

Building Knowledge from Real-Time Sensor Information

BAC Industry Workshop 2013

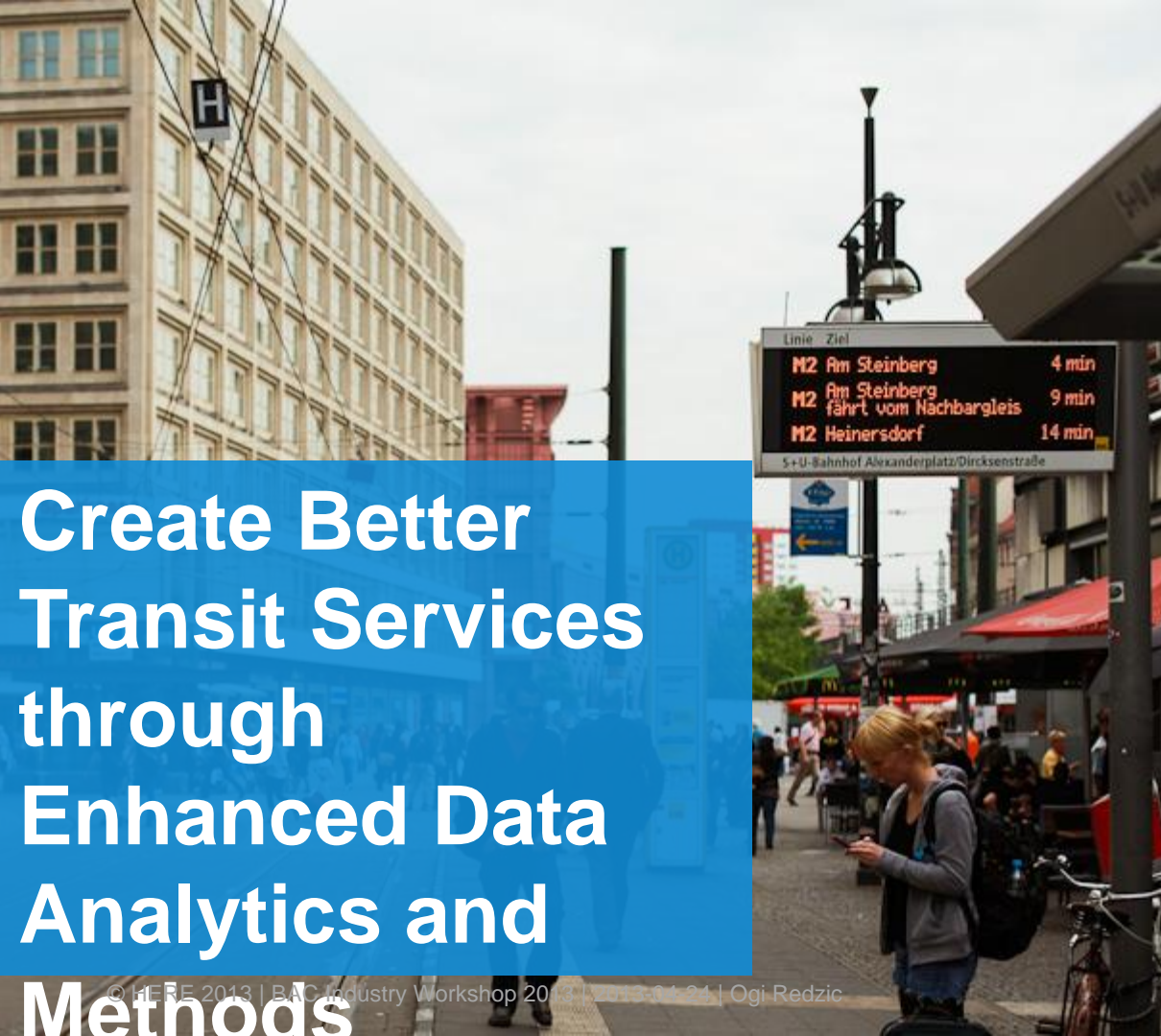
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April 24, 2013

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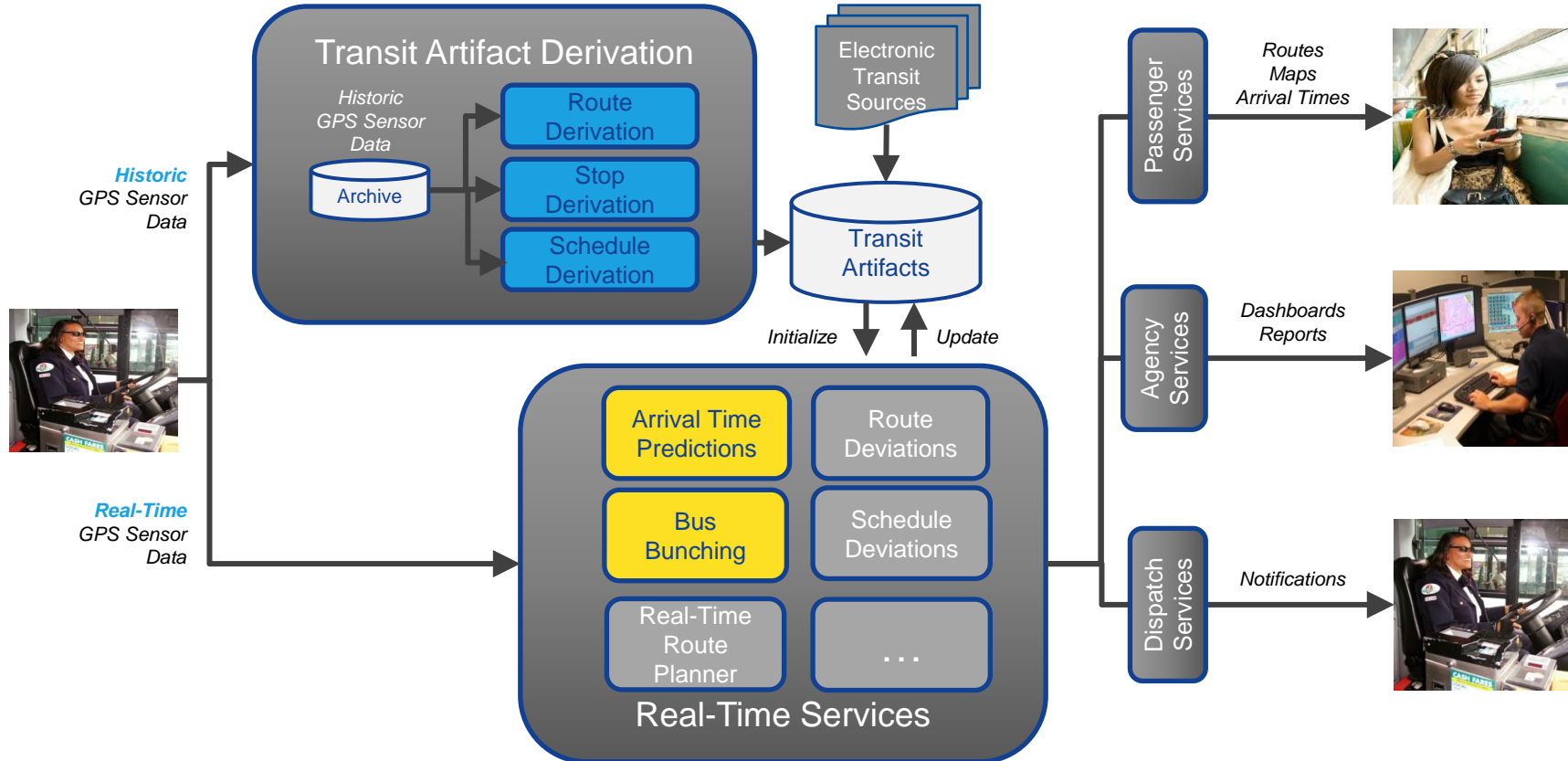
Create Better Transit Services through Enhanced Data Analytics and Methods

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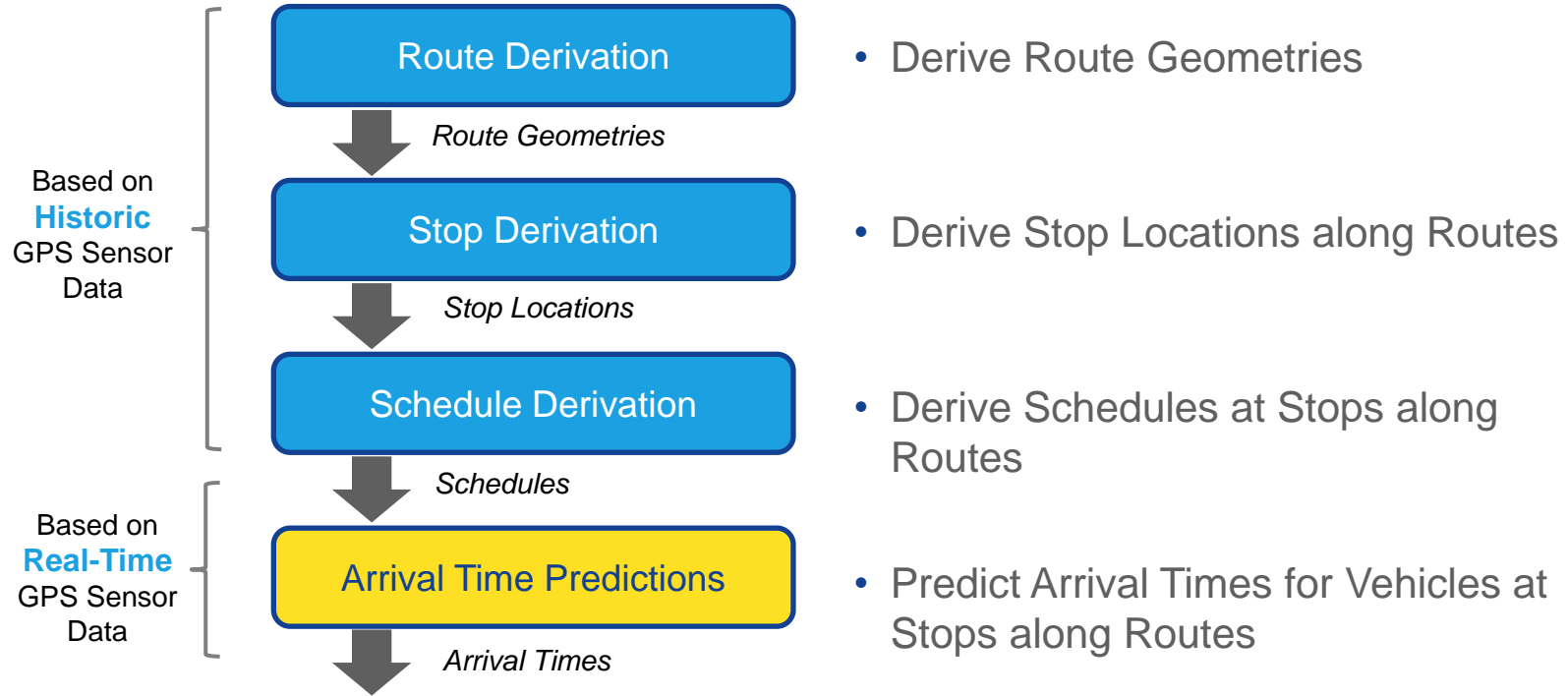
Real-Time Transit Project Objectives

- Derive/Verify Transit System Artifacts from GPS Sensor Data
 - Route Geometries
 - Stop Locations
 - Schedules
- Monitor Transit Systems using GPS Sensor Data to Enable Integrated Real-Time Services
 - Real-Time Route Planning
 - Accurate Arrival Time Predictions
 - Passenger Service Alerts
 - Driver/Agency Notifications
 - Other Services

Real-Time Transit Project Overview

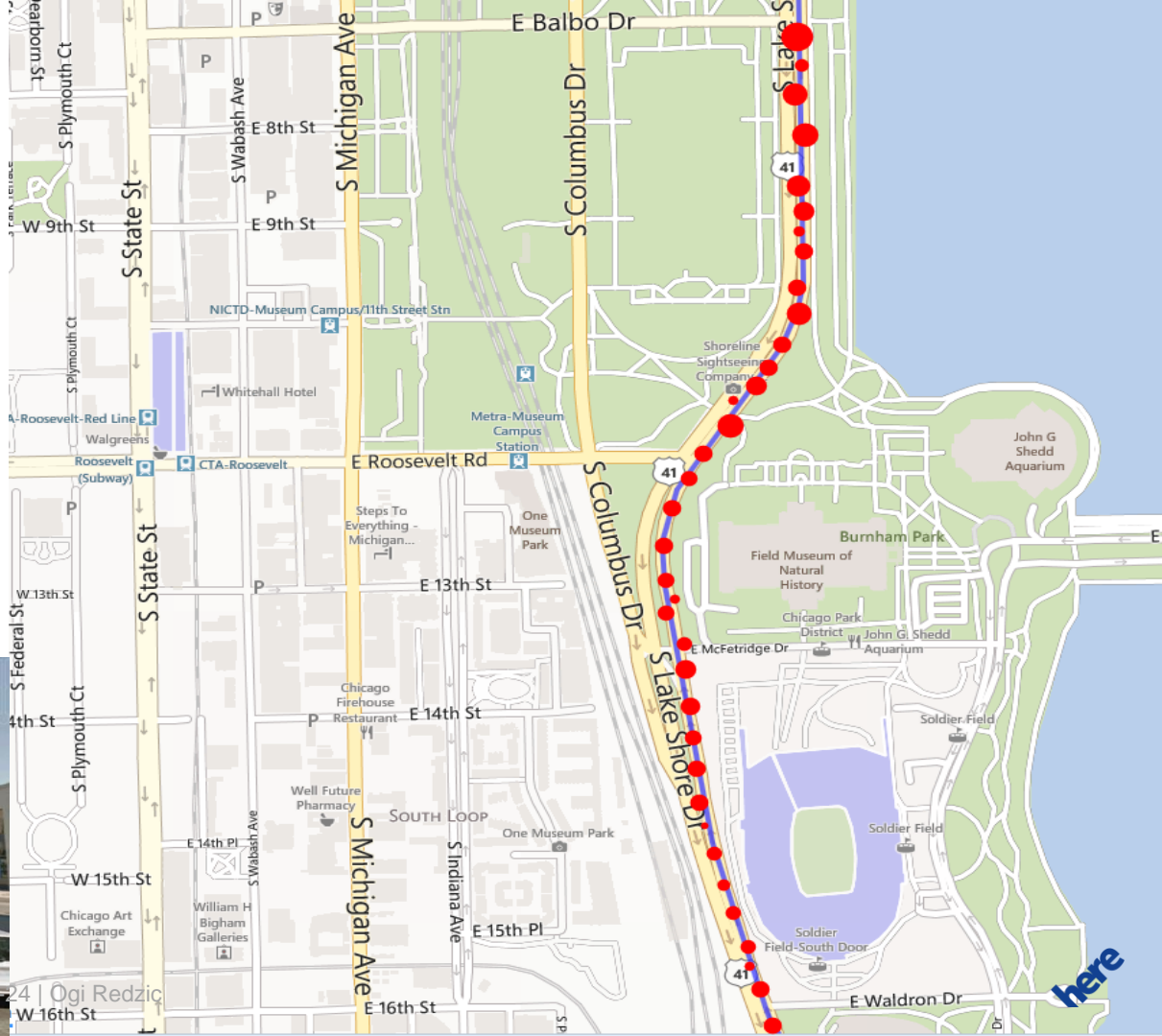


Building Knowledge from GPS Sensor Data



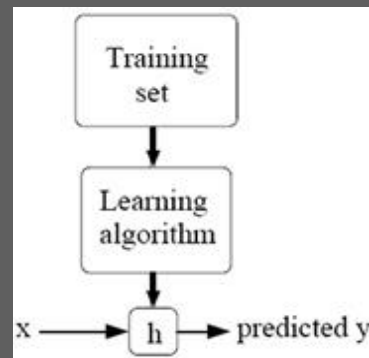
Route Derivation

- Spatial Clustering of GPS Locations
- Outlier Suppression of Low Density Clusters
- Route Formation through Spatial/Temporal Cluster Ordering
- Refine Cluster Accuracy by Aligning Clusters to Road Network
- Refine Route Accuracy by Adding Intersections



Stop Derivation

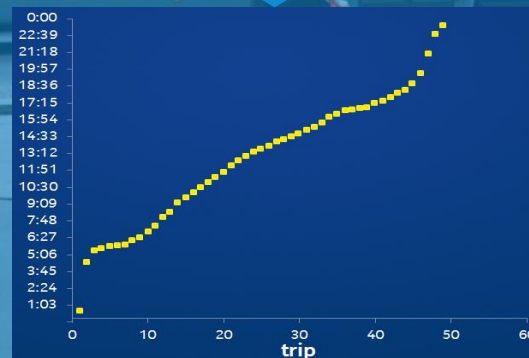
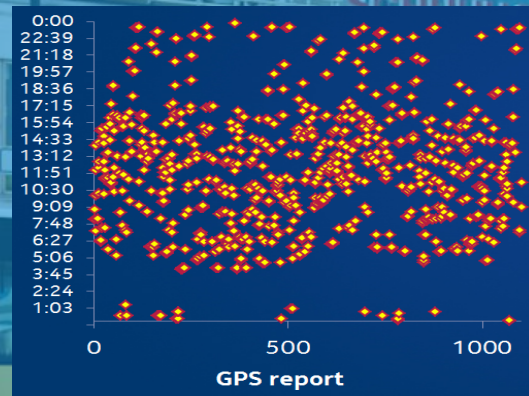
- Uses Supervised Machine Learning Model based on
 - Mini-Clusters at Stop Points
 - Speed
 - Heading
- Training Set (Patterns) Observed in the Real World
 - Transit Stops vs.
 - Stop Signals vs.
 - Stop Signs vs.
 - Combination
- Model Seeded with Training Set
- Artifacts Computed on Most Likely Match
 - Resulting in 90% Accuracy for Stop Derivation



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Schedule Derivation

- Separate GPS Data by Weekday & Weekend
- Cluster GPS Data Temporally (by Time)
- Align Time Clusters with Stops
- Based on the Number of Transit Runs for each Route, for each Stop Compute
 - Mean Arrival Times
 - Standard Deviation (Variances) of Arrival Times



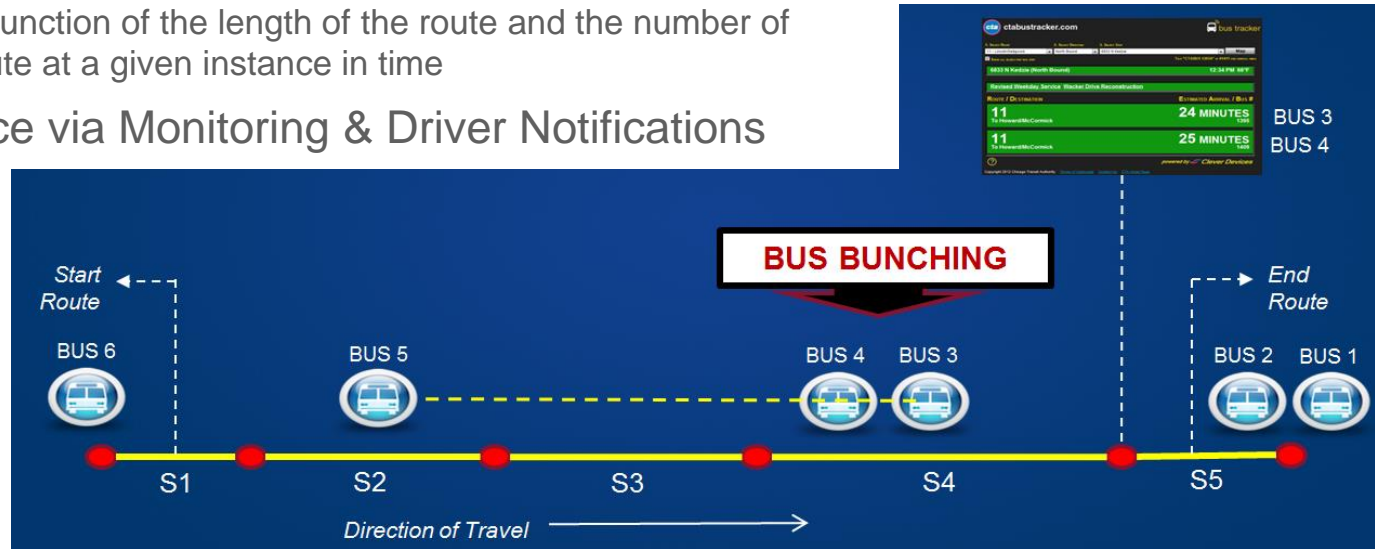
Real-Time Service: Arrival Time Prediction

| Stop: CTA Washington & Franklin Direction: East Bound or INBOUND |
|---|
| ROUTE: 157 ETA: 924 TIMETABLE: 930 |
| ROUTE: 60 ETA: 933 MINUTES REMAINING: 3 TIMETABLE: 937 |
| ROUTE: 20 ETA: 937 MINUTES REMAINING: 7 TIMETABLE: 938 |
| ROUTE: 157 ETA: 943 MINUTES REMAINING: 13 TIMETABLE: 945 |
| ROUTE: 60 ETA: 946 MINUTES REMAINING: 16 TIMETABLE: 949 |

- Uses Adaptive **Kalman** Filter
- Dynamic Weighting Between Historic & Real-Time Arrival Times based on
 - Historic Variances (from Derived Schedules)
 - Real-Time Variances (Estimated)
- Accuracy of Predictions On-Par or Better than Agency Arrival Time Services

Real-Time Service: Bus Bunching

- Bus Bunching occurs when Buses on a Route are too close
 - Bus Bunching leads to *irregular* service
 - *Closeness* is a function of the length of the route and the number of buses on the route at a given instance in time
- Regulate Service via Monitoring & Driver Notifications



Summary

- Artifact derivation from GPS/sensor data produces accurate Transit Models
 - Enables Route Planning for Agencies without Electronic Sources
 - Provides more up-to-date Models for Agencies with Electronic Sources
- Monitoring Transit Vehicles from GPS/sensor data enables Real-Time Services
 - Enables seamless integration of Real-Time Data & Services
 - Provides Services On-Par or Better than Agency-provided Services
 - Optimizes System efficiencies thus increasing Customer Satisfaction