Building Knowledge from Real-Time Sensor Information

BAC Industry Workshop 2013

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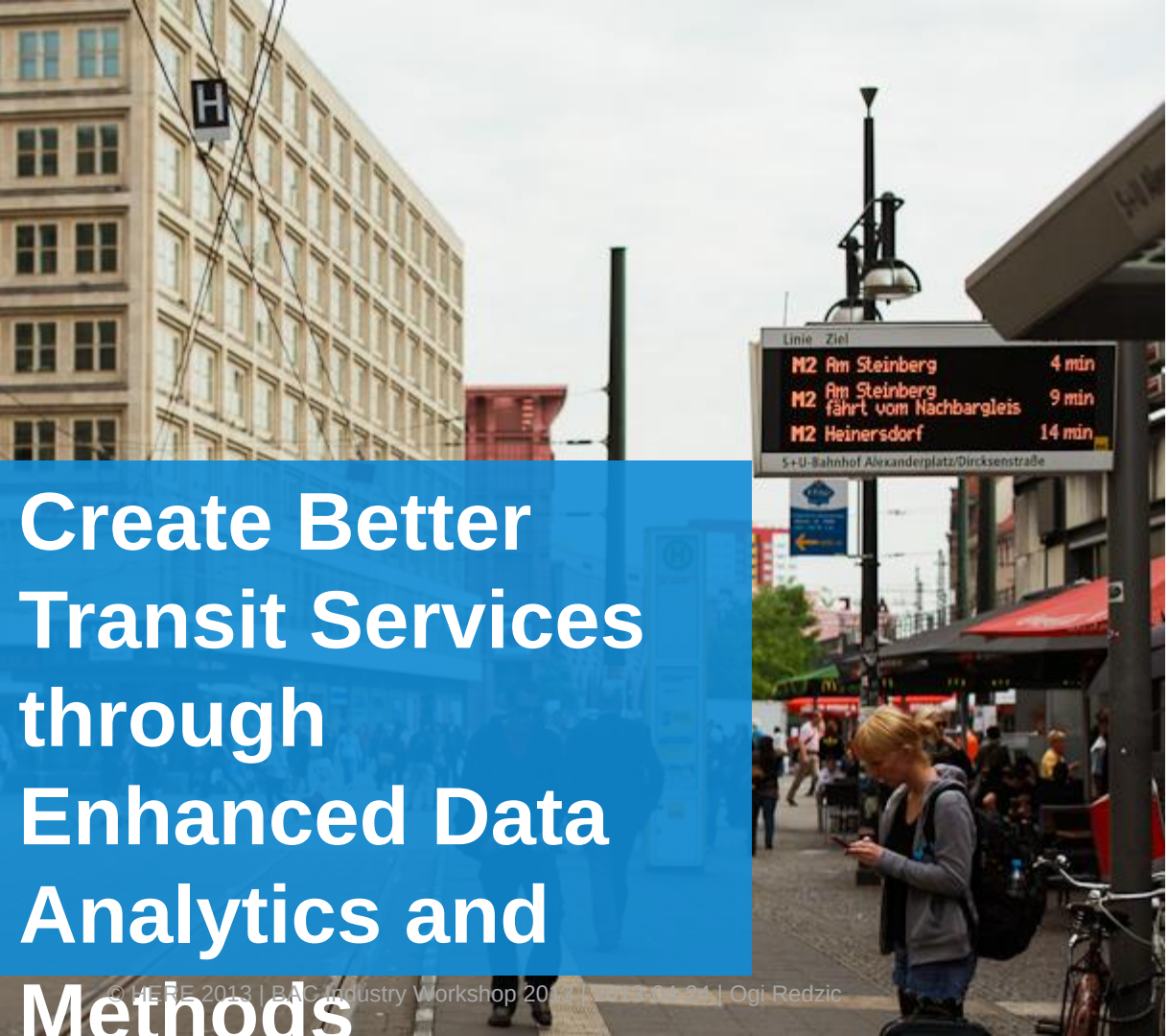
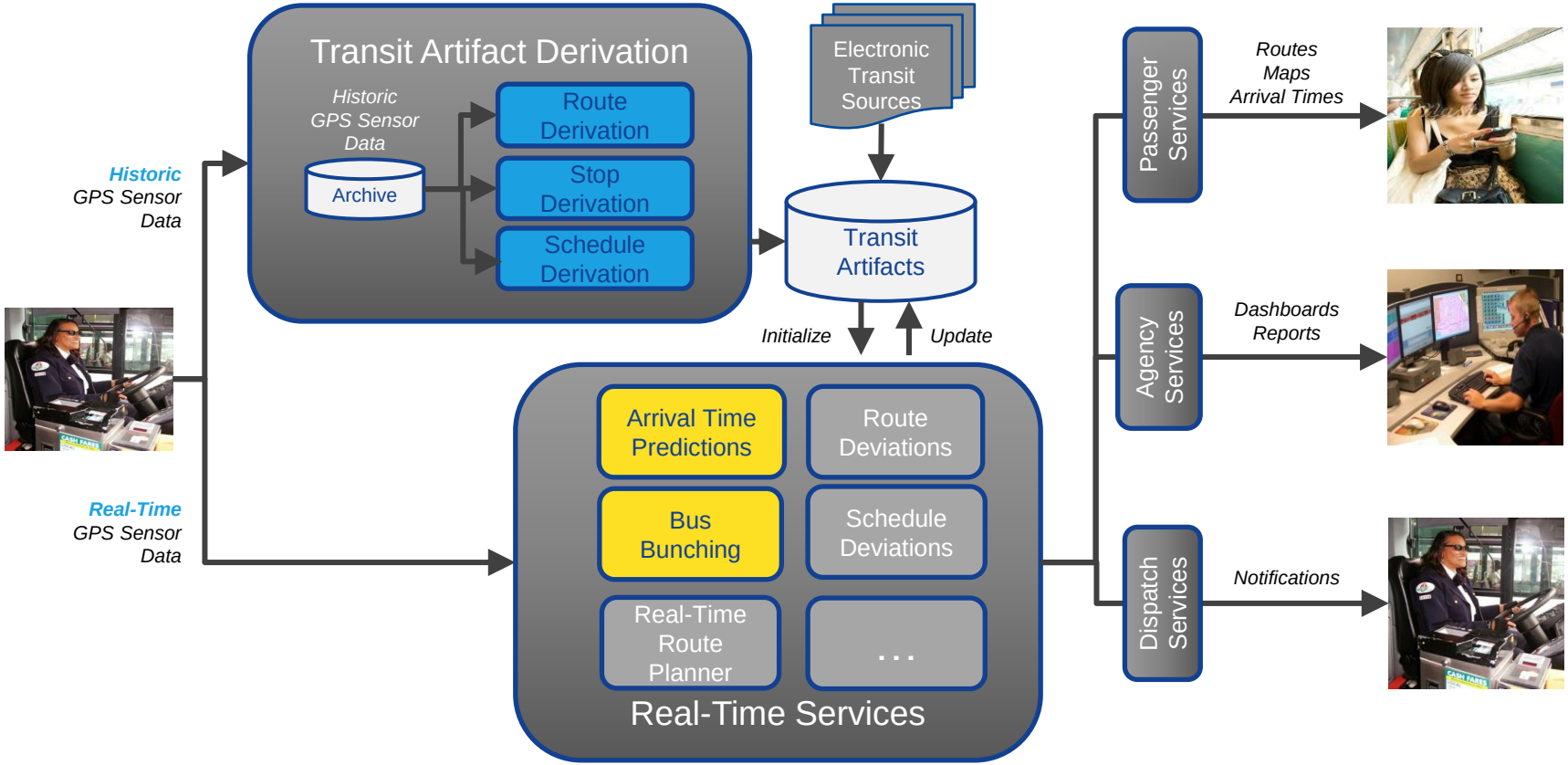


Create Better Transit Services through Enhanced Data Analytics and Methods

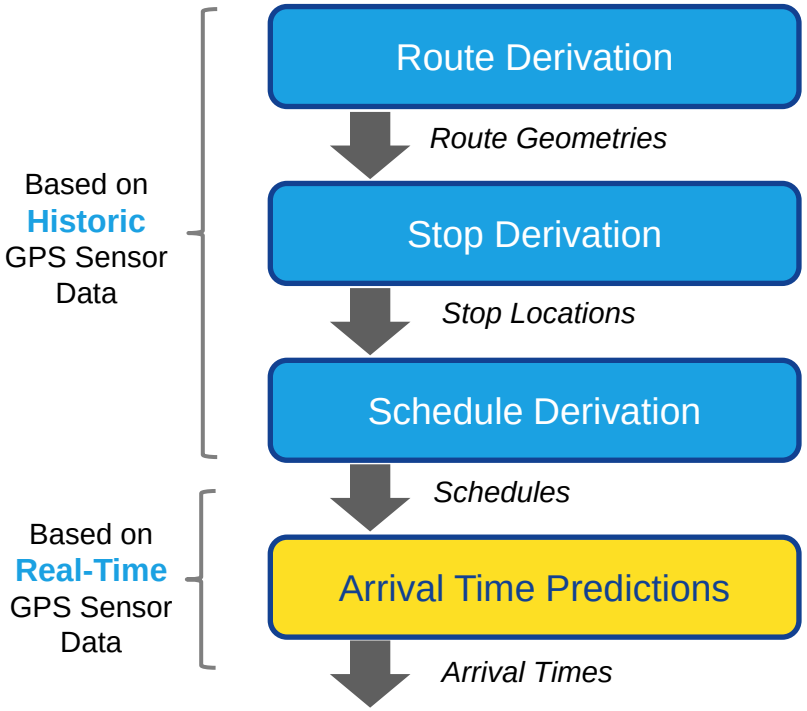
Real-Time Transit Project Objectives

- 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



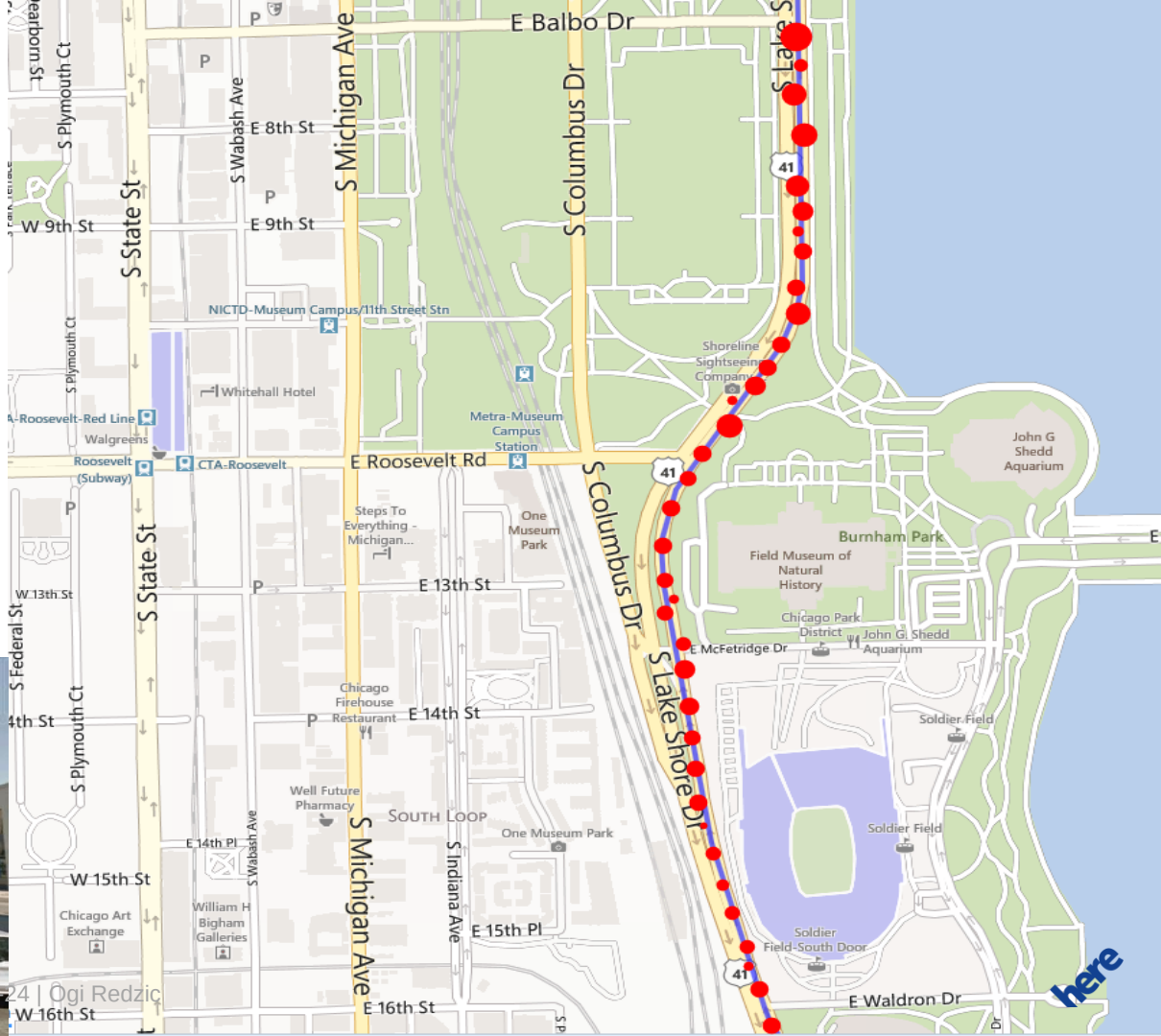
Building Knowledge from GPS Sensor Data



- Derive Route Geometries
- Derive Stop Locations along Routes
- Derive Schedules at Stops along Routes
- Predict Arrival Times for Vehicles at Stops along Routes

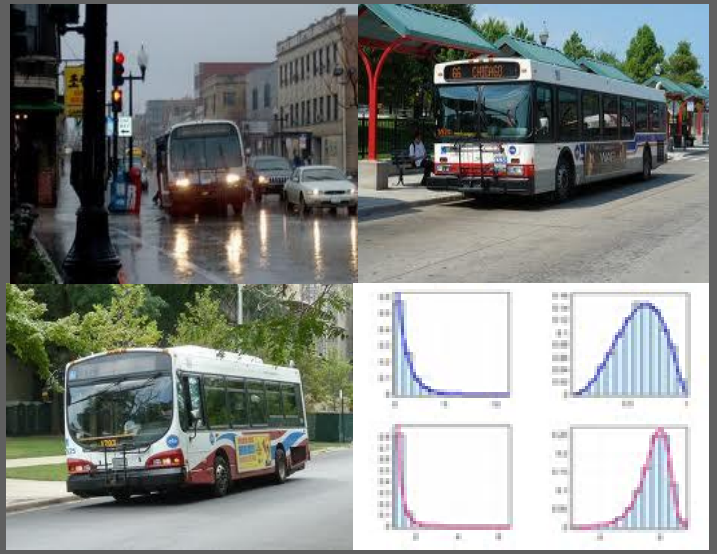
Route Derivation

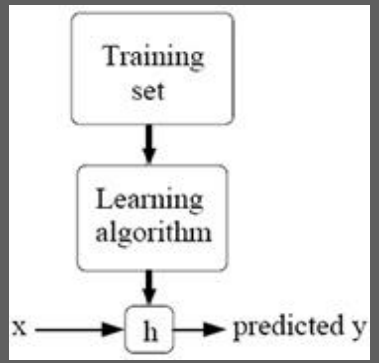
- Spatial Clustering of GPS Locations
- Outlier Suppression of Low Density Clusters
- Route Formation through Spatial/Temporal Cluster Ordering
- Refine Cluster Accuracy by Aligning Clusters to Road Network
- Refine Route Accuracy by Adding Intersections



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

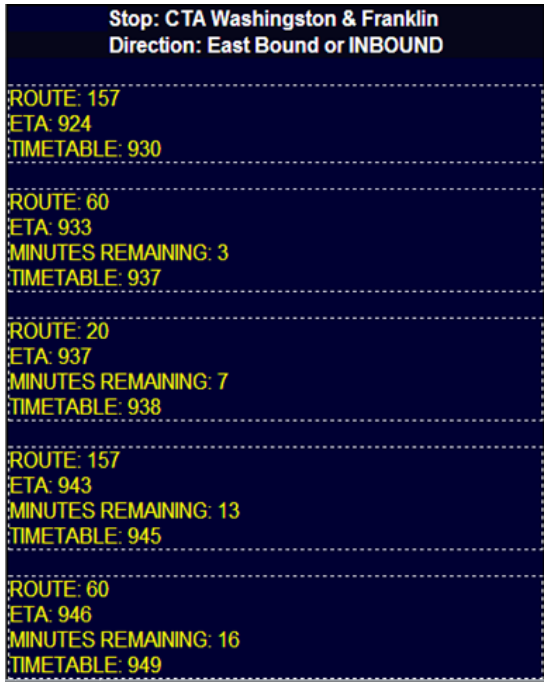




Schedule Derivation

- 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

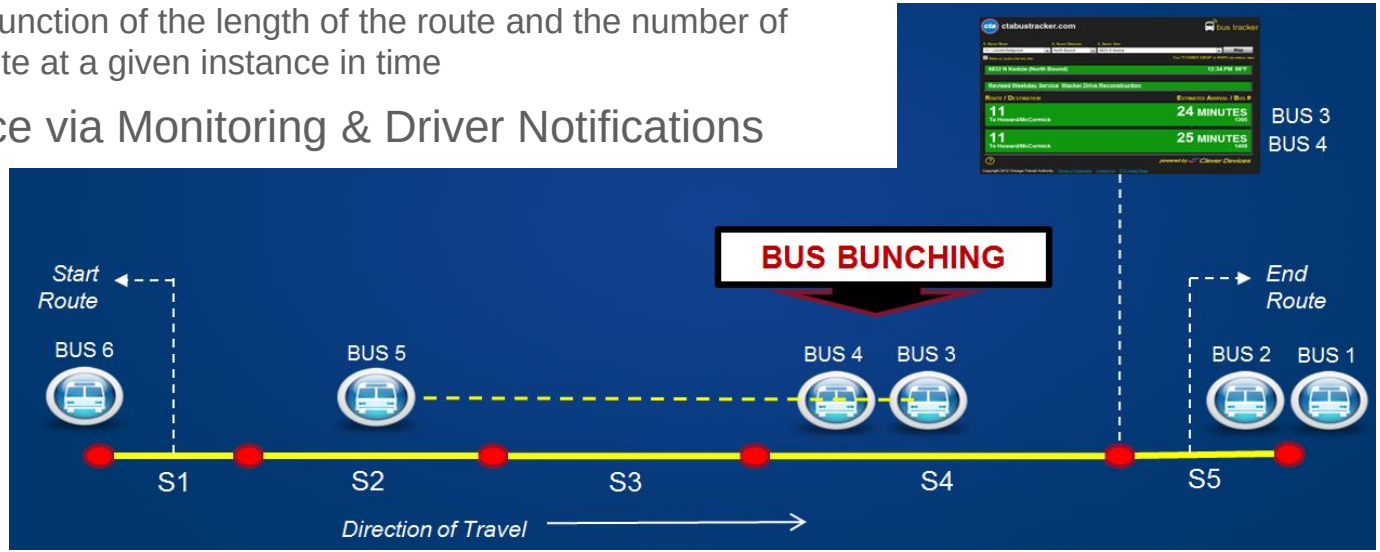
Real-Time Service: Arrival Time Prediction



- 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