Key Motivating Phenomena...
Increasing role of containerization and container handling
Intermodal freight fastest growing form of rail traffic
Major revitalization of rail transport through intermodal
Intermodal freight transportation vulnerability

Transfer nodes: points of high vulnerability

Greater exposure through multiple transfers

Transfer nodes also “choke” points or bottlenecks in system: amplifies economic impact severity of additional delay

Rail mounted gantries for intermodal traffic
CITY LOGISTICS

• “The process of totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic environment, traffic congestion and energy consumption within the framework of a market economy”

Taniguchi et al. (2001)
CITY LOGISTICS

KEY CHARACTERISTICS

TWO WAY INTERACTION

Impact on traffic congestion

Impact on urban fabric and environment

CITY LOGISTICS

Impacted by traffic congestion and constraints of urban fabric and environment

Urban Traffic Congestion and Environment
CITY LOGISTICS

IMPLICATIONS

NEED TO INCLUDE EFFECT OF CITY LOGISTICS DELIVERIES AND COMMERCIAL ACTIVITIES IN SIMULATION MODELS OF URBAN TRAFFIC

MUST CONSIDER TIME-VARYING TRAFFIC CONGESTION AND OPERATIONAL CONSTRAINTS IN ROUTING AND LOGISTICS OPTIMIZATION MODELS
Reliability of Travel

Many sources of unreliability:
- Interactions over space and time; e.g. traffic flow regime change under congested conditions
- External perturbations (changes in demand and supply characteristics)
- Individual link and/or particle stochasticity

**Result:** Tripmakers traveling between an origin and destination in the same departure window experience different travel times; Lack of travel time predictability affects ability to schedule business and personal activities; delay and loss of productivity.

**HUGE ISSUE FOR BUSINESSES AND SERVICES THAT RELY ON PHYSICAL MOBILITY**
Intelligent Transportation Systems

Convergence of location, sensing, telecommunication and automotive technologies for better transportation system safety, efficiency, and user convenience.
TWO STAGES OF ITS DEPLOYMENT

Like any application of computers and communications to complex systems, the process is moving through **two major stages**:

1. The first stage mainly applies technology to specific tasks, but without changing their character or basic sequence.

2. In the second stage, **entirely new approaches to solving problems and conducting business** begin to appear.
Hot lanes typically considered with new facilities or addition of a lane to existing facilities. Conversion of general purpose lanes discouraged in US.

Single Occupant Vehicles allowed to use HOV lanes for a toll

Toll rates vary based on traffic conditions or time of day so as to maintain *high level of service* on managed lane

*Facilitated by AVI and automatic toll collection*
Congestion Pricing as Demand Management Tool

1. Pricing increasingly viewed as one instrument along with two main other controls for integrated transportation system management:
   1. Traffic controls: ramp metering, signal coordination
   2. Information Supply: advanced traveler information systems, parking information systems, variable message signs (VMS)...

2. In real-time: with improved sensing and information technologies, can determine prices, traffic controls and information strategies adaptively, online, based on current and anticipated state of the system
THE BROADER CONTEXT: Technological Drivers

- Communications
- Satellite
- POS Information
- Internet Connection
- Operations Control Center
- Integrated Mobile Communications Terminal

Source: Qualcomm.com
THE BROADER CONTEXT: Technological Drivers

Information & Communication Technologies (ICT)

ITS for Commercial Vehicle Operations (CVO)
2-way Communication Systems
Automatic Vehicle Localization (AVL); GPS

and Supply Chain Management (SCM)
EDI; ERP; MRP; RFID

=> Large amounts of real-time information on state of system at lower cost
Key enabling technologies:

• *Location via wireless-assisted GPS*

• *Georeferencing via accurate GIS mapping*
Satellite-based mobile asset tracking and communication: Tool for truck fleet management and freight tracking
Electronic Payment Services through RFID Tags: m-commerce

*e-Drive*

Drive-thru fast food, gasoline, car wash, etc
Homeland Security and ITS

Using Intelligent Transportation Systems to Improve and Support Homeland Security

Supplement to the National ITS Program Plan: A Ten-Year Vision
Deployment Key Technologies: Field Elements

- AVI and E-Seal Readers (Overhead)
- E-Seal
- In-Truck AVI Transponder
- Disposable Electronic Container Seal
- Weigh-In-Motion (CVISN)
Development trend #1: Handset Capabilities, Wireless Internet

Precise Location Enables Wide Variety of LBS Apps

**GAMING**
- Interactive Gaming
- GeoCaching
- Location aware games for individuals/groups

**PERSONAL SECURITY**
- Roadside Assistance
- Weather Warning
- Child Finders
- GeoFencing

**ENTERPRISE**
- Fleet Management
- Asset Monitoring
- Personnel Productivity

**POINTS OF INTEREST**
- City Guides
- Mobile Yellow Pages
- Navigation
- Traffic reroute

**PEER-TO-PEER**
- Buddy Groups
- Dating
- Geo-marked photo sharing
- Mobile Blogging

**COMMERCE**
- Mobile Coupons
- Customer Service

**m-commerce**

**e-logistics**

**m-logistics**
Telemobility and Telelogistics

- Internet + mobility →

  **TELEMOBILITY** and **TELELOGISTICS**

May entail changes in:

- **Nature** of the activities themselves (doing what?)
- **Location/spatial** characteristics of the activities
- Inter-person and inter-firm interaction in activities
- Process of activity generation and scheduling: more dynamic (real-time) activity generation and scheduling;
PROBE-BASED CONNECTED NAVIGATION SYSTEM: Third-Party Private Subscriber ITS Service

Dash Finds up to Three Possible Routes: You Choose Which is Best - Windows Internet Explorer

TruTraffic
The most accurate and current traffic data

Routing: Choice is good.

Most portable GPS devices today offer you only a single route choice to your destination. Dash goes the extra mile by presenting up to three different routes to a destination, and uses its traffic information to calculate your Estimated Time of Arrival (ETA) for each route. The traffic-based travel times you get from Dash are more accurate, helping you decide which route is best for you, even after you’ve selected a route. Dash even automatically alerts you when traffic conditions change significantly.

Traffic snapshot
Dash can also give you a quick snapshot of traffic in your area. Our map views let you easily visualize current traffic conditions around your location on major and secondary roads. Additionally, traffic conditions on your route are easily identifiable by color. Dash uses accepted conventions to quickly convey traffic at a glance: Stop-and-go traffic is red, moderate congestion is yellow, relatively uncongested is orange, and free-flowing roads are green. If the lines are solid, they represent live traffic derived from the Dash Driver Network—the most timely and accurate source available. If they are dashed, the traffic data is either 3rd party sensor or historical data. As the Dash Driver Network grows in your area, you’ll see more and more of the dashed lines become solid. You’ve never had this much traffic information on the road before. And knowledge is power.
Development trend # 2: Inexpensive wireless sensor networks

Coming to markets near you in next few months...

Relative low cost and high performance of such systems would enable deployment at larger scale than envisioned originally.

In the limit, nano-scale sensors with massively parallel deployment.
Mobile units + wireless internet:

- Provides particle (user-centric) views of system

Inexpensive wireless sensors:

- Provides view from perspective of infrastructure or fixed assets

REAL-TIME INFORMATION
Explosion of real-time information on system state

→ Calls for methods geared for shorter term engineering and business applications

→ Calls for methodologies for real-time decision making under real-time information

   REAL-TIME DECISION-MAKING METHODOLOGIES, e.g. DYNASMART-X for traffic estimation and prediction.

→ Calls for methods to extract knowledge from undifferentiated data

   KNOWLEDGE EXTRACTION, e.g. through data mining
Development trend # 3:
Network Simulation-Assignment Modeling for Advanced Traffic System Management

Irvine network overview:
- 326 nodes and 626 links.
- 70 actuated-controlled urban intersections.
- 61 traffic demand zones

- Morning peak period (4:00 AM – 10:00 AM)
- 30-second observation intervals on 19 freeway links
- 5-minute observation interval on 28 arterial links
Link Density Estimation and Prediction

Subject to considerable academic development in the area of algorithm development and testing

Rapidly coming to market, in conjunction with asset tracking and management technologies

Prospect for tie-ins with predictive traffic management tools, e.g. DYNASMART-X
Example of Collaborative Logistics:
Vendor-management Inventories (VMI)
Online Inventory Routing Problem (OI RP)
Results Summary (for scenarios studied)

• Giesen, Mahmassani and Jaillet (2006) developed dynamic routing methods for collaborative Vendor-Managed Inventory logistics systems.

• On-Line Inventory Routing Strategies:
  – **Decrease** Average Total Cost by 21% vs. Off-line static methods.
  – **Decrease Variability** in Average Cost.
    – Benefits tend to be higher when clusters of customers are close to each other and/or near to the depot (case 3).

• Benefits of dynamic strategies tend to increase:
  – with higher inventory costs.
  – with greater demand variability.
Anticipatory Pricing Strategy for Managed Lane Operation

- What differentiates anticipatory from reactive pricing?
  - Network state prediction
  - Use predicted traffic conditions
  - Calculate link toll within the prediction horizon and implement it in real time
Value Pricing, Managed Lanes

- Value pricing
  - Let travelers choose between two adjacent roadways: priced but free-flowing vs. free but congested

- Applications
  - Predetermined toll values
    - SR-91 in Orange County, California
    - Harris County, Texas
  - Reactive
    - I-394 Minnesota
    - I-15 FasTrak in San Diego, California
Motivation

• Anticipatory pricing
  – Set toll values based on predictive traffic measures in order to prevent traffic breakdown before it occurs

• Managed lanes
  – Anticipatory ramp metering

• Advanced Traveler Information Systems (ATIS)
  – Anticipatory travel time information provision

• Anticipatory measures are expected to be more effective than the prevailing measures when prediction is reliable
Descriptive conditions; PREDICTION

Anticipatory information control pricing

Traffic Management Center

Guidance (VMS, Info to users), Signal control Prices

Network

Real-time Traffic Estimation / Prediction System

Advanced Traffic Models

Fundamental core

• Flow Models
• Behavior
• Algorithms

Real-time traffic data

Sensor systems

Historical data

6/3/2008

Real-time traffic data

Real-time Traffic Estimation / Prediction System
Reactive Pricing Strategy

- How does reactive pricing work?
  - obtain the **prevailing** traffic measures/conditions
  - adjust **current link tolls** accordingly
  - communicate to drivers via local VMS at the entry point
  - could also disseminate via radio, in-vehicle equipment, mobile, internet etc.
Anticipatory Pricing Strategy for Managed Lane Operation

- What differentiates anticipatory from reactive pricing?
  - Network state prediction
  - Use predicted traffic conditions
  - Calculate link toll within the prediction horizon and implement it in real time

**Flowchart:**
- **Link Toll Generator** ➔ **Toll values** ➔ **Real World Traffic**
- **Traffic Prediction** ➔ **Traffic data** ➔ **Predicted data**
The Test Bed Network: CHART

- I-95 corridor between Washington, DC and Baltimore, MD, US
- 2 toll lanes
- 2241 nodes
- 3459 links
- 111 TAZ zones
- 2 hours morning peak demand
Pricing Strategies Compared

- No pricing (base case)
- Static pricing
  - Predetermine the time-varying link tolls based on the historical information
- Reactive pricing
  - Set time-varying link tolls based on prevailing traffic conditions
- Anticipatory pricing
  - Set time-dependent link tolls based on predicted traffic conditions

OBJECTIVE: AVOID BREAKDOWN—optimize throughput, reliability, under economically efficient allocation
Illustrative Results – Travel Time

- Warm-up period: increase in travel time at the beginning
- With the anticipatory pricing strategy, the travel times become steady after 1 hour (free flow condition)
- Static pricing strategy provides free flow condition on the toll lanes, but reduces the LOS on the alternative freeway lanes
Illustrative Results – Traffic Measures

- Concentrations averaged over links along the congested portion of toll road, weighted by the link length
- Throughputs measured at downstream of where traffic breaks down in base case (no pricing)
- Anticipatory pricing strategy can provide higher throughput while maintaining lower concentration (steady traffic flow)
Integrated Corridor Management (ICM) refers to the

- **Coordination** of individual network operations between adjacent facilities to create an **interconnected system** capable of **cross-network travel management**, along major corridors in metropolitan areas.

- Aggressive and targeted application of intelligent transport system (ITS) technologies to influence not only
  - operational performance of highway facilities, but also
  - the demand for travel in the corridor.

- Combined application of judiciously matched operational strategies (supply-side) with travel demand management (TDM) approaches, including dynamic pricing, coupled with operational (access) control

**to bring about improvement in travel time, delay, fuel consumption and emissions, and increase the reliability and predictability of travel.**
A VARIETY OF TRANSIT-ORIENTED AND INTERMODAL OPERATIONAL CONCEPTS

- Contraflow lanes
- Multiple access modes
- Bus Priority at Signals
- Bus Rapid Transit
Network Simulation-Assignment Modeling for Advanced Traffic System Management
RECENT GENERALIZATION: DYNASMART-ICM

Modeling Intermodal Choice and Departure Time Dynamics in Simulation-based DTA Framework

Considers Congestion Pricing, Travel Time Reliability, in addition to Transit Operational Strategies and Traveler Information, with Heterogeneous Users

Example of integrating demand and supply in a micro-assignment simulation-based platform
Potential Benefits of ICM

Potential Range of Benefits

Corridor-wide Travel Time Reduction Benefits

- Corridor-wide Information (Passive Diversion/Roadway Only)
- Proactive Diversion (Multi-Modal where applicable) + operational strategies
- Demand Management/Increased Corridor Capacity

- Congested Small Corridor - Non-recurrent
- Less-congested Large Corridor - Non-recurrent
- Congested Small Corridor - Recurrent
- Less-congested Large Corridor - Recurrent
SEVEN BIG THEMES FOR RESEARCH

• EXPLOSION OF REAL-TIME INFORMATION and REAL-TIME DECISION METHODOLOGIES for OPERATIONS: DYNAMIC NETWORK MANAGEMENT (incl. PRICING), INTERMODAL SYSTEMS, COLLABORATIVE LOGISTICS

• WIRELESS INTERNET, PERSONAL MOBILE DEVICES, RF TAGS, E_SEALS:
  – **TELEMOBILITY** and **TELELOGISTICS** (CHANGES IN DEMAND), AND
  – PEOPLE/VEHICLES/SHIPMENTS AS PROBES (SOURCE OF REAL-TIME DATA FOR OPERATION, SURVEY DATA FOR PLANNING)
  – From a **REAL-TIME ECONOMY** to the **REAL-TIME SOCIETY**

• AUCTIONS and REAL-TIME INTERACTIVE MARKET-BASED MECHANISMS (INCL. PRICING) FOR PROCUREMENT AND CAPACITY ALLOCATION

• PEER-TO-PEER, AD-HOC NETWORKING AS SYSTEM MANAGEMENT APPROACHES: IMPLICATIONS FOR SYSTEM RESILIENCY
SEVEN BIG THEMES FOR RESEARCH (ctd.)

• UNDERSTANDING SYSTEM VULNERABILITY AND RESILIENCY; IMPLICATIONS OF OPERATIONAL CONSIDERATIONS FOR PLANNING AND DESIGN

• USER BEHAVIOR AND RESPONSE: KEY BUILDING BLOCK FOR USE OF INFORMATION AS TOOL FOR POLICY AND CONTROL; BEHAVIOR CHANGE TOWARDS SUSTAINABLE PATTERNS

• NEW BUSINESS MODELS FOR INFRASTRUCTURE DEVELOPMENT, OWNERSHIP AND OPERATION; FOR SYSTEM AND SERVICE DEVELOPMENT AND MANAGEMENT.
LIGHT AT THE END OF THE TUNNEL?

Thank you

Q & A

May 30, 2008