Intelligent Transportation Solutions for Sustainable City Logistics: Issues and Prospects

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LOGISTICS

• “...part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customer requirements”

  Council of Logistics Management (2001)

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

Impacted by traffic congestion and constraints of urban fabric 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
CITY LOGISTICS

MICRO-LOGISTICS

- Fine-grained
- Urban micro-structure
- Limited vehicle access
- Difficult to maneuver

Small-quantity deliveries
High density of delivery points
Growing role for small specialized urban (green) vehicles
Low automation, critical human role
High operational and environmental costs

Critical to optimize operations to minimize number of vehicles, travel kilometers and idle time
Important role for collaborative logistics strategies
CITY LOGISTICS

MACRO-LOGISTICS

- Coarse-grained
- Regional and global scale
- Specialized facilities and equipment
- High degree of automation and ICT use

Large-quantity handling
Low density of delivery points
Larger vehicles, consolidation

Critical to optimize operations to maximize profit and gain efficiencies

Important role for collaborative logistics strategies
MICRO vs. MACRO LOGISTICS ISSUES

- Diverging imperatives of micro vs. macro logistics
- In some communities (especially in US), transporters and fleet managers have addressed micro-level as if another set of nodes in macro-logistics network—e.g. send big trucks to make neighborhood supermarket deliveries
- In other communities (especially in Europe), growth in suburban development with “big box” retailing to enable and leverage lower distribution logistics costs
- Both approaches poor from sustainability standpoint
- Implications for intelligent hierarchical logistics system design to support collaborative logistics strategies
- Both micro and macro logistics benefit from greater ICT use and intelligent transportation technologies
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.
Technological Drivers

Operations Control Center

Communications Satellite

Internet Connection

Integrated Mobile Communications Terminal

POS Information

Source: Qualcomm.com
Technological Drivers

Information & Communication Technologies (ICT)

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

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

=> Large amounts of real-time information
on state of system at lower cost
INFORMATION AND TELECOMMUNICATION TECHNOLOGY (ICT)

Permeating the world of Transportation Systems through:

- Adoption as tool for better system management
  (ATMS, Fleet Management…)
- Ubiquitous availability of mobile information devices to users
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)
Programming the eSeal
eSeal Readers at Border
An early vision-- CVISN (See-Vision): Commercial Vehicle Information System Network
FHWA, 1998

Vision: Safe and Efficient Shipping Operations

- Automated Fleet & Freight Administration
- Seamless Intermodal Operations
- Electronic Tag
- Mobile Comm
- Safety Equipment
- On-board Computer
- On-board Monitors
- On-board Navigation
- Electronic Screening
- WIM
- International Border Clearance
- “Paperless” Vehicle
- Automated Inspections
TRANSPORTATION: PHYSICAL MOBILITY OVER SPACE

- Limited growth in capacity, and in output (compared to information –voice and data--traffic)
- Social expectations and public policy: *diminished expectations* of curtailed access, limited over time and space
- Subject to considerable inefficiencies, high congestion, arbitrary rules for allocation and use of capacity
To escape the physical world, People created a virtual world...
Wireless data rates continue to increase...

THE WIRELESS INTERNET
New Opportunities are created when products go digital (Motorola, 2005)

Today’s handset and mobile unit capabilities (cpu, memory,…) are comparable to large workstations of a few years ago.
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;
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
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 logistics applications, at micro and macro scales

- 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.

  Dynamic vehicle routing and fleet management tools

  Platforms for collaborative logistics

- 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
A Priori Estimation vs. Online Estimation

Example 1: (Density)
Example 2: (Density)

<table>
<thead>
<tr>
<th></th>
<th>A Priori</th>
<th>On-line</th>
<th>% Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>11.6</td>
<td>10.5</td>
<td>9.50%</td>
</tr>
<tr>
<td>Volume</td>
<td>288.8</td>
<td>208.5</td>
<td>27.80%</td>
</tr>
<tr>
<td>Speed</td>
<td>16.7</td>
<td>14.1</td>
<td>25.60%</td>
</tr>
</tbody>
</table>
Time-dependent OD Generation
Network Density Estimation and Prediction
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: Vendor-management Inventories (VMI) Online Inventory Routing Problem OIRP Instance
En-Route Diversion

Retailer n

Retailer n-1

Retailer 1

Distribution Center

Retailer 2

Retailer 3

(!) Demand Disruption Occurs
Plan is updated based on projected state of the system
Recent development in OIRP: Giesen, Mahmassani and Jaillet (2006)

- VMI Agreements and Vertically Integrated Distribution Systems

- Extend Dynamic Vehicle Routing Problems to Incorporate Inventory Control

- In all previously studied *Inventory Routing Problems (IRP)* routes are not modified after leaving the *depot* (Baita et al, 1998; Campbell et al, 1998; Kleywegt et al, 2002)
Results Summary (for scenarios studied)

• On-Line Strategies RDE and RDE+div:
  – **Decrease** Average Total Cost **by 21%** vs. BENCH
  – **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
Real-Time Info for Operational Decisions

Predictive Approaches:

Optimize for forecast demands

Real-time data $\rightarrow$ basis for prediction over next horizon
Real-Time Info for Operational Decisions

Reactive Approaches:
Optimize for realized, known demands
Real-Time Info for Operational Decisions

**HYBRID APPROACHES:**

Optimize for *Predicted* Conditions

React to deviations from forecast conditions

→ requires logic for checking, identifying deviations triggering action: plan modification, rapid response, etc…

**APPLICATIONS:**

Traffic network management– route guidance, traffic control

Real-time fleet operations – truck dispatching, load acceptance and assignment

Collaborative logistics -- online inventory routing
Methodologies for Real-Time Decision Making Under Real-Time Information

- Involves the following:
  - Information gathering
  - Information processing
  - Pattern recognition
  - Algorithm development and refinement
  - Generating system management actions
  - Surveillance and feedback
  - Adaptive learning
IN CONCLUSION

• TRADE-OFFS BETWEEN ADDITIONAL COST AND ENHANCED QUALITY OF LIFE— for many areas, the choice is made; many others are getting on board

• SUSTAINABILITY IN A WORLD OF ECONOMIC EFFICIENCY: Must learn to factor in full costs

• STRONG IMPERATIVE FOR COLLABORATIVE LOGISTICS SCHEMES AT MICRO URBAN LEVEL

• KEY ROLE for INTELLIGENT TRANSPORTATION TECHNOLOGIES to support efficiency, sustainability and security for micro and macro logistics

• TECHNOLOGY PAYS FOR ITSELF: productivity gains to private actors justify investment for societal objectives
## Improving Supply Chain Efficiency

### ESCM vs. Manual per Shipment for Manufacturers

<table>
<thead>
<tr>
<th>Activity</th>
<th>Manual Time</th>
<th>ESCM Time</th>
<th>Time Savings</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filling out manifests</td>
<td>2.35</td>
<td>1.07</td>
<td>1.28</td>
<td>54%</td>
</tr>
<tr>
<td>Contacting motor carriers (from carrier order acceptance)</td>
<td>0.51</td>
<td>-</td>
<td>0.51</td>
<td>100%</td>
</tr>
<tr>
<td>Search out documentation, load verification, driver sign-off</td>
<td>4.12</td>
<td>0.18</td>
<td>3.94</td>
<td>96%</td>
</tr>
<tr>
<td>Paperwork error correction</td>
<td>0.12</td>
<td>-</td>
<td>0.12</td>
<td>100%</td>
</tr>
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## Improving Supply Chain Efficiency

### ESCM vs. Manual per Shipment for Airlines

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<th>ESCM Time</th>
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<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order taking/contact motor carriers</td>
<td>4.09</td>
<td>-</td>
<td>4.09</td>
<td>100%</td>
</tr>
<tr>
<td>Load acceptance</td>
<td>3.03</td>
<td>0.11</td>
<td>2.92</td>
<td>96%</td>
</tr>
<tr>
<td>Clerical time for creating airplane load</td>
<td>3.00</td>
<td>-</td>
<td>3.00</td>
<td>100%</td>
</tr>
<tr>
<td>documentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paperwork error correction</td>
<td>0.41</td>
<td>-</td>
<td>0.41</td>
<td>100%</td>
</tr>
<tr>
<td>Copy and file for FAA audits</td>
<td>1.10</td>
<td>-</td>
<td>1.10</td>
<td>100%</td>
</tr>
<tr>
<td>Contact airline and arrange shipping</td>
<td>4.09</td>
<td>-</td>
<td>4.09</td>
<td>100%</td>
</tr>
<tr>
<td>Delivery to airlines</td>
<td>3.03</td>
<td>0.11</td>
<td>2.92</td>
<td>96%</td>
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### ESCM vs. Manual per Shipment for Truckers

<table>
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<tr>
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<th>ESCM Time</th>
<th>Time Savings</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order acceptance over the phone and data input</td>
<td>0.51</td>
<td>-</td>
<td>0.51</td>
<td>100%</td>
</tr>
<tr>
<td>Load acceptance at manufacturer</td>
<td>4.12</td>
<td>0.18</td>
<td>3.94</td>
<td>96%</td>
</tr>
<tr>
<td>Input to create master manifest</td>
<td>2.08</td>
<td>0.43</td>
<td>1.65</td>
<td>79%</td>
</tr>
<tr>
<td>Reproduction of manifests</td>
<td>1.03</td>
<td>-</td>
<td>1.03</td>
<td>100%</td>
</tr>
<tr>
<td>Paperwork error correction</td>
<td>1.03</td>
<td>-</td>
<td>1.03</td>
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<td>4.09</td>
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<td>2.92</td>
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LIGHT AT THE END OF THE TUNNEL?

Thank you

Q & A

City Logistics Expo
Padova
April 20, 2007