Transportation, ICTs and Future Cities

Symposium on Transportation Network Design and Economics

Northwestern University
January 29, 2010

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Population Density, Urban Roads and Radiotelephone Employees:

100 Largest US Cities in Census Years of 1910-2000

- **Persons/sq. mi; Road miles (00)**
- **Radiotelephone Employees**

- **Pop. Density**
- **Urban Road**
- **RT Employment**
Drivers of Urban Growth

1. Economic and industrial policies: 77.6%
   1. creation of special economic zones: 20.8%
   2. investments in transport infrastructure: 40.8%
   3. investment in information and service: 15.9%

2. Improvements in the quality of life: 10.2%

3. Administrative changes: 12.2%

Megacities

- **World Bank’s Projection for World Population**
  - 2030: 8.13 B Population, 5 B in Urban Areas (61%)
  - 2003: 6.3 B Population, 3 B in Urban Areas (48%)
  - For about 27 years, 2 Billion more residents to be accommodated in cities of the World.
## Resources Needed for A Megacity

<table>
<thead>
<tr>
<th>Consumption/Year</th>
<th>Megacity of Ten Million People</th>
<th>Equivalent to</th>
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</thead>
<tbody>
<tr>
<td>Water</td>
<td>2.2 Billion tons</td>
<td>3 x capacity of Hoover Dam</td>
</tr>
<tr>
<td>Gasoline</td>
<td>3.2 Billion gallons</td>
<td>1,100 tank lorries/day</td>
</tr>
<tr>
<td>Electricity</td>
<td>58 Billion kWh</td>
<td>7.5 x amount generated by Hoover Dam</td>
</tr>
<tr>
<td>Food</td>
<td>5 Million tons</td>
<td>15,000 trucks/day</td>
</tr>
<tr>
<td>Waste</td>
<td>4.2 Million tons</td>
<td>11,500 trucks/day</td>
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Transportation Issues

• Transportation is seen as the single biggest infrastructure challenge by a large margin, and is a key factor in city competitiveness.

• With air pollution and congestion emerging as the two top environmental challenges, stakeholders predict a strong emphasis on mass transit solutions.

• Cities are more likely to focus on incremental improvements to existing infrastructure, rather than new systems.

• Siemens’ Report, p. 26
How to Maximize Both Interests?

• **Public Sector as Leader**
  - Ex: Dynamic Tolls with Real Time Traffic Information toward implementing System Optimal?

• **Users**
  - Ex: Information Providers as well as Receivers for Real-time Information?
Integrated Planning Model

\[ \min_{h,x} \quad Z(h, x) = \sum_{a} \int_{0}^{f_{at}} d_{at}(\omega) d\omega + \sum_{mj} d_{ijt} \frac{x_{ijt}^{m}}{g_{m}} + \sum_{m} \frac{1}{\beta_{m} g_{m}} \sum_{ij} x_{ijt}^{m} \ln \left( \frac{x_{ijt}^{m}}{X_{it}^{m}} \right) \]

s.t. \[ \sum_{i} x_{ijt}^{m} = \sum_{n} a_{ij}^{mn} \sum_{k} x_{jkt}^{n} + y_{jt}^{m} \quad \text{for all} \ m, j, t \quad \text{Material balance} \]

\[ \sum_{r} h_{ijrt}^{m} = \frac{x_{ijt}^{m}}{g_{m}} \quad \text{for all} \ m, i, j, t \quad \text{Conservation of flow} \]

\[ h_{ijr}^{m} \geq 0 \quad \text{for all} \ m, r, i, j \quad \text{Non-negativity} \]
Integrated Urban Systems Model

\[
\min_x \quad Z(x) = \sum_a \int_0^{f_a} d_a(x) \, dx + dE
\]

\[s.t. \quad X = AX + E\]

\[E_c + E_s \geq E\]

\[X \geq 0\]
Real-Time for Ubiquitous Mobility

• Develop sensing and access systems on both vehicles and roadways
  – sense and monitor fuel and energy consumption, pollution emission, traffic density, noise, street conditions (e.g. slick, dry, gravel, potholes), pedestrian sensing, etc.

• Develop methods for utilizing real-time data for providing ubiquitous mobility access.
Enabling Technologies for Implementing Ubiquitous Access

- **Ubiquitous Access Technology**
  - Sensor/Sensing Technology
  - Ubiquitous Computing Technology
  - Sensing Technology
  - GIS/GPS Technology
  - LBS/Telematics

- **Supporting Technologies**
  - Web Mapping
  - Component GIS
  - Data Provider
  - Spatial Decision Support System
  - Position Tracking Tech
  - LBS Application Car Navigation
  - Real-Time Moving Feature Processing Tech
Transportation Planning for Ubiquitous Technology Spaces

Services or Applications

Real Time Traffics Information

Infrastructure Monitoring

Disaster Management Planning

Emergency Evacuation

100% O-D Data

Concierge Services

USN-OIS

USN-ODS

Management Agent

BcN

USN Gateway

USN Gateway

USN Gateway

Sink Node

Sink Node

Sink Node

RFID Reader

RFID Reader

Mobile RFID Reader

Repeater

Sensor Network dev.

Sensor Network dev.

USN common tech dev.
Cities in Ubiquitous Technology Space

Sustainable Transportation

Products/Outcomes

U. Public Service
U. Education Service
U. Transport Service

U. Facility Mgmt Service
Crime Prevention System

Location-based Service
Environmental Protection

U. Emergency Service
Emergency Evacuation

U. Portal Service
U. Health Service

U. Emergency Service
Emergency Evacuation

Enabling Technology

Ubiquitous Computing
Sensing Technology
Ubiquitous GIS

Location-based Service
Intelligent Transport
Global Positioning

Knowledge Base

Analytic Methodologies
(Algorithms, modeling, statistics, and simulations)

Urbanization Process
Market Behavior
Urban Form/Structure

Data Structure and Retrieval

Travelers' Behavior
Location Choice Behavior
System Optimum Principle

Research Domain

Multi-disciplinary Approach

Cyber-Physical System