Optimization of Transit Operations for GHG Reduction

Overview

Blacksburg Transit’s (BT) stated primary goals are “Safety, Courtesy, Reliability and the Environment”. The primary aim of the TIGGER program is to employ new transit strategies to reduce energy use and Green house Gas (GHG) emissions. The proposed project, recently awarded $1.85 million by the Federal Transit Administration (FTA), directly supports these goals through increased operations efficiency, reliability, utilization, and passenger satisfaction; and through decreased fuel usage per-passenger-mile, adverse environmental impact, and infrastructure degradation.

The project is a collaboration between BT and Virginia Tech, where the progressive adoption of transit technologies and performance measurements undertaken by BT are leveraged with the research, technology, and methodology innovation strengths of Virginia Tech resources to create a very capable team. Key team members include experts in transportation technology, wireless communications, travel optimization, heavy vehicle technology including anti-idling systems, fuel consumption and emission modeling, dynamic traffic signal control, and more.

The project team proposes that recent technological advances in computing and communications and improved methodologies may provide for a revolutionary change in transit operations through dynamic optimization of bus routing and scheduling where normal routes are a thing of the past. This will be accomplished through real-time acquisition and analysis of passenger capacity and demand data followed by real-time bus route and schedule control. Such controls would include selection buses of different capacities based upon current demand; temporary bus parking in service areas (potentially with provisions for climate control and engine warming from shore power), and bus recall. BT currently has 44 fixed-route buses of 30 ft, 35 ft, 40 ft, 60 ft articulated buses and two large Body-on-Chassis (BOC).

In accordance with BT’s policies these goals will increase transit efficiency and must also maintain or improve the current levels of safety, courtesy, and reliability. It’s likely given the probable improvement of service levels that such a system would provide that these goals will be raised to new levels.

The monitoring and control required to enable this level of route/scheduling optimization in real-time necessitates system-wide employment of both proven and state-of-the-art technologies. Improved communication systems utilizing a “mesh” topology where every bus stop is a node on the network will provide for high-speed, high bandwidth, low latency, and secure data transfer. Bus stop queue assessment will require that video machine vision, magnetic card stripe reading, cell phone detection, radio frequency identification, or some combination of these technologies be used. The presence of power and communications infrastructure at bus stops will also provide for timely presentation of projected bus arrival times and other information.

“We were awarded this grant based on our collaborative abilities to study ways to reduce energy consumption and provide a greater return on investments. VTTI brings a unique perspective to this project through our expertise with innovative data collection technologies and optimization modeling and simulation.”

-Andy Alden, senior research associate, coordinator of Virginia Green Highway Initiative and principal investigator for VTTI on the project.

Passenger reservation and destination communication will require that new applications be developed for use on standard phones (text or voice recognition), smart phones, and through standard web access.

Improved, and possibly totally dynamic, bus routing and scheduling will require that new optimization routines be developed, modeled, and tested using real-world data. Bus operation reliability, utilization, time
in route can be further enhanced through integration of traffic signal phase and timing information (SPaT) and traffic signal preemption for transit using the same real-time data.

Finally, temporary bus detention at service area parking spots will provide optimal benefits if anti-idling technologies are used in combination with power alternatives for climate control and engine temperature management.

**Project Scope**

Four main tasks are proposed as described in further detail below. The order of task implementation will be determined during the initial planning stage and tasks may be performed consecutively or concurrently dependent upon dependencies and schedule.

**Project Planning**

The overall project plan including schedule will be developed in this task for data collection, routing/scheduling model development, and routing/scheduling plan implementation.

**Data Collection**

**Evaluation and determination of methods and respective hardware required for data collection and routing/scheduling system implementation** – Numerous methods for the collection of data required for determination of system capacity, demand, and other factors have been identified. BT has already implemented passenger counting systems as part of its own data collection initiatives. Additional equipment is required for better communication of data already being collected and data proposed for collection, primarily passenger demand data. The types and quantities of this equipment will be determined in this task.

**Develop specifications and bid package for equipment** – Specifications and bid packages will be prepared for the equipment identified in the previous tasks.

**Equipment acquisition** – Received bids will be reviewed and equipment will be purchased.

**Install equipment** – The equipment acquired will be installed in buses, bus stops, bus parking areas, and at supporting infrastructure locations such as signalized intersections.

**Software application development, testing, and implementation** – Where available and appropriate, the software provided by equipment vendors will be used for data collection and communication. Configuration of this software and the development of additional software applications will be required for collection and transfer of data. This software will include the requirements for real-time bus capacity determination, bus stop queue counting, passenger ride scheduling, and routing/optimization system operation. These applications may be hardware-based (firmware), web, point-of-service (POS), SMS (phone text), Smart Phone applications or others as required.

**Data collection** – High resolution, low latency, real-time capacity and demand data will be collected from buses, bus stops, passengers, intersections, and elsewhere. This data will be transmitted to servers at BT’s facility via a combination of wireless and hardwired communications.

**Routing/Scheduling Model Development**

**Data analysis and modeling algorithm development** – Data collected using the equipment installed on buses, bus stops and elsewhere, will be analyzed in conjunction with historical, weather, special event, and other data to develop a bus routing/scheduling algorithm that can be applied in real-time to operations. It is anticipated that an optimized model of bus operations could be modeled in computer simulations to demonstrate a maintained or improved level of service while decreasing passenger miles-per-gallon, energy consumption, and production of GHG and other emissions.

**Model calibration and finalization** – The pilot implementation task proposed below will be used to test and calibrate the routing/scheduling model algorithms developed.

**Implementation and Testing of the Routing/Scheduling Plan**

**Pilot implementation** – To avoid potential disruption of transit services, a pilot implementation of the bus routing/scheduling will be performed on either non-critical and/or test sections/routes. The data collected during this task will be used to validate and calibrate the routing/scheduling models previously developed.

**Revision of optimization model** - The lessons learned from the pilot implementation will be used to modify the data collection methods and routing/scheduling model for full scale roll-out.

**System-wide implementation** – The finalized routing/scheduling system will be implemented across the entire BT system.

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