Solving the Bus Bunching Problem using Self-Synchronizing Buses

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Background and Motivation

One of the biggest problems facing bus transit today is a lack of reliability. Passengers at a bus stop will experience inconsistent waiting times because buses bunch (see picture). What causes this to happen?

Conventional Approach

Currently, the most common method is to use control points, but this has two main problems for large systems with high frequencies:

- Too Complex
- Not Forceful Enough

How to Fix

In order to prevent bunching, buses would need almost continuous control. We have discovered that by allowing each bus to control itself, communicating only with neighboring buses and GPS, the system of buses will self-organize. We have developed a control algorithm and software to implement this:

\[
\begin{align*}
\text{filter} & : v_{di} \\
\text{driver} & : u_i \\
\text{bus} & : v_i \\
\text{integration} & : \frac{d}{dt} h_i = \dot{h}_i \\
\text{controller} & : h_i = K_i \int u_i \\
\text{middle} & : h_i + 1 = h_i \\
\text{GPS} & : z_i
\end{align*}
\]

What We Plan To Do

The control will be tested in three different environments:

- Computer Experiments
- Controlled Experiments
- Real World Experiments

An application that will act as the interface between the driver and the control must be developed. This software will have two functions:

Data Collection
Conversion of GPS data to route location data

Analysis
Communication with neighboring buses and calculation of desired speed

The application will use a Middleware interface to communicate between buses.

The Cause of Bunching

The number of passengers waiting at a bus stop is proportional to time since the last bus arrival. If a bus is running late, it will tend to pick up more passengers at each stop, slowing it down further. If a bus is early, it will have fewer passengers to pick up, causing it to be even earlier. The end result of this is bunched buses as shown below. Can we fix this problem?