Oberseminar Schöbel
Integration of several Planning Steps in Public Transportation

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Problem

Traditionally, the construction of a public transporation network, like for busses, metro or intercity trains, consists of the following planning steps

1. **Network Design** Where to put the stations?
2. **Line Planning** How to layout the lines?
3. **Passenger Routing** Which paths will passengers take?
4. **Timetabling** At which times will lines arrive/depart at the stations?
5. **Vehicle Scheduling** How should the lines be served by vehicles?
6. **Crew Scheduling** How should the crew circulate within the vehicles?
7. **Delay Management** What to do in case of delays? What is the overall delay sensivity?

Usually, the steps are done in the order above by hand and heuristics. But the questions arise:

> "Of what quality will our network be? How far is it away from optimum? Can we do it better?"

LinTim, a project by Prof. Schöbel, is a collection of methods to perform some of the planning steps above automatically. With LinTim we can e.g. evaluate the impact of different line planning methods on the average traveling time or the delay robustness.

> "Why can't we simply compute the optimum? Aren't we mathematicians?"

Traditionally, there exist linear formulations for the single steps. Let's have a look at the periodic timetabling objective function:

$$\min \sum_{a \in \mathcal{A}} w_a x_a,$$

where w_a is a fixed number of passengers that take the activity a (drive, wait or change) and x_a its duration.

In that model, the number of passengers is *fixed*. If we assume that passengers will take the shortest path in time to get from one station to another, lets say they looked it up at `reiseauskunft.bahn.de`, their number is actually *not fixed*. As expected: in general, the average traveling time decreases, if we reroute the passengers and recalculate the timetable. This holds event for small networks and means that the traditional model only delivers an *approximation* to the optimum, which is dependent on the initial assumption about passengers routes.

If we follow the traditional traffic planning workflow, another problem arises: some steps at the beginning actually depend on data we only get at the end, as we have seen for the timetabling where we need to perform some initial guess. But this goes down much further: At the line planning step we also made assumptions about how many passengers will use certain links within the network, which we only know after timetabling. The same is true for network design.

Approach

But how to tackle these omnipresent chicken egg problems? As we have seen with timetabling, we can iterate the passenger distribution, even further down to line planning or network design. Another approach is to solve a mathematical problem, that incorporates several steps. Unfortunatly, altough it can be made linear with some effort, it is gigantic in its dimensions and of course NP hard, as its single steps timetabling and line planning already are.

So there are four big challenges:

1. Find good initial solutions for timetable rerouting iterations
2. Use the freedom of choice with the shortest paths in a way the timetabling can profit from it in the iteration
3. Reduce the size/complexity of the big problem
4. Find heuristics for the big problem

The talk will be a continuation of the talk in February with a short formal introduction and present some results on timetabling-routing integration on small networks and counterexamples to illustrate the interdependence of the steps.