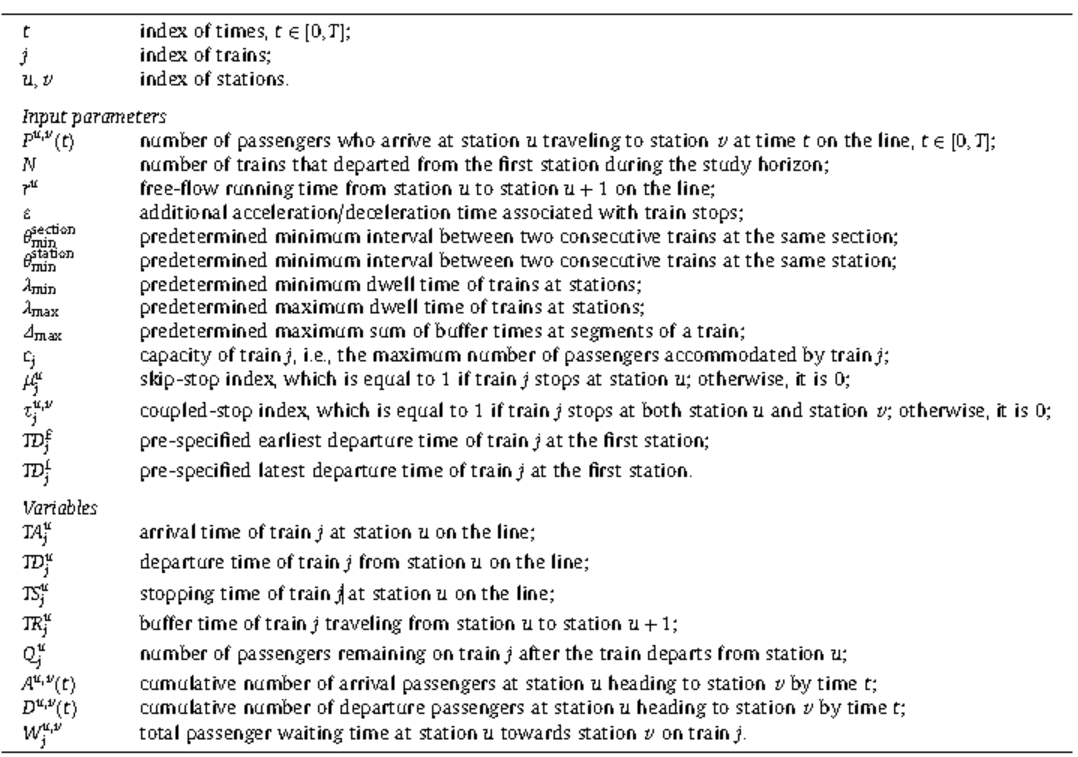
*Reference: Train scheduling for minimizing passenger waiting time with time-dependent demand and skip-stop patterns: Nonlinear integer programming models with linear constraints*

Huimin Niu, Xuesong Zhou, Ruhu Gao

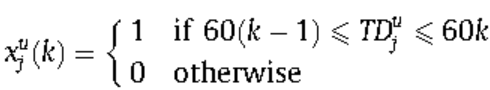
Problem Statement

This paper focuses on how to minimize the total passenger waiting time at stations by computing and adjusting train timetables for a rail corridor with given time-varying origin-to-destination passenger demand matrices. Given predetermined train skip-stop patterns, a unified quadratic integer programming model with linear constraints is developed to jointly synchronize effective passenger loading time windows and train arrival and departure times at each station.

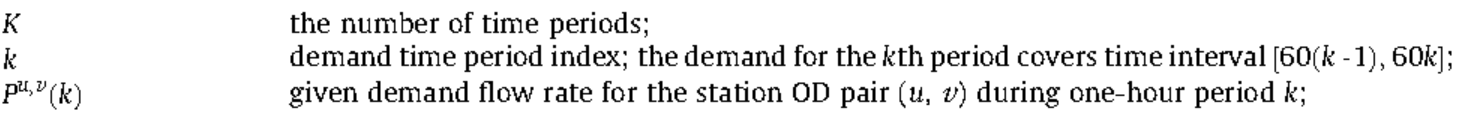
1. **Notations**



1. **Binary variables for low-resolution model**



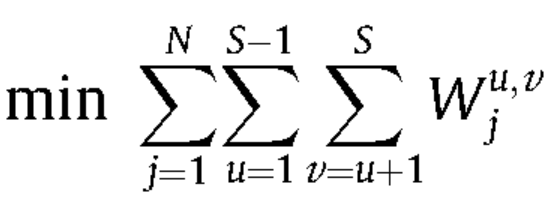
1. **Other variables for low-resolution model**



1. **Low-resolution demand model summary**

*Attention: Assuming that train j and dummy train at either the same time period or adjacent time periods*

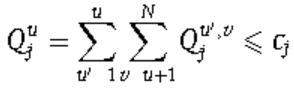
1. Objective function- minimize total waiting time: *Equation-(1)*



*Equation-(2)*

*Equation-(3)*

1. Train capacity constraints

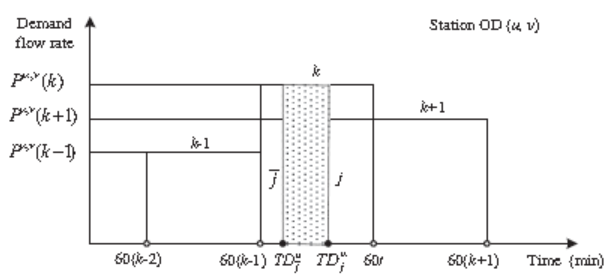


*Equation-(4)*

Scenario-1: train-j and train- within same time period-k

*Equation-(5)*

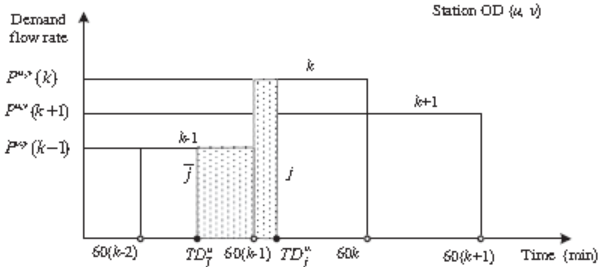
=1 *and*



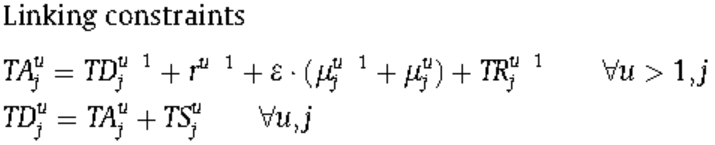
Scenario-2: train-j and train- within different time period-k and k-1

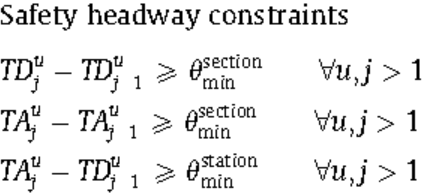
*Equation-(6)*

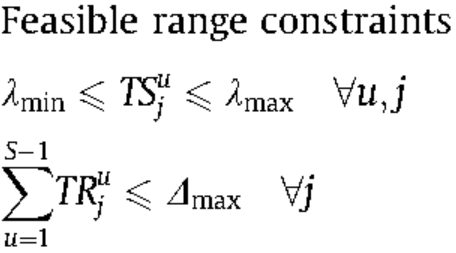
For k,

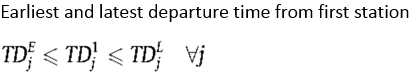


1. Other Constraints

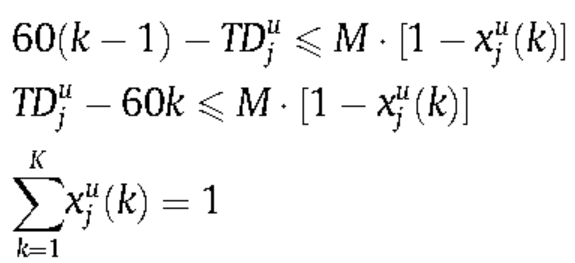








Constraints for



Conclusions

A unified nonlinear integer programming model with linear constraints is developed for both high-resolution and medium-resolution time-varying demand data. By introducing binary loading indicator variables, a train timetable optimization model with minute-dependent passenger demand inputs for short-term scheduling applications was formulated.