Connected Vehicle-Infrastructure Application Development for Addressing Safety and Congestion Issues Related to Public Transportation

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Introduction

The idea that vehicles, travelers, and infrastructure can be “connected” and communicate one another and function as one unit of transportation system will bring about many potential benefits and opportunities to improve human mobility. Traditionally, transportation is viewed as having two basically separate parts: demand and supply. Demand is about the people (and goods) who wish to travel (or needs to be transported). Their motivation is driven by economic and social needs. The supply side of the transportation system consists of the vehicles, the ways, the terminals, the control, and the management, which must function together. This traditional framework of transportation is changing with the introduction of the connected vehicle concept. That is, this concept is an instrument to connect the elements of demand and supply.

The traditional problems of transportation are caused by disconnect between supply and demand. In other words, the supply side could not respond to demand, and the demand side could not adjust to the supply side requirements and limitations. Imbalance between supply and demand has been the main cause of congestion and all other problems of transportation.

The concept of connected vehicle can change this imbalance. The vehicles do not literally mean the automobiles or trucks. Essentially it means the people, who have the desire to engage in the act of traveling. The automobiles are the means to travel, but people are the units of travel. Hence, the proposed connected vehicle project is about connecting people, vehicles, and transportation infrastructure.

Major Tasks Accomplished Under Project

Task 1. Construct the overall image and description of the system consisted of the elements of the system (passengers, buses, infrastructure, other vehicles, and pedestrians), connectedness among them, operational details, control, management, and performance measurement scheme.

Task 2. Develop the parametric relationships among all the variables, including vehicle requirements (e.g., fleet size and capacity), demand, route characteristics, operations (headways an stops).

Task 3. Define the role of connected vehicle concept for its effectiveness and technical capabilities and limitations in implementing *the Ideas.*

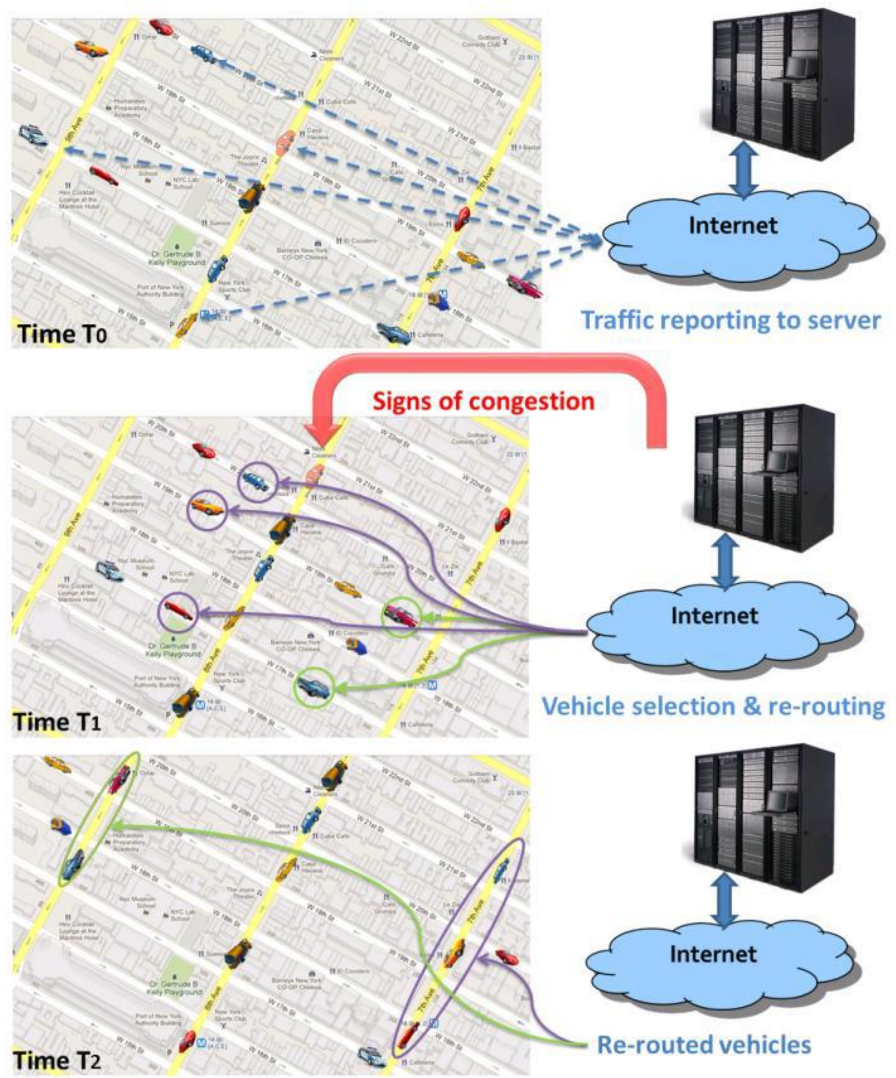
Task 4. Identify the preliminary performance specifications of the connected vehicle concept application and the system as a whole.

Important Variables

- Vehicles: Fleet size, Capacity, Dynamic characteristics (acceleration, deceleration, max speed)
- Route Characteristics: Route length, speed limits, number of turns, traffic control, travel time during different times of the day)
- Demand: Number of passengers, origin and destination pattern, average travel distance, average number of passengers traveling together, transfer between routes)
- Operations: Departure headways at the terminal, policy headway between consecutive vehicles, the role of connected vehicle (communications capabilities)

Connections Between System Elements

- Passengers to Bus (P2B): Passenger informs the bus about details of his/her travel desire including, origin, destination, desired arrival time, disability status, the number of persons traveling together.
- Bus to Passenger (B2P): availability of bus at the bus stop, bus arrival time, the level of occupancy, transfer location (if needed), expected arrival time at traveler’s destination, and fare.
- Bus to the vehicles traveling near the stop (B2V): impending bus stopping, impending bus departing from the stop.
- Passengers to vehicles on the street before street crossing (P2V): impending passenger crossing the street.
- Passenger to roadside infrastructure (P2I): street light intensity change, activation of pedestrian crossing alert device.
- Bus to bus (B2B): locations of individual buses, occupancy level.
- Bus to infrastructure (traffic signal, roadside infrastructure including street light) (B2I): activation of street light intensity, bus operating status information.



Basic Server System Design

Passenger Demand Scenarios

1. When transit demand is very small, small capacity vehicles travel without fixed schedule to pick-up and drop-off passengers along the route. The vehicles go back and forth in response to the random demand of passenger travel.
2. When transit demand increases, medium sized vehicles travel along the route as if they are the horizontal elevators. Travelers share the same vehicle if necessary. Although their trip origins and destinations may differ, the general direction of travel is the same.
3. When train demand is steady and large, the conventional bus operation where the departure time at the terminal is fixed and each vehicle travels the entire route as a fixed scheduled vehicle. However, along the route, the vehicle’s arrival times at stops may deviate from the schedule due to the traffic congestion and other reasons.

Design Scenarios

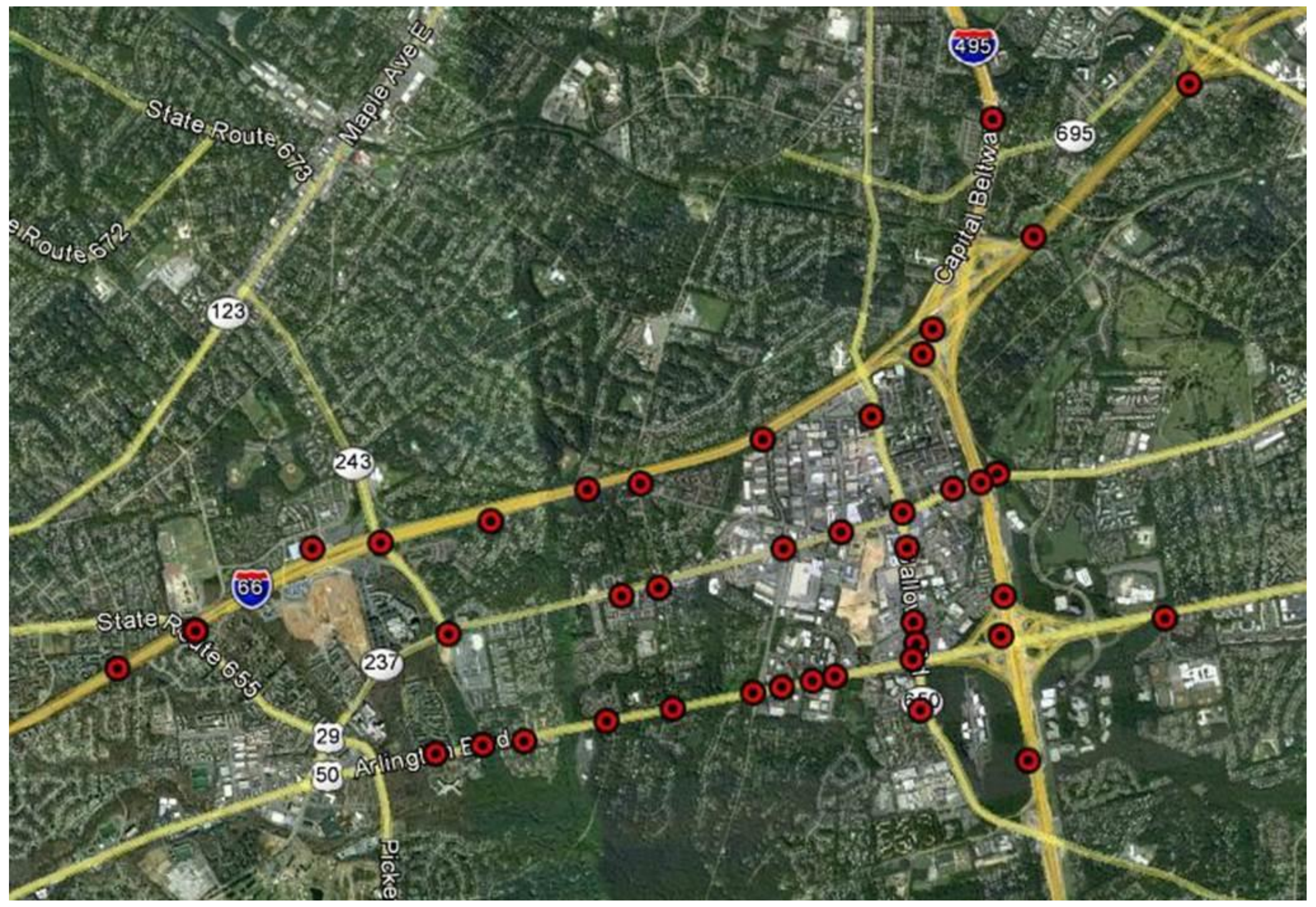
The system setup, configuration, and architecture. The proposed research in using the C2V concept for public transportation use will be facilitated by means of Dedicated Short Range Communication (DSRC) radios installed along the Northern Virginia Test Bed (see Figure 1). DSRC is one-way or two-way short- to medium-range wireless communication channels specifically designed for automotive use and a corresponding set of protocols and standards. The problem with first generation in-car navigation systems and web services is that they considered just the road network, but not the traffic conditions, when computing the shortest route to destination. This was due to the unavailability of traffic data.

With the deployment of DSRC, we have started to witness web-based services/applications that present the passengers with the current view of the traffic and let them decide which bus/route to follow.

Basic Centralized Design. We consider that each passenger has a smart phone or some kind of web-service and each bus has a GPS enabled communication device. The phones communicate with an [initially] centralized traffic monitoring and guidance version of our system over the Internet, as shown in Figure 2. The system which will be located at Morgan State collects real-time traffic (including instantaneous location of buses) information from DSRC radios placed along the Northern Virginia Test Bed.

The phones have similar resources with current iPhones or Android-based phones. Relevant for our discussion, they have a GPS device, can connect to the Internet over WiFi or 3G, can use the WiFi interface in ad hoc mode, and can be programmed to execute user applications. The phones can use their sensors to determine the Bus locations. It is assumed that the system knows the road network.

Traffic data collection an representation. The system determines the traffic conditions and bus locations on the roads based on the information reported by DSRC radios and individual smart phones of the passengers. Each smart phone reports its unique ID, current road segment, destination, and average speed or travel time on its previous road segment. With the needed communication link established among the server, DSRC, and individual smart phones of the potential users, a series of special algorithms will facilitate the required communications (e.g., P2P, V2B, B2B, etc.), for various scenarios outlined in the preceding sections.



Northern Virginia Connected Vehicle Testbed in Merrifield, Virginia, Fairfax County

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