Accelerating Innovation in Intelligent Transportation Systems Research and Application

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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
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.
Technological Drivers

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

Source: Qualcomm.com
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
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

e-logistics
m-logistics

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
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:

Inexpensive wireless sensors

- Provides particle (user-centric) views of system
- 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

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
Greater Baltimore Network Redundancy Analysis Project Overview

General objectives:
• Decision Support Tool to
  – examine the ability of the transportation network to withstand shocks and disruptions
  – develop contingency measures and strategies

Methodology:
• DYNASMART-P: A dynamic network modeling capability, to represent the impacts of the disruptions on the performance of the system
• Overcomes limitations of conventional planning tools, and provides combined network assignment and traffic simulation capability for large network
Greater Baltimore Network DTA Model

**DTA Model Run**

- 1,901,000 vehicles generated for AM peak period (6-10 AM)
- 210,000 vehicles simultaneously in the network
Estimation performance for link 12893
(MD 108 at Old Stockbridge Dr/Golden Bell Way)
Dynamic Pricing, Managed Lanes and Integrated Corridor Management: Challenges for Advanced Network Modeling Methodologies
Motivating Phenomena:
- Growing congestion in metropolitan areas...
- Budget constraints for highway authorities...

Objectives of road pricing:
- Revenue generation: road/bridge tolls
- Congestion management: congestion pricing, cordon tolls and high occupancy toll (HOT) lanes...toward dynamic pricing (with time-varying tolls)...

Examples of road pricing applications
- London cordon pricing: charging private vehicles in downtown area to reduce traffic congestion and raise revenues for transport improvements.
- I-15 HOT lanes in San Diego: allowing solo drivers to pay a dynamic toll to use the express lanes normally reserved for high occupancy vehicles (HOV).
- Highway 407, the Express Toll Route (ETR), in Toronto: collecting tolls based on distance traveled in the multi-lane electronic highway.
- State Route 91 in Orange County, California: express toll lanes constructed and operated by private company.
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
HOT LANES

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*

Hot lanes will only be considered with the addition of a lane to the Beltway. No general purpose lanes will be converted to HOT lanes.
Value Pricing

• 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
**Anticipatory Pricing Strategy**

- 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

![Diagram](image.png)
The Greening of Freight in Europe:
Assessing the Market Potential of New Services and Lower Barriers Using a Dynamic Intermodal Simulation Assignment Methodology

Coordinated Action Project
European Commission
6th Framework
• Intermodal network representation
  – Physical network
  – Service network (train and ferry routes with time table)

• Multiple products intermodal shortest paths
  – Based on the simulation output (cost and delay)
The REORIENT Network

- Spans 23 countries
- Rail portion
  \[(\text{Nodes};\text{Arcs})=(5577;5753)\]
- Road portion
  \[(\text{Nodes};\text{Arcs})=(4713;5460)\]
- Sea portion
  \[(\text{Nodes};\text{Arcs})=(54;21)\]
Network Modelling Structure

- **Demand**
  - Mode and Path Choice
  - Assignment
  - Simulation
  - Intermodal Path Computation

- **Supply**
  - Modal/Market Shares
  - Service Travel Times
  - Terminal Delays

- **Infrastructure**
  - Schedule Design
  - Route Design

- **Network Services**
  - CDM* Operation Rules

*Collaborative Decision Making*
Dynamic Intermodal Simulation-Assignment Platform

Consolidation at Origin:
Shipments to trucks.

Intermodal Terminal:
Shipment transfer from trucks to railcars

Shuttle Service (for traditional trains):
From terminal to classification yard

Classification Yard:
Train assembly process. Not required for intermodal block trains.

Border Station:
Train is delayed

Classification Yard:
Train is disassembled. For intermodal block trains, this process is not required.

Port:
Transfer of shipments from rail cars to ferry. Ferries move based on given timetables

Shuttle Service (for traditional trains):
From classification yard to port

Destination:
Unloading shipments

Simulation-assignment method:
- processes simulated to determine processing costs and times at nodes and links of path
- Shipments assigned using joint mode-path choice assignment
- Detailed representation allows us to test various policies, such as infrastructure improvements, service frequency changes, and improvement in border crossing procedures.
Intermodal network representation (zones)
Simulation
Proposed Service Routes

**T1 = Green (Bulk)**
Swinoujscie - Vienna/Bratislava - Budapest

**T2 = Yellow (Unitized)**
Trelleborg-Swinoujscie-Bratislava/Vienna

**T3 = Red (Unitized)**
Gdansk/Gdynia-Bratislava/Vienna-Budapest-Beograd-Thessalonica

**T4 = Blue (Bulk and Unitized)**
Bratislava-Budapest-Bucharest-Constantia
Do Border Crossing Delays Hinder Rail Utilization?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Border crossing times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservative</td>
<td>3-4 hours</td>
</tr>
<tr>
<td>Sophisticated</td>
<td>15-45 min</td>
</tr>
</tbody>
</table>
Findings

- Improved border operations, infrastructure improvements, greater access to services, relaxing scheduling constraints have considerable potential to increase intermodal rail share.
- Further improvement possible through more sophisticated operation of the rail network to allow more efficient priority allocation to different services.
- Managing the rail system in the 21st Century will require new management models. Most promising models will be based on collaborative decision-making architectures.
EIGHT 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)

• 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

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

• STRATEGIC MOBILITY, ENERGY AND SUSTAINABILITY
LIGHT AT THE END OF THE TUNNEL?

Thank you

Q & A

Transportation Center
Northwestern University
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