Using Real-Time Tracking Data to Better Understand Public Transit

Adam Iaizzi*
and
Dries Sels

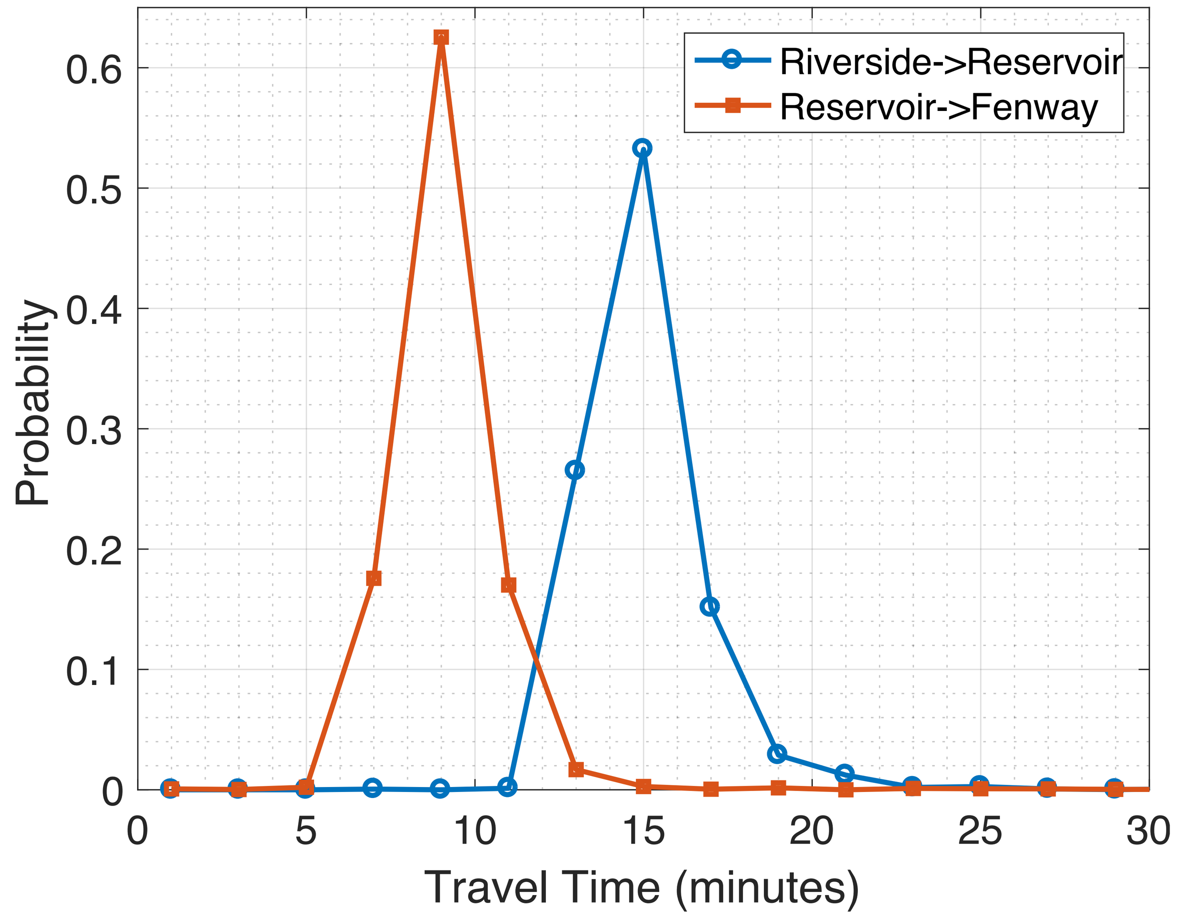
Introduction

Every day, millions of people commute on public transportation. Evenly spaced buses or trains exhibit headway instability: a tendency to bunch up due to external perturbations, especially passenger-mediated interactions between trains.[1,2] The result is familiar to many: wait 20 minutes for a train that should come every 10 minutes, and then two arrive one after another. How does the headway change as trains move down the tracks? Previous studies have been based on limited, manually collected data. The Massachusetts Bay Transportation Authority (MBTA) recently made live position data for Green Line trains available online.[3] We recorded for several months, collecting millions of train positions. Using this data, we study of the motion of Boston's Green Line light rail network.

The Green Line is the most heavily used light rail system in the United States, consisting of an underground portion which splits up into four separate lines above ground. We analyze the motion of inbound trains on the above ground portions of two branches of the Green Line: the Riverside (or D) Line and the Boston College (or B) Line. The Boston College Line operates at street level, stopping frequently to pick up passengers and wait for crossing car traffic. The Riverside Line runs in a trench, separated from other vehicle traffic and its stops are much more widely spaced. For simplicity, we consider only 'midday' traffic between 9:00 and 15:30.

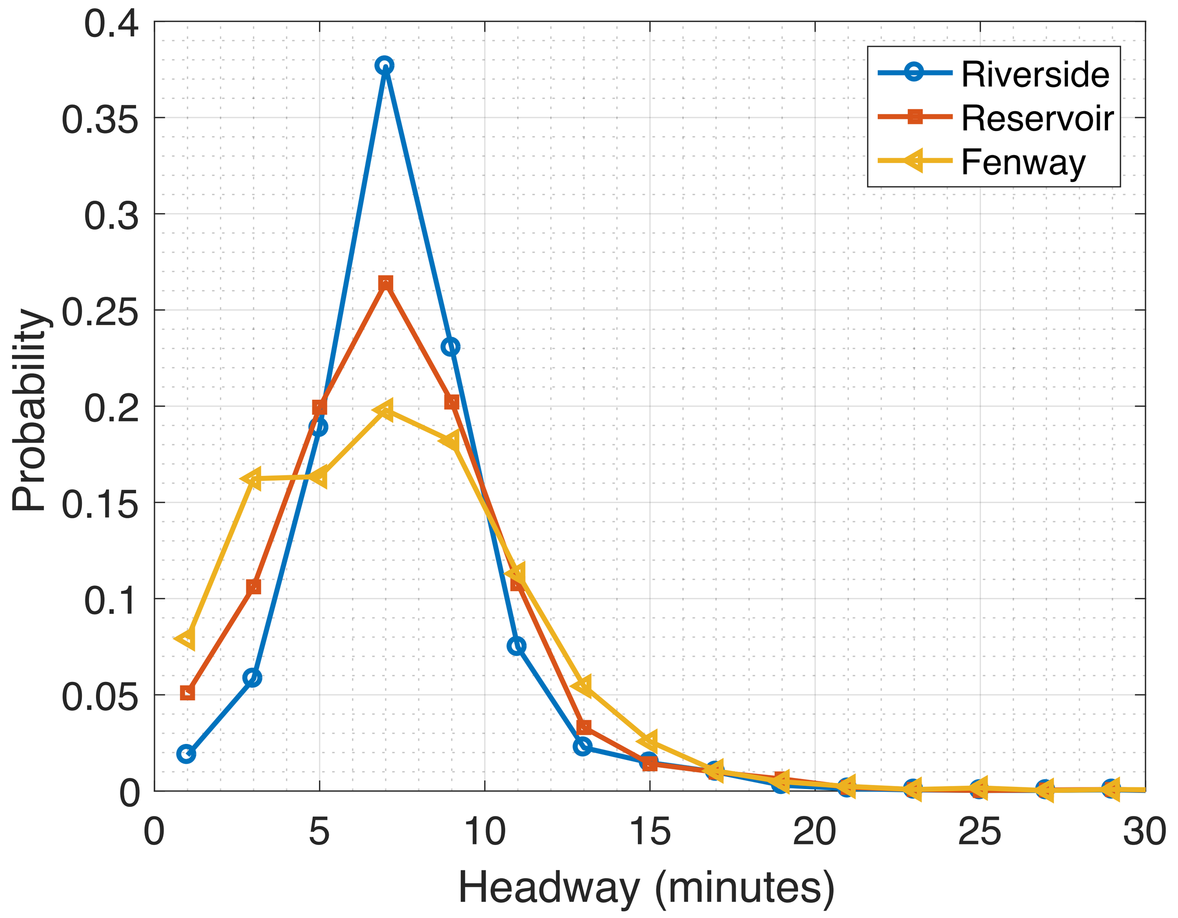
1-2 Step

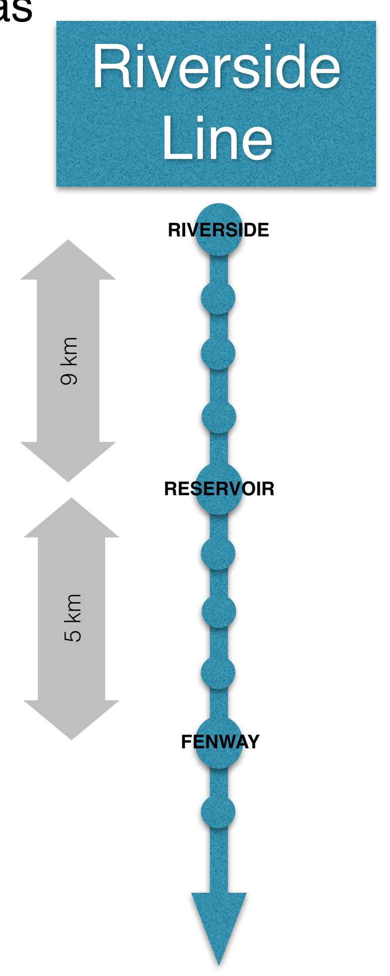
Total trip time can be broken down into two components: time spent waiting to board the train and travel time once on board the train. The latter time is relatively predictable. **Below** we present a histogram of travel time for the Riverside Line. Both distributions are sharply peaked around their averages. The travel time contributes little to the variability in the total trip time.

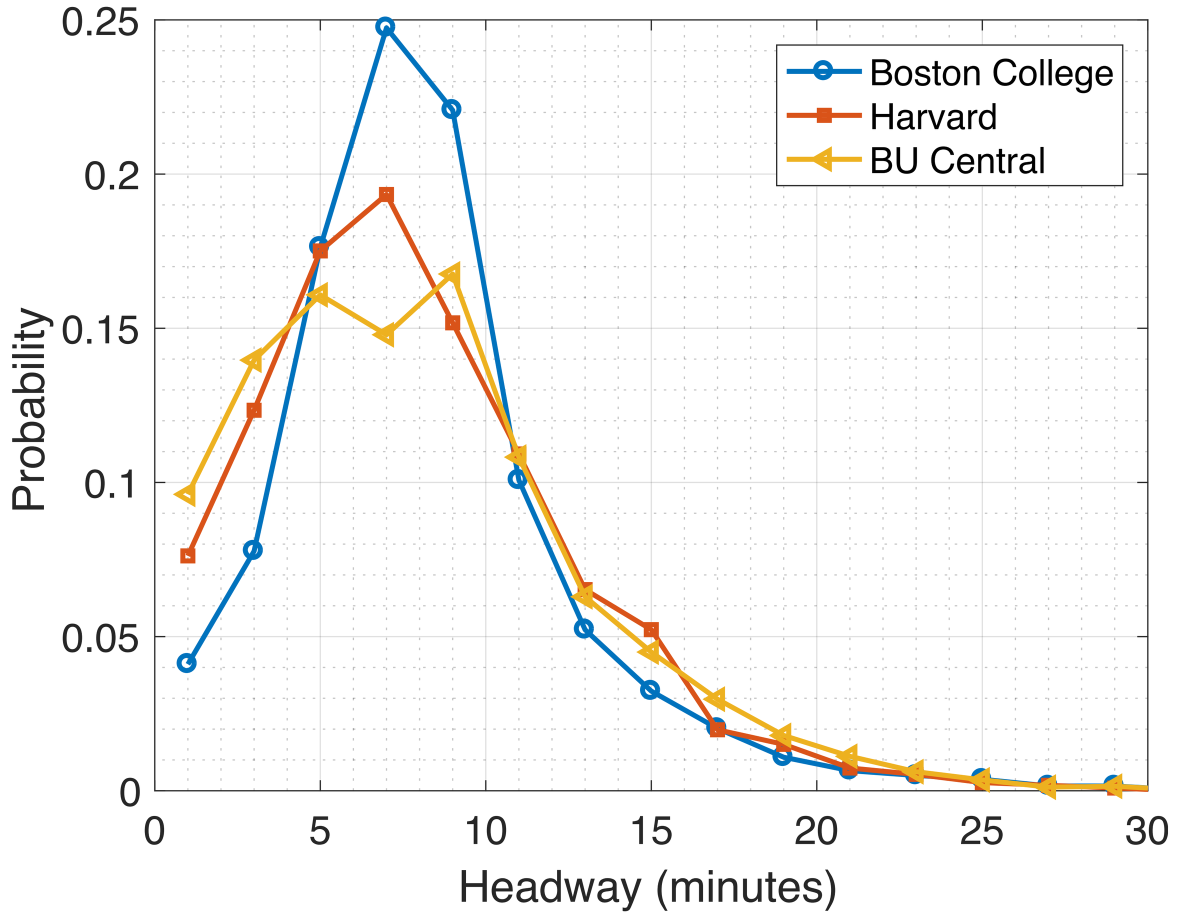


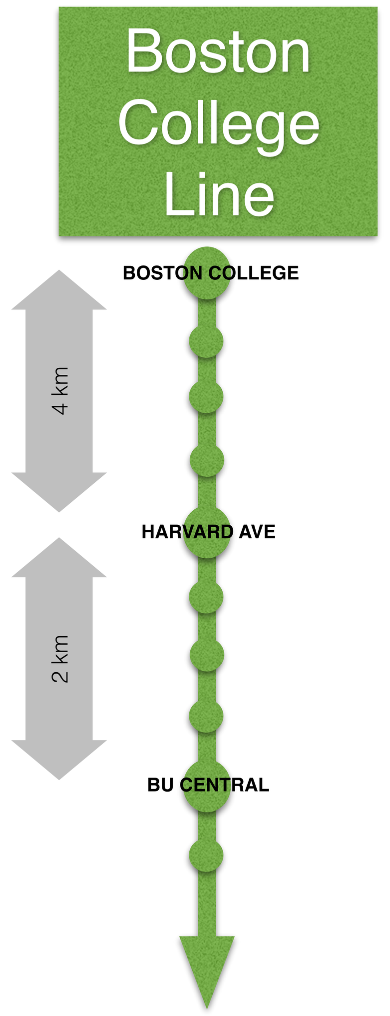
Headway

Headway is the name given to the time between train arrivals. Below we present histograms of headway for the Riverside (**top**) and Boston College (**bottom**) Lines. For trains leaving the origin stations (Riverside and Boston College, respectively) we indeed observe a sharp peak around the advertised frequency of 8 minutes. As trains move further down the line the peak collapses and the distribution develops a long tail, indicating that trains frequently form bunches separated by long gaps. This effect is more pronounced in the Boston College Line, which has more sources of noise. Note the different y-axis scales.



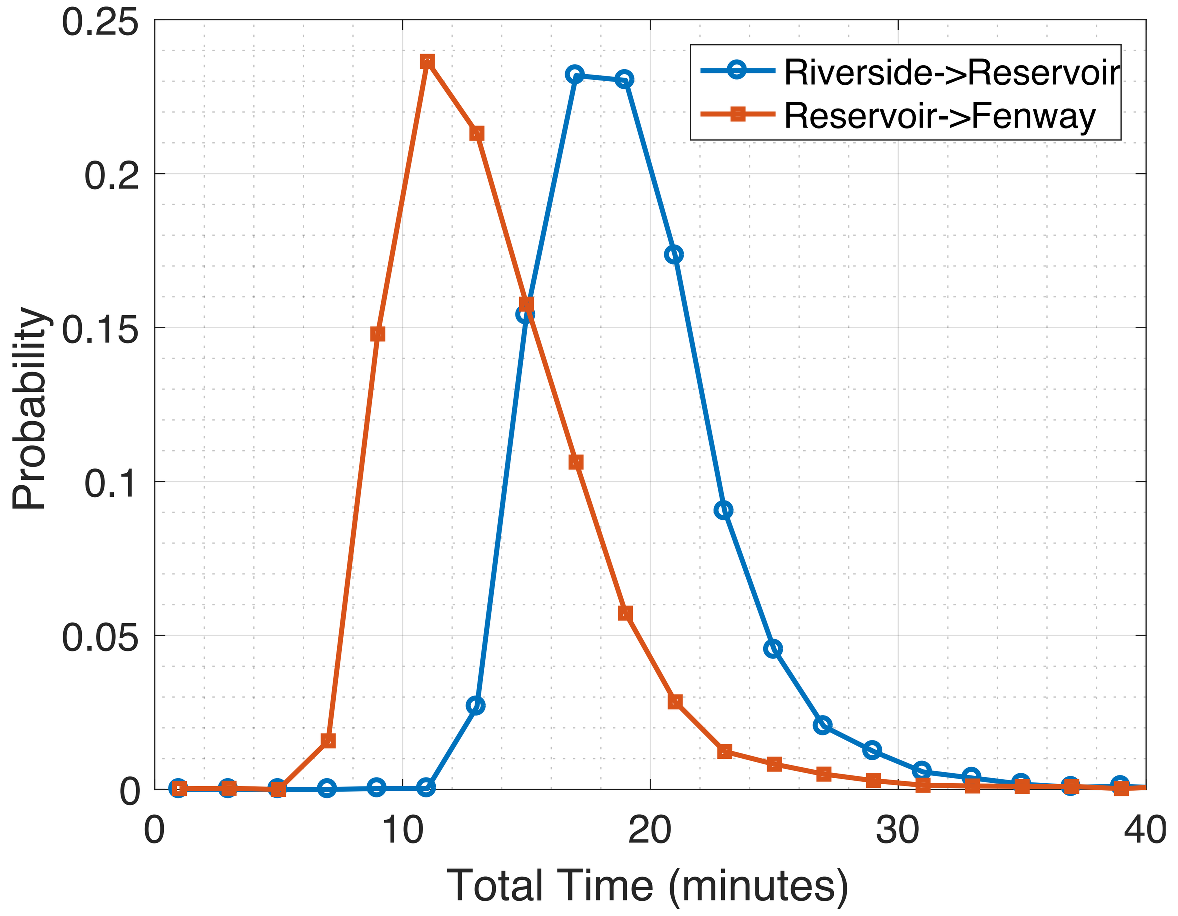


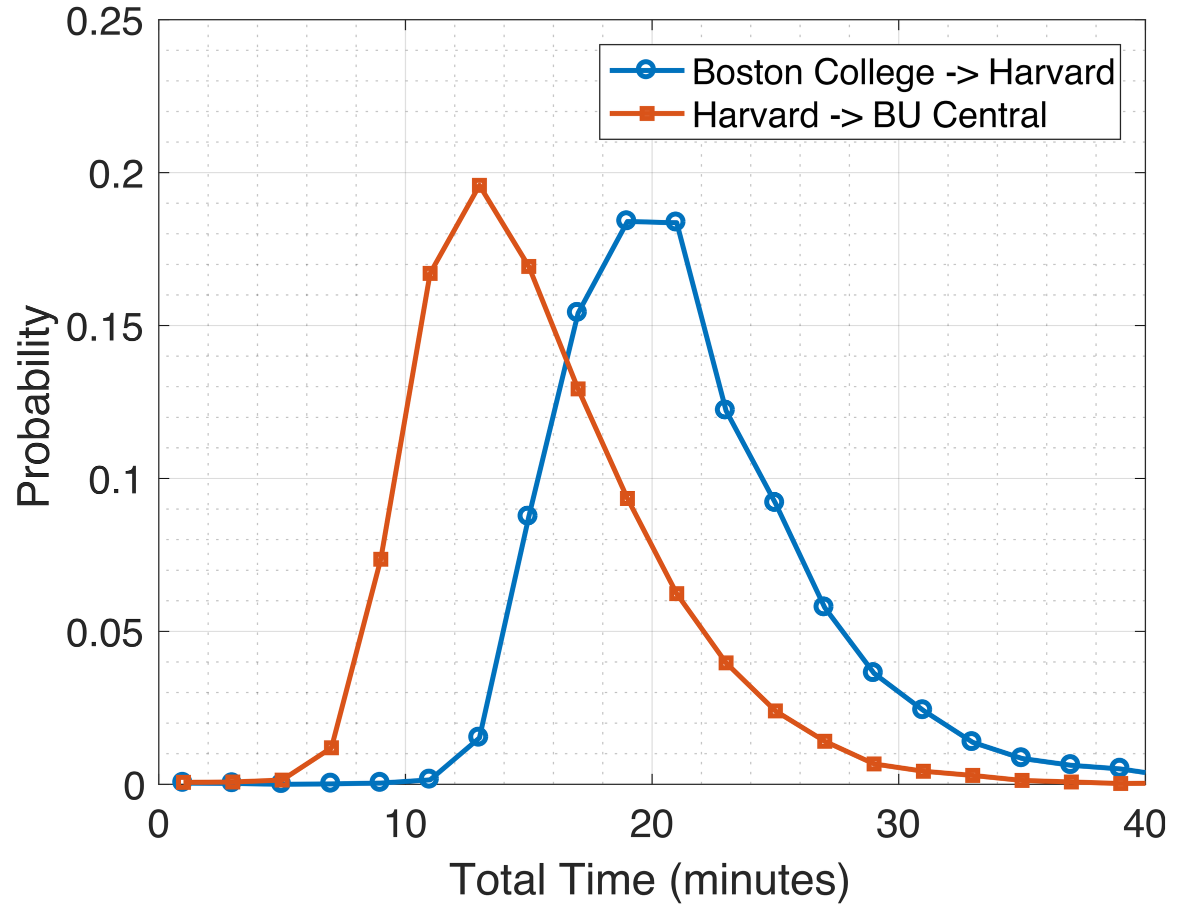


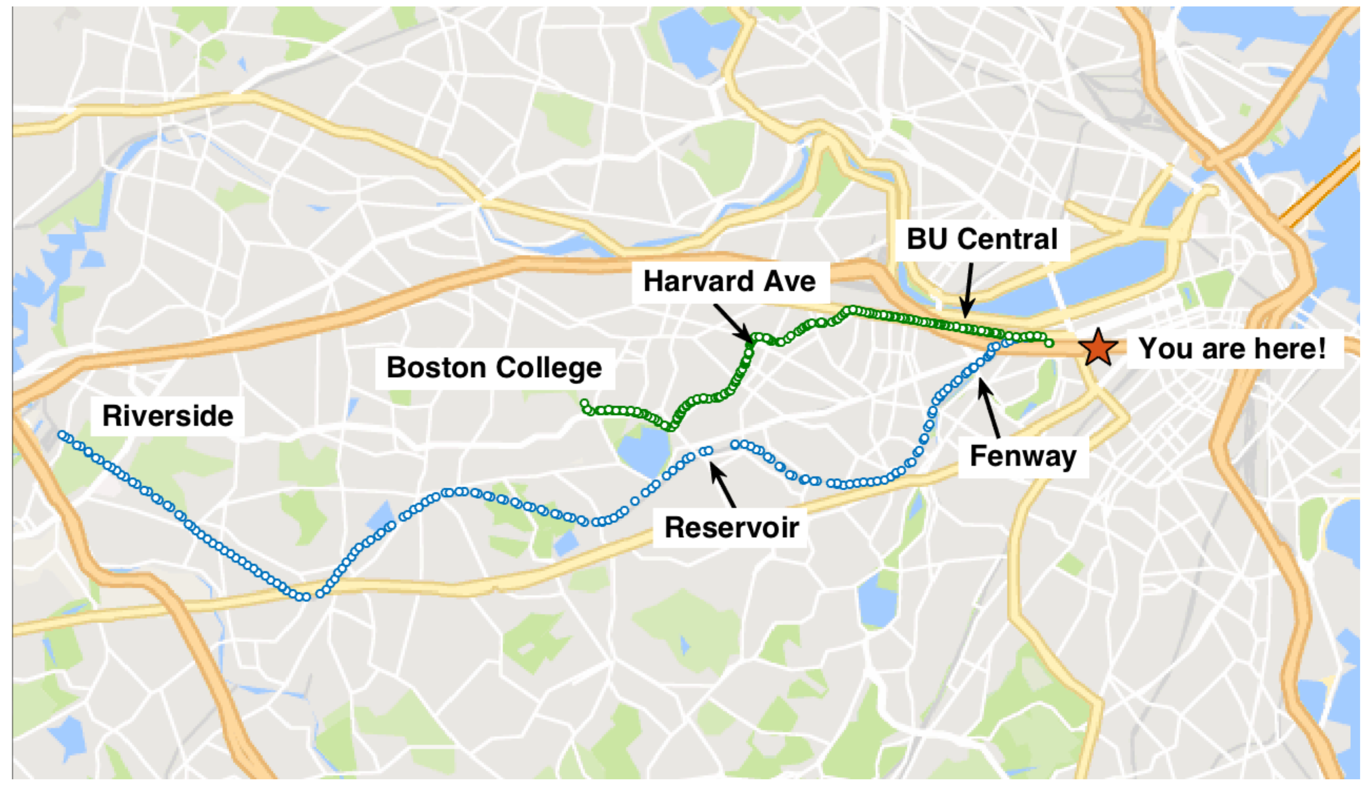


Total Trip Time

(**Top**: Riverside Line, **bottom**: Boston College Line) Histograms of the total trip time including waiting at the station and time spent riding the train produced by combining real train data with simulated passengers arrivals. For passengers, long tails are problematic, because they correspond to high variability in the time required to complete a trip.







Green Line map. The Boston College Line is shown in green and the Riverside Line is shown in blue.

Conclusions

Using MBTA Realtime data,[3] we have conducted a study of travel times of two Green Line branches. In both cases, the headway distribution collapses rapidly as trains move down the line. Headway instability causes large variations in the time required to complete a trip. This is a serious problem for commuters, who must leave well in advance of their average travel time in order to guarantee that they arrive on time most days. Commuters that must transfer between lines are doubly exposed to this effect. Decisions about public transportation should consider both the *average* and the *distribution* of travel times. In some cases, interventions that increase the average travel time may have the effect of reducing commute times if they substantially reduce the variance of total trip times. Although both lines suffer from the headway instability problem, the effect is noticeably worse on the Boston College Line most likely due to the higher frequency of stations and interference from vehicle traffic.

References

1. O.J. O'Loan, M.R. Evans, and M.E. Cates, Phys. Rev. E **58**, 1404 (1998)
2. M. Krbalek and P. Šeba, J. Phys. A **36**, L7 (2003)
3. Data obtained using the MBTA Realtime interface. Available at realtime.mbta.com

Additional references available on request.*

This work is not funded or endorsed by the MBTA.

D.S. acknowledges financial support of the Research Foundation Flanders - FWO.

***email: iaizzi@bu.edu**