (so-called simple allocation; situation is demonstrated in Fig. 2), or they can be located to working zones of several “hubs” (so-called multiple allocation). The advantage of the multiple allocation is in partial elimination of so called “duplicated transport” and so there is a reduction of the objective function value in comparison with the simple allocation; the disadvantage lies in more complicated organization (transport is not carried out to or from the junction point but only through one junction point as it is in case of simple allocation. The choice of the relevant couple of hubs depends on particular relation of junctions i and j). There also arises a general necessity to dispatch more trains to ensure transportation to and from “hubs”. The basic suggested model represents a simple allocation, if it is convenient. It is possible to use a different organization of transportation i.e. through a different “hub“, rather than the one to which the attraction zone of dispatch or destination belongs).

The advantage of the above –mentioned transport organization arises from concentration of transportation streams to train formation yards – hubs, which makes transportation possible economically (higher volumes of transportation) and in acceptable time periods (higher frequency of transportation). The result of load processing in train formation yards and possibility of prolonging of the routes can lead to extending delivery times in comparison with direct transportation; that is why it is suitable to organize preferred transportations and transportations on lines with high volume of traffic as certain values H. Each railway is evaluated by the number d_{ij}, which direct transportations (shuttle trains).

The question of optimal location of train formation yards is thus dependent on the question of ideal location of “hubs”. The aim of this task is to decide about the location of particular hubs and allocation of attended junction points to these hubs. The traffic network is simulated by a complete diagram G with a set of junctions V and set of railways with represents the distance of i junction from j junction in real traffic network. The volume of the traffic stream from junction i to junction j is labelled as b_{ij}.

Each shipment between nodal point i and nodal point j consists of three components: the movement from nodal point i to hub k (combined part), transfers from the hub k to hub l final distribution of shipments from hub l to nodal point j (distribution section). Direct transportation between nodal points that are not hubs, are prohibited, as well as not permitted shipments through more than two hubs. Shipments through a single hub are allowed because hubs sludge may be the same (if the nodal points i and j lie up in a single operated area). The transport costs per unit of mass flow from nodal point i to nodal point j via hubs sludge will be calculated according to the relationship: $c_{ij} = \chi * d_{ik} + \alpha * d_{kl} + \delta * d_{lj}$. The parameters χ, α, δ resolution allow the cost of collection, transport and delivery between hubs. The parameters χ and δ are usually equal to 1 (in some applications can distinguish the costs of collection and delivery), the Value parameter α can reflect the amount of savings in transport costs resulting from the concentration of transport between hubs (the value of the parameter α in the practical tasks typically ranges 0.6-0.7). The transport costs per unit of quantity c_{ij} may be using the appropriate values of parameters χ, α, δ also expressed in monetary units, a prerequisite is, however, a linear increase in financial expenses in relation to the kilometres distance.

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Own decision as to whether the node is also assigned to hub j or not, will be modelled variables H_{ij}. The Value $H_{ij} = 1$ means that node i is assigned to hub j, otherwise the value $H_{ij} = 0$ since each node k, which becomes the hub, is assigned to itself, the value $h_{kk} = 1$ indicates that the node is a Hub.

The basic shape of the role of the number of pre-established hubs, referred to as p. Each nodal point firmly assigned to a single hub (the free allocation), i. e. each shipment to / from this nodal point will be realized through this hub.

The custom mathematical formulation of the role is as follows:

Minimize $$\sum_i \sum_j b_{ij} \left(\sum_k \chi \, d_{ik} \, h_{ik} + \sum_k \sum_l \alpha \, d_{kl} \, h_{ik} \, h_{jl} + \sum_l \delta \, d_{jl} \, h_{jl} \right) \qquad (1\text{-}1)$$

On conditions: $$\sum_k h_{kk} = p \qquad (1\text{-}2)$$

$$\sum_k h_{ik} = 1 \qquad pro \;\; i \in V \qquad (1\text{-}3)$$

$$h_{ik} \le h_{kk} \qquad pro \;\; i, k \in V \qquad (1\text{-}4)$$

$$h_{ik} \in \{0,1\} \qquad pro \;\; i, k \in V \qquad (1\text{-}5)$$

The objective function (1-1) expresses the total cost (e. g. tkm, where b_{ij} transport currents expressed in tonnes and d_{ij} the distance in kilometres). Condition (1-2) ensures that p was chosen up, the condition (1-3) guarantees that every node will be assigned to a single hub. The condition (1-4) ensures that all goods are transported only through nodes that are hubs (i.e., prohibiting direct shipments between nodes that are not hubs).

Formulated task belongs to so-called NP-hard problem; This means that its exact solution is restricted to tasks with a very small scope. To solve hub location tasks, heuristic and metaheuristic methods are used. These methods are based on the principle of BBMIP (branch-bound mixed integer programming), theory of neural network, simulated annealing, Tabu Search or genetic algorithms. Efficiency and correctness of existing methods is tested on standard data CAB (Civil Aeronautics Board) and AP (Australian Post) –The first contains data of transport streams from passenger air transport between 25 biggest US cities, the second gathers data of mail transports between 20 Australian cities. The best existing methods enables finding practically ideal solution in real time for tasks ranging within about 50 junctions. For larger tasks, it is necessary to find an acceptable (sub-ideal) solution to make both ends meet.

Transport streams between particular junction railway stations were considered in numbers of wagons. Values of parameters χ, δ were equal 1, value of parameter α was set 0,7 (for comparison we carried out calculations also for value α = 0,6, with similar results). We considered simple allocation. This means that every junction was assigned to the attraction zone of just one train formation yard. The experiment verified that, in the case of multiple allocation of junctions to train formation yards, the final optimal location of train formation yards more or less differs. Nevertheless the quality of the solution, acquired on the basis of simple allocation, is not far from the ideal solution corresponding to multiple allocation. In other words – the results acquired from the solution of the simple allocation task represent quality solution even for the case of multiple allocation.

Individual solutions were analyzed in details, while following criteria were monitored:

sufficient intensity of freight traffic volume (at least 20 trains per day),

acceptable number of relations created between train formation yards,

acceptable average extent of the transportation effort when ensuring freight collection to train formation yards and distribution from them.

Considering the above-mentioned criteria, we selected, as a suitable solution, the alternative with 7 train formation yards. It is possible to organize goods transportation (with the above mentioned number and location of train formation yards) as the model „Hub-and-Spoke“. Program output for 7 hubs, when processing data file A, looks as follows: Břeclav, České Budějovice, Kolín, Ostrava, Plzeň, Přerov, Ústí nad Labem. Regarding the existing infrastructure, there were carried out corrections in some stations: Břeclav → Brno-Maloměřice, Kolín → Nymburk, Ústí nad Labem → Most. Quality of the objective function got worse for 1,6 % (from 222,25 to 225,89). Considering a relatively high frequency of transportation between suggested train formation yards, it is possible to introduce the system of small quantity shipment.

Tab. 1 Suggested location of train formation yards using the arrangement „Hub-and-Spoke“

Suggested location of train formation yards:

Brno-Maloměřice, České Budějovice, Nymburk, Ostrava, Plzeň, Přerov, Most

Source: Authors

Tab. 2 Rate of dispatched trains among train formation yards (percentage of the total number of transported wagons)

Brno-Maloměřice	České Budějovice	Most	Nymburk	Ostrava	Plzeň	Přerov
13 %	8 %	11 %	24 %	23 %	8 %	12 %

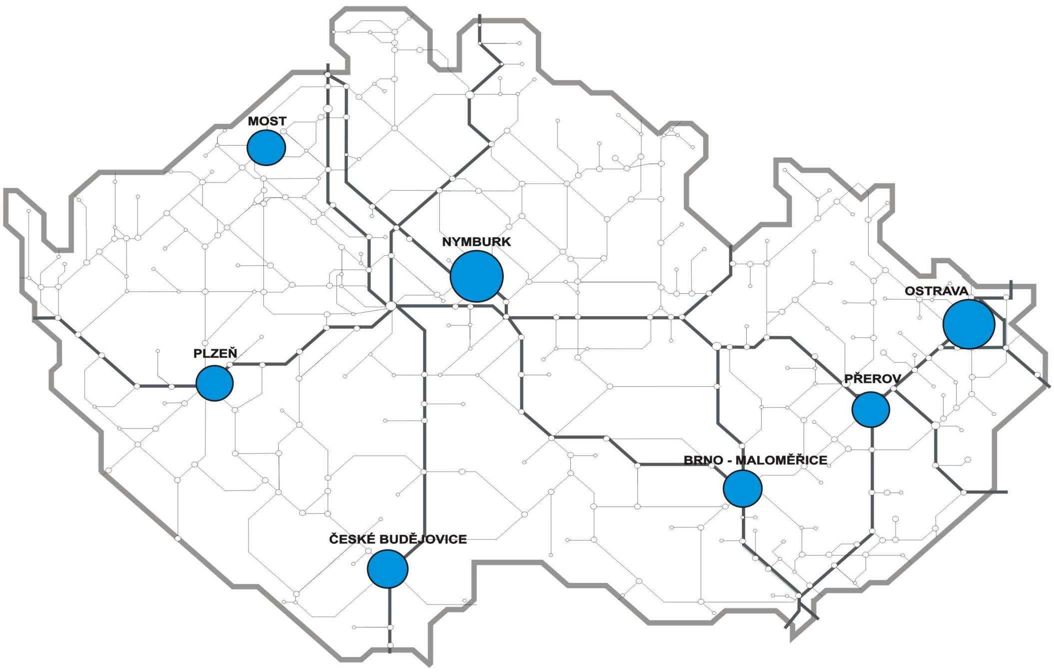
Source: Authors

When the number of train formation yards is lower, then the distances for freight collection to hubs and their distribution are quite high. This disadvantage can be eliminated by introducing the system of secondary sorting stations, permitting direct transportation between them. This is a different kind of organization than the considered arrangement „Hub-and-Spoke". While correcting location of train formation yards, considering existing infrastructure, it is possible to select suitable location of a smaller number of main train formation yards, which are presented in Tab. 3.

***Tab. 3** Selected location of a smaller number of train formation yards when introducing the system of secondary train formation yards.*

Number of main stations	Possible location of train formation yards
3	Nymburk, Ostrava, Přerov
4	Most, Nymburk, Ostrava, Přerov
5	České Budějovice / Plzeň, Most, Nymburk, Ostrava, Přerov
6	České Budějovice, Most, Nymburk, Ostrava, Plzeň, Přerov

Source: Authors



Source:Authors

Fig. 3 Location of train formation yards

When the number of train formation yards is higher, then the intensity of the freight traffic volume decreases to under 20 trains per day (for 8 train formation yards the intensity is, in case of 5 relations, under this limit – when processing data file A) and the requirements for the train formation yards effectiveness goes up (in accordance with the number of relations being created, the absolute number of processed wagons decreases). However, the suggested arrangement „Hub-and-Spoke" becomes ineffective. Presented optimization of number and location of FTC is one of the examples of using mathematic methods in transportation. Regarding the fact that this issue is very wide, we presented only the main points of the approach leading to Freight Transport Centre optimization. There are many other aspects, which could be included into this model. However, this is the subject of further solution development of this question.

3 The Price and Quality of Outputs and Services

3.1 The Cost of Services and Performance

For a customer is the crucial price you must pay for the logistics service provider, or its performance. Of course, the customer is best for the lowest price, but the opposite is perceived for the provider (logistics organization).

The lowest prices are offered to operators in the transport logistics market operating in a perfectly competitive environment. Such work environments where transport infrastructure is state owned equally, and that it maintains.

Such examples include commodity corridors, which offer at least two transport modes at a technical and performance-comparable infrastructure. The customer can not talk about the optimal price, if he can not choose from several modes.

The cargo centres (or logistics centres) should offer a combination of commodity flows, using at least two modes, it is called multimodal transportation.

3.2 The Quality of Outputs and Services

There are many factors affecting the quality of the relationship between supplier and customer, but that is probably the most important customer satisfaction with the level of service and performance.

The services provided by the customer are broad term that is difficult to define short. Include contacts between the two entities both tangible and intangible nature. The basic premise of customer satisfaction is logistical prowess companies from which derives a high level of service and performance, which has a direct impact on the quality of the relationship and customer retention. Such a strategy, logistics providers and performance leads to long-term profitability.

On the basis of established criteria, to determine the level of customer's services, which may differ for individual customers, market segments and distribution channels vary. Among the critical factors include the following:

a) timeliness of delivery of *t*, we find that according to the formula:

$t = \frac{T_c}{Q} \cdot 100$ [%], where

T_C .... number of deliveries made during the agreed delivery period [-]

Q ... the number of orders [-]

b) the delivery is completed *k*, we find that according to the formula:

$k = U \cdot Q \cdot 100$ [%], where

U .... number of complete (full) supply [-]

Q ... the number of all orders [-]

c) *b* is a state with no errors, we find that according to the formula:

$b = (B \cdot F) \cdot 100 [\%]$, where

B .... number of error free invoices [-]

F ... all invoices [-]

The overall supplier performance indicators can be calculated as the product of those sub-factors: $V = t \cdot k \cdot b$ [%]

4 Conclusion

The Freight Centre is a place that can be classed as a public logistics centre, into which enter both profit and non-profit businesses to provide customers with a wide range of logistics services and activities on the non-discriminatory principle. Such space shall be connected to at least two modes (each road and rail transport and the local conditions in inland waterway and air transport). On the basis of compliance with this condition provides the modality of transport and modality of transport capacity. Precondition for the emergence respectively location on the transport network is that there is sufficient current and potential development of the production/consumption. The benefit of such a centre is the optimal and efficient transport service of a particular area and reducing the negative effects of so dominant road transport on the environment and public health and the provision of logistics services to small and medium business entities.

The public interest is such an interest, which is mainly borne by public authorities to apply the public interest (corporate interests). These interests must not be in conflict with applicable laws and as such must be certificated by the authorities. The term "public" can be combined with the concept of public interest, which is mainly applied in public policy, public economics, ethics and law. It refers to the general good and social welfare. Generally, the public interest is called a policy that promotes the development of society and solves its real problems. From this definition it is clear that the identification and recognition of public interest can be (and is) a source of conflict in society, because ideas about what is good for society and what the problems are different. Recognized public interests may be formulated by the legislation. The public interest is associated with sustainable development, economic growth, public health and safety.

The public logistics centre is involved in sustainable development, which is a way of development of human society, in reconciling the economic and social progress with full preservation of the environment. The main objectives of sustainable development include the preservation of the environment to future generations in the least modified form. The European Parliament has defined sustainable development as "improving living standards and welfare of people within the capacity of ecosystems for the conservation of natural values and biodiversity for present and future generations."

The public interest in the existing legislation is substantively defined, but often used to mean so-called indeterminate terms. The Public interest is the opposite of the interests of "private" group, intermediate or short term. It often used in the defence bills, other legislation and practical application of the requirements of public administration, for example in the field of spatial planning and decision-making in nature conservation and landscape protection of the agricultural land fund or investor activity in the building management. In terms of specific interests may (public and private) operate not consistently, but against each other.

The nature of things can be inferred that the public interest or interests are those whose owners are primarily the public authorities, which apply in their jurisdiction to the public interest (corporate interests). These interests must not be in conflict with applicable laws and as such must be certificated by the authorities.

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