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INTERCHANGING POINTS IN PUBLIC PASSENGER MASS TRANSPORT

PŘESTUPNÍ UZLY VE VEŘEJNÉ HROMADNÉ OSOBNÍ DOPRAVĚ

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Summary: The paper is focused on meaning of interchanging points in the public passenger mass transport. The impact of interchanges over total travel time is expressed in the paper. The relation to capacity of interchanging points is also mentioned in the paper. The proposal of interchanging points classification from operational point of view is mentioned in the final part of the paper.

Key words: public passenger mass transport, interchanging, interchanging points, capacity.

Anotace: Článek se zabývá významem přestupních uzlů ve veřejné hromadné osobní dopravě. Je zde vyjádřen vliv přestupů na celkový cestovní čas. Je zde zmíněna i vazba na kapacitu přestupních uzlů. Závěrečná část článku je zaměřena na návrh klasifikace přestupních uzlů z provozního hlediska.

Klíčová slova: veřejná hromadná osobní doprava, přestupy, přestupní uzly, kapacita.

1. INTRODUCTION

Interchanging is essential part of public passenger mass transport operation, because it is not possible to provide this service as a door-to-door system. On the other hand every interchange is an obstacle for passengers and the number of interchanging passengers has to be minimized in the frame of acceptable operational binding conditions.

Creation of structured set of lines with utilizing of interchanging is also able to bring significant effects from the operational point of view. Operational costs are able to be optimized; some effects are leading to improved quality of transport service etc.

2. INTERCHNANGE AND TRAVEL TIME

It is useful to define a meaning of interchange in the transportation process. The most significant is increased time consumption of passenger. It is able to been seen on following formula (1) characterizing the calculation of travel time in public passenger transport.

$$T_c^{VHOD} = t_p + t_z + t_v + \sum_{j=0}^{n_p} \left(t_{p\,j} + t_{zj} + t_{vj} \right) + t_k + t_o \ [\mathrm{min}] \qquad (1)$$

where is:

T_c^{VHOD} total travel time of passenger [min],

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t_p access time (walking time) [min],
t_z waiting time at boarding stop [min],
t_v travel time in the first vehicle on the transport route [min],
j index for interchange,
t_{pj} time for transfer in *j.* interchanging point [min],
t_{zj} waiting time in *j.* interchanging point [min],
t_{vj} travel time in *j.* consequential vehicle [min],
t_k time spent in alighting stop [min],
t_o egress time (walking time) [min].

Special role is played by waiting times t_z and t_{zj}. The calculation formula for these values is able to be constructed as following formula (2).

$$t_z = k_{\mathrm{int}} \cdot I_{nl} + t_{konst} \quad [\mathrm{min}] \tag{2}$$

where is:
t_z total waiting time of passenger [min],
k_{int} factor for incorporation of part of consequential line interval [-],
I_{nl} interval of connection on consequential line [min],
t_{konst} constant penalty [min].

The travel time expressions [1] based on the formula (2) are significant for implementing of (non)established time coordination of time schedules into consideration. In the case if the time coordination of time schedules of both lines is not established, it is often used the value 0.5 of interval factor. It means that the (average) waiting time is a half value of line interval I_{nl}. The knowledge of time schedule and its acceptance by passengers is able to be expressed by the constant penalty t_{konst}. This is useful e.g. in regional transport where people know the departures of connections and do not feel waiting time as a half of interval, because they are orienting in consonance with known time schedule.

For above mentioned reasons it is necessary to focus on these waiting times, especially by interchanging to reduce of these waiting times.

3. PREFERENCES OF PASSENGERS

It is important to know what type of transport organization is preferred by passengers. It is able to be realized a transport survey focused on this factor. For instance two interesting values were surveyed in the frame of opening of new segments of the line C of Prague underground by the ROPID (Prague Integrated Transport Organizer) in the year 2008 [2]. Direct connection without interchanges in spite of longer travel time is preferred by 62 % of asked passengers and lower number of lines with higher number of interchanges and shorter interval on these lines is preferred by 65 % of passengers. This type of information is important by transport planning, because it is representing claims on transport quality.

4. ORGANIZATIONAL REQUIREMENTS FOR INTERCHANGING POINTS

Every public transport stop with more lines than one is able to be an interchanging point. But there are able to be found some requirements on interchanging points from the organizational point of view.

The organizational requirements are connected usually with time schedule. It is necessary to make optimized location of interchanging points in the area especially from the point of view of integrated improved frequency time schedule, because the condition for so called “edge time” has to be kept. The condition is that the edge time (time for passing of edge between two neighbour interchanging points) has to be an integer multiple of half of time schedule period.

Second time schedule based condition is connected with capacity of interchanging points. In the case of integrated improved frequency time schedule, all connections have to meet in an interchanging point together. The capacity requirements are increased in this case, because every connection has to have a platform edge available at the moment creating so called axis of symmetry [3].

The dimensioning of interchanging points capacity is also necessary to been taken into account. Capacity estimation methods used on railway (SŽDC D24 [4] or UIC Codex 406 [5]) have limited information capability for this purpose, because of macroscopic character of these methods. For instance occupation grade of tracks with platform edge in the railway station Plzeň main station estimated in the case study [6] is only 0.3, but 80 % of disponible tracks with platform edge are occupied at the moment creating axis of symmetry for studied operation scheme (proposed operation, these values are not corresponding to state-of-art reality). The disproportion between theoretically estimated and real values is illustrated by this case.

The similar situation is able to be seen also in the case of bus stations especially where the necessary number of stops has to be ensured. This problem is also connected with area requirements in the solved place.

The location of interchanging points is discrete optimization problem as follows from above mentioned facts. It is usually not possible to locate an interchanging point anywhere in the area. There is able to be found a finite set of existing and potential locations of interchanging point, especially in the case of railway infrastructure. The space requirements for location of bus stations are limiting also in the road transport.

5. EQUIPMENT OF INTERCHANGING POINTS

Specific role is also played by equipment of interchanging points, because interchanges have to be comfortable for acceptation by passengers.

Passengers have to be protected from inclemency of weather; they also have to be informed and protected from danger.

The possible danger is seen in two levels – protection from criminal cases and operational safety (protection from traffic accidents). These questions may be very important because in the case of threat of passengers, passengers are able to decline the provided transport service.

Equipment of interchanging points is also able to be divided in two groups. The first group is equipment connected with provided transport service like information system, ticket vending machines, information centre, waiting rooms, toilets etc. The second group is able to be classified as equipment for customer care (shops, fast food etc.) [3].

As follows from German experiences [7] providing of services in the interchanging points is able to stimulate transport demand. This is especially case of important railway stations. Closed station buildings without any services for passengers will not attract passengers. The interchanging points with additional services will compensate waiting time of passengers by possibility of using of these additional services and from the theoretical point of view it will make optically shorter travel times.

On the other hand from economical point of view it is not possible to ensure these additional services in every interchanging point. For that reason also in this case there is a claim to create a defined structure of interchanging points which will be modernized and developed.

Extent of equipment of interchanging points are mentioned also in the Czech Technical Norm ČSN 73 6425-2 [8] focused on interchanging points.

6. CLASSIFICATION OF INTERCHANGING POINTS

Interchanging points are sorted as interchanging point for city transport, for regional transport (with lesser or higher traffic density) and for supraregional transport by the Norm ČSN 73 6425-2 [8].

The base for classification of interchanging points is created by the norm, but there are able to find more points of view, how the interchanging points are able to be classified.

Specific classification of interchanging points with regard to the function and meaning in the ITrS was been proposed [9]. The interchanging points are divided into: interchanging terminal, interchanging place, interchanging stop and double interchanging point.

Interchanging point – is general term for all stops and places, where interchanging is possible.

Interchanging terminal – is an interchanging point served by higher number of connected lines or modes of transport. The stops are divided after individual lines or groups of lines. The additional services (waiting room, fast food etc.) are provided in these terminals.

Interchanging place – is an intersection of two or more lines (or lines of more transport modes). The stops are divided after individual lines or groups of lines or groups of lines. Basic additional services are at the disposal only.

Interchanging stop – is an intersection of more lines of one transport mode in one stop.

Double interchanging point – is specific case of two individual interchanging points located on different places, but with strong transport relation. Typical example is railway and bus stations in one city, but located on different places. It is sometimes useful to consider these interchanging points together as one point.

The classification is proposed in general way because it is able to be specified for the concrete conditions. The classification creates the basic scale only. The claims for including of interchanging points into categories are able to differentiate by extent of solved area (city, region, state). For instance interchanging terminal of city public passenger transport can be considered as an interchanging place in point of view of whole state.

There are able to be found two accesses to classification of interchanging points. The first is connected with type of public passenger transport (e.g. city, regional, supraregional) as it is based in the norm ČSN 73 6425-2 [8] and the second access is connected from the point of view of solved area. This access will be better because in the case of integrated public transport systems all types of transport are able to be dissolved.

Determining of claims on interchanging points is important because willingness of passengers to interchanging is able to be influenced by equipment, location and safety of interchanging points. It is necessary to study all of aspects influencing the willingness to interchange and to create clear requirements on interchanging points.

Tab. 1 – Table of requirements on interchanging points

Point of view	Terminal	Place	Stop
State (supraregional)	requirements on terminals from state point of view	…	…
Regional	…	…	…
City	…	…	requirements on stops from city point of view

Source: Author

Every interchanging point planned or operated in the area has to be included from all points of view. Three fields of table 1 will be selected and the strictest requirements from these 3 selected fields will be realized (proposed) in the project. The relation between both accesses (type of transport, based in the ČSN 73 6425-2 [8]) and proposed operational access will be ensured by the table 1.

7. CONCLUSIONS

Interchanging is a serious problem of transport planning, because the final product – transport service is able to be influenced by realized solution. There is able to be found relation to travel time. The location of interchanging points has to be realized also in the frame of integrated time schedule with other specific requirements on the construction of the transport network. The capacity of interchanging point is also one of binding conditions for solution of this problem. For that reason the location of interchanging points is seen as a discrete-optimization problem. On the other hand also the passengers have not pronounced preferences if they prefer transport without interchanges by longer interval between connections or transport with interchanges by shorter interval. The classification of interchanging points is proposed as one of helpful tools for solution of these questions, because the specification of requirements on interchanging points is able to help by optimizing of location problem (possibility of construction of interchanging point in selected area) or by creation of line structure (number of interchanging points of each type in context of construction and operational costs). The relation between proposed classification and the norm ČSN 73 6425-2 [8] is also introduced in the paper.

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