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ANALYZING SYNCHRONIZED TIMETABLES IN PUBLIC TRANSPORT PLANNING

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Summary: The timetabling problem is addressed at the tactical stage of public transport planning and involves determining the departure times for each run. One suitable approach to this problem is through the synchronization of runs, which considers that each ordered pair of runs is synchronized if their arrival times fall within a specified time window. Considering a time window allows accommodating some of the variability inherent to operations.

The main objective of this study is to reduce passenger waiting time and improve overall service quality through enhanced timetable synchronization. We studied the Metro do Porto network timetables in the first runs of the day. Special emphasis is placed on improving synchronization at longer-distance connections, seeking smoother and faster transitions for their passengers.

The methodology involves generating and evaluating synchronized timetables. To create these timetables, we applied a synchronization model using Mixed Integer Linear Programming (MILP). The model objective function prioritizes longer-distance connections, thus enhancing the coordination of transport services between central and peripheral areas. A baseline scenario was established, aligning the model's parameters with the existing real-world timetables as closely as possible. Additionally, five alternative scenarios were analyzed by adjusting parameters related to transfer time windows and allowable headway variations.

The evaluation process involves comparing the existing timetables with those generated by the optimization model. The assessment criteria include six metrics: the value of the objective function, the number of synchronizations, the optimization gap, processing time, and two indicators quantifying bunching. Additionally, timetables are analyzed using space-time diagrams for visualization.

The analysis results demonstrate the model's effectiveness in improving synchronization and reducing bunching. Although the synchronization model does not eliminate bunching, it significantly mitigates its effects.

Future research could explore the development of constraints to prevent bunching events. Additionally, it could extend this case study by adopting an integrated approach to timetabling and vehicle scheduling and by examining connections between Metro do Porto and other transport modes in the city. Further investigation could also include analyzing additional daily demand periods to enhance service coordination.