Interactive Transit Information and Decision Support System

The Connected Vehicle Technology Challenge

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1. MOTIVATION

Nowadays, it is usually difficult for a transit rider to get accurate and close-to-real-time information from the transit service providers. Endless times have been wasted on waiting for the next bus to come without knowing the availability of other alternatives nearby. Frustrations rise when unintended interruptions in services or other incidents occur but the travelers are not notified. Thus, supplying the real-time transit information to its users will certainly support the users’ decision makings and improve their satisfactions.

The cellular network and the internet have made it possible to connect the transit passengers to the service providers more closely by sharing the real-time transit information onto passengers’ personal devices. However, the current transit information system mostly provides only status notifications to users, such as arrival times. There is still no efficient way to allow travelers to make real-time service requests, although cell-phone networks can connect the riders to transit providers’ centralized system on the fly. Simply put, there is no real interaction between transit service users and providers. One reason is that cellular networks were not designed for short-distance, back-and-forth, on-and-off communications. More importantly, it will be very difficult and inefficient for a centralized system (e.g. a website/server maintained by a transit agency) to gather and to process all the user requests remotely while still maintaining a real-time fashion. Therefore, a decentralized and individualized system, where each transit vehicle can make their only decisions and suggestions to nearby travelers, can be much more efficient.

The short-range communications technologies, such as DSRC, advocated by connected vehicle initiative are very well suited for this purpose. Thus, we propose the system as follows.

2. SCOPE

1.1 Purpose of the System
To connect transit passengers to all modes of transit services in real-time.

1.2 Goals and Objectives
The goal is to build a highly interactive ad-hoc platform which allows individual systems to dynamically connect to each other so as to fetch context-specific transit information for individual decision makings. Specific objectives are:

- To dynamically establish connections among transit service users and providers, who are in close proximity, through wireless communication channels
- To implement individualized decision making system in every transit vehicle (e.g. bus, light-rail train)
- To provide an interaction mechanism for users submitting demand requests and transit providers giving responses on an individual and real-time basis
1.3 Vision for the System
The ubiquitous computing and short-range wireless communications technologies will play a central role in connecting bus to pedestrian, pedestrian to taxi, taxi to light-rail trains and so on. We envision that numerous instances of the ad-hoc system will be formed dynamically and locally from all kinds of nearby wireless-enabled devices. At the minimum, each transit vehicle (e.g. a bus) will be equipped with a computing device that can be wirelessly communicating with nearby computing devices on other public transit vehicles; nearby travelers who need for transit rides can simply hop on to this locally formed communication platform and fetch for transit statuses and make service requests. The onboard computing device will not only monitor the number of onboard passengers but also accept or reject seat reservations made by travelers on the sidewalk nearby. More applications can be generated from connecting users and transit service providers on an individual basis. For example, a passenger can search for available taxi around the corners and make reservations with a fee before even getting to the taxi; a bus can avoid pulling into a bus stop if the bus cannot take additional passengers anymore. That is, each computing device on the public transportation vehicle will be a decision making system that collects and sends real-time decision information from and to surrounding wireless-enabled devices.

Figure 1: An Example of Interactive Transit Information and Decision Support System
As a result, transit service users and providers are connected with respect to their locations and needs in a very interactive and timely fashion. Figure 1 has illustrated some examples of such system.

3. **SYSTEM ARCHITECTURE**

   The architecture of proposed system is illustrated in Figure 3. We describe the system according to three different levels: sub-systems, their functionalities and physical connections.
**Sub-Systems**

- Individualized public transit sub-systems: including bus/light-rail/subway/taxi systems. Short-range wireless communications devices should be installed on Individual transit vehicle to communicate with each other, with roadside equipments (RSEs), and with control centers. Depending on data needs of particular applications, each individual system at minimum provides the positions, loadings, current running speeds, schedules and schedule adherence information. In some necessary conditions, individual vehicle can communicate with customers directly. Such sub-systems are “individualized” because each individual transit vehicle can make decision itself, such as minor routing adjustments to avoid congestion and adjustments in schedule timing to better connect with other transit vehicles.

- Customers: can use their wireless communication devices (cell phone, PDA etc.) to query/request services/schedules of individual transit vehicles and to provide individual trip information to transit control centers. Customers is able to query the estimated waiting time at the station, real-time positions of certain public vehicles on service, the duration from origins to destinations, preferred price of fares and waiting times, through direct wireless communication with the nearby individual transit vehicle. Based on the information and recommendations from the system, the customers could make a comfort plan for their trips/travels.

- Sub-system control centers: to collect traffic/service information and to dynamically make decisions, such as rescheduling all transit vehicles within some certain duration, though communication with individual transit vehicle and other modes of transit subsytems.

**Functionalities**

- Individualized decision makings: an individual transit vehicle constantly collects running status and decision information from other transit vehicles within its local area; it also collects its own running status and makes application-dependant decisions; then nearby customers can connect to these vehicles and make their own plans for transit ridings.

- Centralized decision makings: running status are collected and sent back to the control centers of each transit agency. Based on a rich set of historical as well as up-to-date traffic and service demand data, the transit agencies can make a number of centralized decisions for planning purposes; for example, to optimize transit schedules and routes.

**Physical Connections**

- Wireless and wired communications: every individual transit vehicle is wirelessly connected to others in the local vicinity through all kinds of short-range communications channels. Fixed point road-side-equipments (RSEs) serve as portals bridge the wireless ad-hoc networks to the fiber-optic back-bone communication networks. The backbone network backhauls data to the control center of each transit agency.
**Center servers:** historical data are stored in the mainframe servers and can be analyzed by centralized decision system.

### 4. POTENTIAL APPLICATIONS

#### 4.1 Query of service, information collection and response

**Description**
A customer sends a request for service to all transit vehicles within a local area and queries the schedule; one individual transit vehicle along the right route sends the information back to the customer about estimated arrival time and the estimated duration from origins to destination, based on temporary traffic condition.

**Data**
Customers’ location, time of taking transit, origins and destinations, location of individual transit vehicle, traffic condition along the route;

**Communication type**
Vehicle to customer directly;

#### 4.2 Alternative trip recommendation

**Description**
A customer takes one transit vehicle. Because of congestion downstream, the transit vehicle could not complete the trip of customer in time. Through communication with other transit vehicles within the same sub-system or from other transit modes, such vehicle can make several alternative plans, recommending the customer to take other transit vehicles to arrive destination in time or with less delay.

**Data**
Origins and destinations of customer, location of individual transit vehicle, traffic condition along the route, schedules of other transit modes and locations of other transit vehicles;

**Communication type**
Vehicle to vehicle and customer;

#### 4.3 Individual transit vehicle rerouting

**Description**
An individual transit vehicle detects congestion or a vehicle incident on some segment of road downstream. It can reroute to avoid such segment if possible, and at the same time it should inform the customers along the original route.

**Data**
Location of individual transit vehicle, customer demand along the route, traffic condition downstream;

*Communication type*
Vehicle to vehicle and customer;

### 4.4 Seat reservation for disabled passengers

*Description*
Disabled customer is able to reserve a seat in advance from an individual transit vehicle. He/she only needs to send his/her information directly to the transit vehicle which he/she will take.

*Data*
Disabled customer location, origin and destination of such customer, transit vehicle location;

*Communication type*
Vehicle to vehicle and customer;

### 4.5 Local taxi calling

*Description*
A customer who wants to call a taxi sends a call message directly to nearby taxies. Within a local area, the taxies can communicate with each other to determine the nearest available one to pick up the customer. Note that such application does not need a control center ---- all decisions can be done by the collaboration of a few taxies within a local area. Hence, it improves the response time.

*Data*
Customer location, taxi location;

*Communication type*
Vehicle to vehicle and customer;