April 1, 2017

Event Sponsors:

DISTRICT HALL
A NEW HOME FOR INNOVATION IN BOSTON

HARVARD Kennedy School
RAPPAPORT INSTITUTE for Greater Boston
Agenda

Welcome – Steve Poftak, Rappaport Institute Executive Director

Opening Remarks – Dr. Tommy Chang, BPS Superintendent

Transportation Challenge Overview – John Hanlon, BPS Chief of Operations

Panel Discussion

Breakout Sessions
- Stop Assignment
- Route Creation
- Bell Times
- Policy & Regulations

Closing Remarks
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Closing Remarks
Transportation Overview

Our long term financial plan highlighted these challenges

Fixing transportation challenges comprised a third of the “10 Big Ideas” in our Long Term Financial Plan

“Big Idea #3: Maximize Efficiencies in Transportation” is the focus of this challenge

Learn more about the LTFP at bostonpublicschools.org/financialplan
Transportation Overview

BPS spends the 2\textsuperscript{nd} most per student on transportation nationally

Per Pupil Transportation Spend, 200 Largest Public School Districts, 2013

- Average of Largest 200 Districts: $333 per pupil

Note: Largest 200 indicate the districts with the largest fall enrollment. The 200\textsuperscript{th} district for reference had an enrollment of 31.4K

Source: US Census 2013 Survey of School System Finances
Transportation Overview

Meanwhile, our transportation costs have continued to rise even as the number of total riders has fallen.

This decline reflects the impact of home-based assignment and the shift of 7th & 8th graders to the MBTA.
Transportation Overview
Meanwhile, our bell times are not perfectly balanced increasing the number of “peak” buses

Number of Buses on a Route, FY17

Our peak number of buses is at 8:30 a.m.

Balancing our bell times could reduce the peak to this estimate

Note: The number of active routes varies throughout the school year therefore these numbers are constantly changing
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- Balancing Bell Times
- Challenge Overview

Closing Remarks
This is our starting point

The above is a graphical representation of all student-school assignment in our simulated data file (dense nodes are schools). This was helpfully created by a group of faculty and students at Boston University’s Hariri Institute.
Route Creation
Creating a route for a given bus is a multi-step process

1. Given our existing student locations, we pair students with bus stops

All students walk less than 0.5 miles to their nearest bus stop.

We try to cluster as many students as possible into one stop...

...But often there are stops that can only serve one student.

Some students require a “door to door” pickup.

Note: These are randomly selected addresses. BPS students may or may not live at these stops.
Route Creation
Creating a route for a given bus is a multi-step process

2. We then work to connect these bus stops into efficient routes

- The average route connects 6 bus stops
- At a typical stop, we see ~3 students get on
- The typical route has ~18 students on it
- The first student cannot ride the bus for longer than an hour, limiting the possible number of pickups along the route

Note: These are randomly selected addresses. These may or may not reflect actual stops
Route Creation

Creating a route for a given bus is a multi-step process

3. Buses will then serve as many schools as possible during the day

<table>
<thead>
<tr>
<th>AM Routes</th>
<th>PM Routes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00:00 AM</td>
<td>2:00:00 PM</td>
</tr>
<tr>
<td>6:15:00 AM</td>
<td>2:15:00 PM</td>
</tr>
<tr>
<td>6:30:00 AM</td>
<td>2:30:00 PM</td>
</tr>
<tr>
<td>6:45:00 AM</td>
<td>2:45:00 PM</td>
</tr>
<tr>
<td>7:00:00 AM</td>
<td>3:00:00 PM</td>
</tr>
<tr>
<td>7:15:00 AM</td>
<td>3:15:00 PM</td>
</tr>
<tr>
<td>7:30:00 AM</td>
<td>3:30:00 PM</td>
</tr>
<tr>
<td>7:45:00 AM</td>
<td>3:45:00 PM</td>
</tr>
<tr>
<td>8:00:00 AM</td>
<td>4:00:00 PM</td>
</tr>
<tr>
<td>8:15:00 AM</td>
<td>4:15:00 PM</td>
</tr>
<tr>
<td>8:30:00 AM</td>
<td>4:30:00 PM</td>
</tr>
<tr>
<td>8:45:00 AM</td>
<td>5:00:00 PM</td>
</tr>
<tr>
<td>9:00:00 AM</td>
<td>5:15:00 PM</td>
</tr>
<tr>
<td>9:15:00 AM</td>
<td>5:30:00 PM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bus 101</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead-head time</td>
<td>Drive Time</td>
</tr>
<tr>
<td>(i.e., driving from last</td>
<td>(i.e., picking up /</td>
</tr>
<tr>
<td>stop of one route to first</td>
<td>dropping off students)</td>
</tr>
<tr>
<td>pick-up on the next route)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dwell Time</td>
</tr>
<tr>
<td>(i.e., time at school,</td>
<td>(i.e., time at school,</td>
</tr>
<tr>
<td>loading or unloading the</td>
<td>loading or unloading the</td>
</tr>
<tr>
<td>bus)</td>
<td>bus)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bus 102</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Bus 103</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12
## System Overview

These routes and trips add up to a large and complex system

<table>
<thead>
<tr>
<th>~25,043 daily routed riders</th>
<th>231 schools served</th>
<th>646 buses running each day</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,536 daily trips</td>
<td>20,204 times a bus stops each day</td>
<td>44,937 miles driven per day</td>
</tr>
<tr>
<td>4,759 bus stops</td>
<td>170,000 pounds of daily carbon dioxide (CO2) emissions</td>
<td>$120M FY18 requested budget</td>
</tr>
</tbody>
</table>

Note: All figures above are snapshots in time and fluctuate – sometimes significantly – throughout the year. They are intended to suggest scope and scale only.
Transportation Overview
Ridership has decreased, but the number of routes has plateaued

Routes and Riders, FY12-FY17

Number of Routes (AM + PM)

FY12 FY13 FY14 FY15 FY16 FY17

Number of Riders

0 5,000 10,000 15,000 20,000 25,000 30,000 35,000

Routes

Riders
Transportation Overview
Part of this is because the number of stops – especially door to door stops – has increased over that time frame.

Number of Active AM Bus Stops by Stop Type, FY12-FY17

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Stops</th>
<th>Number of Riders</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY12</td>
<td>3,500</td>
<td></td>
</tr>
<tr>
<td>FY13</td>
<td>4,000</td>
<td></td>
</tr>
<tr>
<td>FY14</td>
<td>4,500</td>
<td></td>
</tr>
<tr>
<td>FY15</td>
<td>5,000</td>
<td></td>
</tr>
<tr>
<td>FY16</td>
<td>5,500</td>
<td></td>
</tr>
<tr>
<td>FY17</td>
<td>6,000</td>
<td></td>
</tr>
</tbody>
</table>

CAGR FY12-FY17
Door to Door Stops: 5%
Corner Stops: 1%
Transportation Challenge Overview

The transportation challenge has two goals:

1. Using anonymized student location data, create an algorithm that will optimally route all of our buses, producing efficient routes and improving on-time performance.

2. Create a series of bell times that are equitably and efficiently balanced, reducing transportation costs and accommodating community feedback.

These two are inextricably linked, as it is difficult to adjust school start times without factoring in how buses are routed.
Transportation Challenge Overview: Routing Challenge
This is not a one day event – participants have time to perfect their solution

Routing Challenge

- Event at District Hall
- Submission Deadline Round 1
- Round 2 Participants Announced
- Submission Deadline for Round 2
- Selected Applicants Interview with BPS
- Award Recipient and Next Steps Announced

Challenge timelines are subject to change; any changes will be communicated to all participants.

Routing Data released on a rolling basis to applicants who submit an NDA
Transportation Challenge Overview: Routing Challenge
The Routing Challenge involves more than just efficient routing

**The desired outcome of the Routing Challenge will:**

1. Allow us to **automate our routes efficiently and reliably**
2. Enable our buses to achieve **high levels of on-time performance**
3. Consider **creative solutions**
4. Function as a **flexible tool**, making it possible to **test multiple scenarios** based on **changes to policy and practice**

This will allow us to **prove the costs of different policy choices and current practices** such as walk-to-stop distances, maximum ride lengths, grandfathering transportation eligibility from previous assignment systems, etc.
Transportation Challenge Overview: Start Times Challenge
This is not a one day event…

Routing Data and Start Time Preference Data released on a rolling basis to applicants who submit an NDA

Challenge timelines are subject to change; any changes will be communicated to all participants.
Transportation Challenge Overview: Start Times Challenge

Solutions for the Start Times Challenge must address a tension point in the system

The desired outcome of the Start Times Challenge will help us to understand and quantify the tradeoffs between reducing costs and accommodating schools’ preferences for start times.

The above will allow us to bring multiple plausible solutions to the community
## Transportation Challenge Overview

We’re letting participants look under the hood by releasing never-before-available data.

<table>
<thead>
<tr>
<th>Publicly Available</th>
<th>Available with Submitted and Approved NDA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Routing Data</strong></td>
<td></td>
</tr>
<tr>
<td>• Fictionalized route information</td>
<td></td>
</tr>
<tr>
<td>o Student address (and lat/long)</td>
<td></td>
</tr>
<tr>
<td>o School assignment and school info</td>
<td></td>
</tr>
<tr>
<td>o Type of rider (corner or D2D)</td>
<td></td>
</tr>
<tr>
<td>o Estimated walk-to-stop distance</td>
<td></td>
</tr>
<tr>
<td>• Fleet information (buses by type, buses by lot)</td>
<td></td>
</tr>
<tr>
<td>• “Rules of the Road”</td>
<td></td>
</tr>
<tr>
<td>• “Principals Handbook”</td>
<td></td>
</tr>
<tr>
<td>• Anonymized route information</td>
<td></td>
</tr>
<tr>
<td>• List of currently in-use stops</td>
<td></td>
</tr>
<tr>
<td>• Route overview (e.g., stops on each route)</td>
<td></td>
</tr>
<tr>
<td><strong>Start Time Preference Data</strong></td>
<td></td>
</tr>
<tr>
<td>• Aggregated survey results by school will be available</td>
<td></td>
</tr>
<tr>
<td>• Individual start time preferences at the school level</td>
<td></td>
</tr>
</tbody>
</table>

We are not publicly releasing everything to protect student privacy.
Transportation Challenge Overview

To help us evaluate submissions, we are looking for three things within each challenge:

1. **A short memo or presentation outlining how you solved this problem**

2. **<Optional> If you see us partnering together in the future, describe what that partnership would look like** (e.g., “my solution will be open source”)

3. | Scenario              | # of Required Buses | Service Hours | Service Miles | Dead-Head Hours | Dead-Head Miles | Metric Measuring School Preference |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Current System</td>
<td>630</td>
<td>3,600</td>
<td>44,500</td>
<td>1,400</td>
<td>2,300</td>
<td>Text</td>
</tr>
<tr>
<td>Your proposed system</td>
<td>###</td>
<td>###</td>
<td>###</td>
<td>###</td>
<td>###</td>
<td>Text</td>
</tr>
</tbody>
</table>

Primary criteria for Round 1 of Routing Challenge

Only required for Bell Time Challenge
Transportation Challenge Overview

Harvard University’s Rappaport Institute for Greater Boston aims to improve governance of Greater Boston by fostering better connections between scholars, policy makers, and civic leaders. Steve Poftak and the Rappaport Institute have been instrumental in planning and hosting today’s event.

The generous donation of space from District Hall has enabled us to host this event in such a wonderful space that truly champions innovation -- both private and public -- in the City of Boston.
Transportation Challenge Overview

Thank you to our Challenge Sponsors

Microsoft’s support has been instrumental in building support and engaging community stakeholders across Boston. They have also made available Microsoft Azure to all participants.

Google has generously donated one billion point to point distance calculations for participants who complete an NDA to use as part of this challenge.

The Hariri Institute has helped us develop a more robust anonymous routing dataset to publicly post on our website – an essential step in encouraging widespread participation while protecting student data.

SAS has donated nearly a thousand pro-bono hours of computer science support to improve our stops and routes. The progress that they have made has opened our eyes to the power of computer science and is one of the inspirations for the Transportation Challenge.
Transportation Challenge Overview

Awards

Thanks to the generous donations of the Longfield Family Foundation and an anonymous donor we are pleased to announce that we will give out awards at the end of each challenge:

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Award Amount for Best Idea</th>
<th>Award Amount for Proving It Works</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routing Challenge</td>
<td>$9,000</td>
<td>$6,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$15,000</td>
</tr>
<tr>
<td>Start Times Challenge</td>
<td>$9,000</td>
<td>$6,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$15,000</td>
</tr>
</tbody>
</table>

More detailed terms and conditions, will be announced on our website
Transportation Challenge Overview
Where can I go to learn more?

www.bostonpublicschools.org/transportationchallenge

More Information

Speakers and Panelists

Resources and Datasets

Background Information

- The Challenge Overview: <Available April 1st, 2017> This is your one-stop shop for everything you need to know about the challenge - including an overview, evaluation criteria, timelines, and more!
- Kickoff Presentation: <Available April 1st, 2017> This is a copy of the presentation shared at our kick-off
- Non Disclosure Agreement (NDA): This NDA must be submitted in order to advance through the Challenge. This NDA, accompanied by a one-page letter outlining your qualifications (read more in the Challenge Overview) will enable access to a more realistic routing dataset
- Principal Transportation Handbook: A helpful resource created by our transportation team providing more context around our transportation policies
- Rules of the Road: A punny named resource that summarizes the constraints and guidelines that need to be considered as part of your solution
- Sample Output <Pending>
- List of Answers to Submitted Questions <Available April 7th, 2017>

Raw Data

- Simulated “Fake” Student Address Dataset: This file was created with the support of students and faculty from BU's Harri. This file contains data similar to the data set we will share with those who choose to submit an NDA - a necessary step to move into Round 2 of the Challenge - but contains simulated data very similar to our overall student assignment patterns
- One Page Overview of Simulated “Fake” Dataset: This file contains instructions on the information included in this dataset

*A note on this dataset: this information is based on fake students - but real addresses in Boston, randomly pulled from the property tax records - assigned to fake schools. We did this to protect student confidentiality.
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Regina Robinson  Andy Rotherham  Velecia Saunders  Dimitris Bertsimas  Jascha Franklin-Hodge  Mike Hughes
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THANK YOU!!