Attractiveness of public transit can be evidently improved by optimum schedule synchronization without noteworthy investment. Optimum synchronization means minimizing transfer cost (passengers * waiting time) of transfer points. This special operational control task should be integrated into computer aided scheduling; prerequisite is a dialogue-oriented implementation which allows dispatching in form of sensitivity analysis, i.e. direct evaluation of computation results on a work-station.

1 Introduction

Quality of public transit is characterized by different features such as cycles (headways), accessibility, direct relations. The attractiveness of the public transportation system can be improved if a demand oriented route network with fixed cycle operation is additionally tuned concerning the dispatch aspect so that transfer times are minimized.

2 Problem

The problem of schedule synchronization is to minimize the total transfer waiting times which are the sum of individual waiting times within given operation hours.

The problem is described in the figure below:

![Transportation network with 3 routes](image)

*Figure 1: Transportation network with 3 routes*

The given network comprises 3 routes with transfer possibilities:

- at station A from route 2 to route 3 and vice versa,
- at station B from route 1 to route 2 and vice versa,
- at station C from route 1 to route 3 and vice versa.
Departure times of modes at the routes' respective terminals cause certain arrival times at stations A, B, or C and therefore waiting times for transfer. Multiplying the waiting time of transfer relation by the number of commuters who use this transfer point results in the "transfer cost" for this relation. The sum of the cost for all transfer relations of a transport network is the total transfer cost.

It is the objective of this optimization problem to minimize the total cost given the following restrictions:

- the riding times between the stations are constant;
- all routes are operated with equal or different but fixed cycles;
- the transfer flows are not dependent on arrival times of modes.

\[
\begin{align*}
\text{route 1 with cycle } &= 2 \text{ minutes} \\
\text{route 2 with cycle } &= 2 \text{ minutes} \\
\text{route 3 with cycle } &= 3 \text{ minutes}
\end{align*}
\]

- operated in one direction
- transfer between all routes

\[
T_1 = 2, \ T_2 = 2, \ T_3 = 3
\]

\[
K_1 = \{1,2\}, \ K_2 = \{3,4\}, \ K_3 = \{5,6,7\}
\]

\[\text{arc values} \ (\text{passengers} \times \text{waiting times})\]

\[\text{----- = permissible timetable (permissible solution)}\]

Figure 2: Route-graph