Transit-Hub
An Extensible and Smart Decision Support System
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Overview of the project

• **Challenge:**
  – Create a solution that improves engagement and efficiency of public transport system.

• **Approach:**
  – A smart phone application and a backend system that enables
    • Riders to compare and choose between available transit options.
    • Provides real-time feedback and prediction of performance
    • Gathers data and provide simulation based analytics for MTA planners.

• **Broad Impact:**
  – Several high-visibility demonstrations in the city.
  – We are exploring other city-specific CPS projects.
  – The project will be made available to commuters in January. The system is already in beta test.
  – Active participation of undergraduate students in the project. They are interested in the project because of its direct impact to the city.
Problem Context

Nashville - the Music City, is a fast growing metropolis
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Public transit is essential to servicing the current and future traffic needs, but ...
Problem Context

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By 2035, our region will be more populous than today’s Denver region (courtesy: Nashville MPO)

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But public transport services and usage both lag behind comparable cities
Increasing the usage of public transit services and reducing personal vehicle trips is important to reduce traffic congestion in Nashville.
Transit Hub Approach

- Get real-time data update from the vehicles.
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- Collect usage information to improve the service.

Configure and study the impact of incentives.

SMART PHONE APPLICATION

BIG DATA ANALYTICS

DATA FILTERS

PHYSICAL AND HUMAN NETWORKS

AVL
Data Sources

- Data from Automatic vehicle locators (AVL) on buses
- Static transit schedule data in General Transit Feed Specification (GTFS)
- Transit trip plans, walking distances, real-time transit data, etc.
- Weather, traffic data, big events in the city, etc.
Data Analytics

- Feature Identification
- Model Generation
- Anomaly Identification
- Gaussian Distribution Analysis
Example - Analysis and Prediction of Schedule Adherence

Blue curve: Cluster 1
Between 7 AM to 1 PM
• The 95% confidence interval of delay: 18.2 sec to 89 sec
• Mean value is 53.6 sec

Green curve: Cluster 2
Between 1 PM to 7 PM
• The 95% confidence interval of delay: 94.8 sec to 193.8 sec
• Mean value is 144.3 sec
Example - Analysis and Prediction of Schedule Adherence

Observations:
- If the current data fits in the distribution, then we use the historical data for prediction.
- If the current data is anomalous then we use other data points to generate hypothesis for explaining the anomaly.
- And, use simulation based estimation for prediction.
Simulation based Estimation

Vehicles simulated in SUMO displayed using Google Maps
Companion Smartphone Application

In Beta Testing
Companion Smartphone Application

Trip Planning

Real-Time View

In Beta Testing
Companion Smartphone Application

Trip Planning

Real-Time View

Route Update View

In Beta Testing
Companion Smartphone Application

- **Trip Planning**
- **Real-Time View**
- **Route Update View**
- **Incentives**

*In Beta Testing*
**Extending the Framework**

**Key problem space challenges**
- Highly dynamic behavior
- Transient overloads
- Time-critical tasks
- Context-specific requirements
- Resource conflicts
- Interdependence of (sub)systems
- Integration with legacy (sub)systems

**Key solution space challenges**
- Enormous accidental & inherent complexities
- Continuous evolution & change
- Highly heterogeneous platform, language, & tool environments
Extending the Framework

Common middleware & data models that can integrate large-scale Industrial Internet deployments
  - These large-scale systems often span multiple domains

Domain A: Smart buildings
  - Incident Report

Domain B: Smart building servers
  - Incident location forwarding

Domain C: Cluster of small satellites
  - GPS location dissemination

Domain D: Smart road-side units
  - GPS notification

Domain E: Emergency response vehicles

Domains/Subsystems
  - Inter-domain interaction

Smart Cities
SCADA Systems
Air Traffic Mgmt
Healthcare

Institute for Software Integrated Systems
World-class, interdisciplinary research with global impact.
Extending the Framework

Common middleware & data models that can integrate large-scale Industrial Internet deployments

- These large-scale systems often span multiple domains
- Cross-domain interaction must therefore support heterogeneous
  • APIs & protocols

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Summary

• Real-time data ingestion
  – MTA Real-time GTFS feed
  – Real-time current traffic feed using Nokia HERE APIs

• Advanced decision support
  – Advanced trip planning
  – Notifications and alerts
  – Rescheduling
  – City services planning

• Incentive-based ridership promotion
  – Integrated health monitoring
  – Cost and gas savings
  – Carbon credit calculations
  – Integration with city incentives
Broader Impacts

- Several high visibility demonstrations all over Nashville including the chamber of commerce, and Mayor’s office.
- Initial research results have encouraged us to set up a center focusing on smart city research.
- Transit Hub will be deployed next year in Nashville.
- We are in discussion with the city to extend this framework to include parking management services.
Integration Platform for Human Cyber-Physical Systems In Smart Cities

**Social Challenge:**
- Public Transit System is currently significantly underutilized in Nashville.
- Making transit services easier to use is important

**Technical Challenge:**
- Data-Driven Decision Support System
- Integrating heterogeneous sources of data
- Making the service extensible

**Solution:**
- HUB Middleware - New data, middleware, platform services are added using adapters at runtime.
- A smart phone based application that provides
  - Real-time planning
  - Service Alert Integration
  - Incentive Campaigns
- A decision support system
  - Data-driven analytics
  - Integrated Simulation based approach for "what-if" analysis

**Scientific Impact:**
- An extensible middleware framework that can be used to integrate other city services e.g. parking management
- Framework to combine historical data-driven analytics with simulation-based real-time analytics within a H-CPS
- Understanding how decision support systems and incentive campaigns affect human engagement with the system

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