CONNECTED SYSTEMS, SMART CITIES AND URBAN MOBILITY: REALIZING THE POTENTIAL OF USER–CENTERED INTELLIGENCE

Hani S. Mahmassani
Northwestern University
Outline

➢ The Context: Data Sources-- Sensors, Probes, Transactions

➢ The Opportunity: System Intelligence through Predictive Analytics
  ▪ Weather-related traffic management
  ▪ Opportunities for user-centric intelligence

➢ Connected Vehicle Applications
  ▪ Speed harmonization in connected vehicle environment

➢ Concluding Thoughts
  ▪ ITS: local or global?
  ▪ Smart cities: the way forward
KEY TAKEAWAYS

1. We can no longer afford non-intelligent transportation systems.

2. ITS has evolved from highways and vehicles to encompass multimodal systems and urban mobility; the next generation places the user at the center of a mobile connected system and delivers personalized mobility as an application.

3. Developments in transportation systems are inexorably moving towards greater connectivity and automation—orders of magnitude more data and data opportunities.

4. System intelligence is work in progress; prediction and customization are critical elements.
5. We can do much more to reduce congestion by targeting behavior through predictive strategies at various levels; we give some examples.

6. Private sector integral player in connected systems development; role of agencies is to facilitate through shared data and application platforms, and to act as “flow management agent” to ensure public safety and efficient system operation.

7. How will Smart cities come about? Wait until the end of my presentation...
The Context:

*Data Sources*—Sensors, Probes, Transactions
Convergence of location, telecommunication and automotive technologies for better transportation system safety, efficiency, and user convenience.
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.
1994 to 2014

20 YEARS--
DEPLOYMENT OF A LOT OF
TECHNOLOGY

NOT AS MUCH INTELLIGENCE
Transportation agencies

Have deployed sensors to measure traffic conditions at selected points along major highways
Also at intersections to drive the traffic signals ("vehicle-actuated")

Typical set up
Smartphones—people and vehicles as probes, and interface

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

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

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

**ENTERPRISE**
Fleet Management
Asset Monitoring
Personnel
Productivity

**COMMERCE**
Mobile Coupons
Customer Service
THE USER IS AT THE CENTER OF THIS WEB OF CONNECTIVITY AND “ALWAYS AWARE” SYSTEMS AND DEVICES
WHY IS THIS RELEVANT TO TRANSPORTATION?

SEAMLESS CONNECTIVITY

TRANSPORTATION DELIVERS PHYSICAL MOBILITY IN A VIRTUALLY CONNECTED MOBILE ENVIRONMENT
The vision for connected vehicle research is to transform surface transportation systems to create a future where:

- Roadway crashes and their tragic consequences are significantly reduced.
- Traffic managers have data to accurately assess transportation system performance and actively manage the system in real time, for optimal performance.
- Travelers have continual access to accurate traveler information about mode choice and route options, and the potential environmental impacts of their choices.
- Vehicles and traffic signals can communicate to eliminate unnecessary stops and help drivers operate vehicles for optimal fuel-efficiency and emissions reduction.
Apps for V2V and V2I connectivity

V2V Safety Applications
- Emergency Brake Light Warning
- Forward Collision Warning
- Intersection Movement Assist
- Blind Spot and Lane Change Warning
- Do Not Pass Warning
- Control Loss Warning

V2I Mobility Applications
- Intelligent Traffic Signals
- Speed Harmonization
- Enable Traveler Information
- Transit Connection
- Incident Management

V2I Environmental Applications
- Eco-Signal Systems
- Eco-Routing
- Smart Parking
- AFV Charging/Fueling Information

Vehicle To Vehicle (V2V)

Vehicle To Infrastructure (V2I)

RSE Unit

U.S. Department of Transportation
Smart city vision– powered by Intel

Source: Intel
Everybody is talking about it

The real value of the Internet of Everything lies in the value of connections among people, process, data, and things, not simply in the sheer number of things that are connected.

When your car becomes connected to the Internet of Everything...

...more numerous, valuable, and relevant connections with other cars, stop signs, your home, and even the road itself will make your driving experience safer, more fun and informed, and even more efficient.

It’s the connections that matter most.

The Internet of Everything

#InternetofEverything
#IoE
INTELLIGENT VEHICLE-HIGHWAY SYSTEMS

ITS 0.9
- Vehicles
- Highway infrastructure

ITS 1.0
- Buses, trains, multimodal services
- Urban mobility

ITS 2.0 = CS 2.0
CONNECTIONED SYSTEMS

FOCUS: THE USER
- Mobility as an APP in seamless connected environment

Digital 6th Sense
- Learns what you like
- Discovers things relevant to you
- Interacts with networks
- Senses local content and services
- Knows you and what is around you
- Filters out irrelevant
So many sensors

SMALLER, CHEAPER, UBIQUITOUS, CONNECTED
Not limited to cars and objects
The Opportunity:
System Intelligence through Predictive Analytics
Opportunity

Connectivity
How is more data allowing me to

**Do things differently** (*better– faster, cheaper, safer, higher impact, customer-pleasing...*)

**Do different things** (*grow activities, revenue, improve image, employee retention...*)
APPS, APPS, EVERYWHERE

ARRANGING FOR A CAB in REAL-TIME (UBER)

REAL-TIME PARKING APPS (Crowdsourced)
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
Traffic Estimation and Prediction System (TrEPS)  

**DYNASMART-X**

- Current traffic conditions
- Prediction (no intervention)
- Prediction (with intervention)
PREDICTIVE ANALYTICS: Basis for Intelligent Control Strategies

Consistent anticipatory travel time information and routing decisions

(Dong and Mahmassani, 2010, 2014)

Dynamic pricing for managed lane operations

Link Toll Generator

Toll values

Real World Traffic

Traffic Prediction

Predicted data

Traffic data

(Reference: Dong et al. 2012)
Weather-sensitive TrEPS

Weather-sensitive traffic operations model

**Estimation**: weather-sensitive traffic simulation-assignment model

**Prediction**: weather-sensitive traffic simulation-assignment model

Weather-responsive traffic management strategies

Weather data

Weather monitoring systems

Weather forecast

Alert weather conditions

PREDICTIVE ANALYTICS
6:30 am

07-00.Regular  07-01.NoWRTM  07-02.VSL7  07-03.VMS2
8:00 am

25-00.Regular
25-01.NoWRTM
25-02.VSL7
25-03.VMS2
8:30 am
9:00 am

37-00.Regular
37-01.NoWRTM
37-02.VSL7
37-03.VMS2
9:30 am

43-00.Regular
43-01.NoWRTM
43-02.VSL7
43-03.VMS2
10:00 am

49-00.Regular
49-01.NoWRTM
49-02.VSL7
49-03.VMS2
Off-line Implementation (Salt Lake City)

- Demand Management
  - Analysis Results

(a) Time-dependent network throughput measure

(b) %Change in performance measures for different demand levels relative to base-case
Project Objectives

• Integrate and operationalize the weather-sensitive TrEPS models calibrated for Salt Lake City to support weather-responsive traffic signal timing implementation
  – Evaluate different possible signal timing strategies under weather-related scenarios
  – Determine when to deploy such weather-responsive signal timing plans

• Monitor the implementation of the TrEPS-based decision support system, and its effectiveness in terms of weather-responsive traffic management
Real-time Surveillance Data

- Freeway detectors
  - 30-second observation interval
  - occupancy, vehicle counts, speed

- Riverdale road cameras
  - Vehicle counts, speed
Real-time Traffic Management

before implement management strategy

after implement management strategy
PREDICTION essential in real-time traffic management and urban logistics

Considerable opportunities: new sources of personal information, emerging technologies

Computational challenges remain

User behavior: will remain moving target, because users will adapt hence need for adaptive schemes

Growing role of private sector as business models become more compelling
Leverage system state information and individual characteristics (and preferences) in generating interventions that are

- dynamic (timely)
- localized (consider network and non-network factors)
- anticipatory (consider predicted events and system evolution)
- adaptive (learn about individual responses and system impacts)
- distributive (across modes, times of day, user groups)
- economically efficient (e.g. consider value of time distribution)
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FLOW MATTERS: CONNECTED VEHICLES TECHNOLOGY and PROGRAMS
Connected vehicle research is a suite of technologies and applications that use wireless communications to provide connectivity:

- Among vehicles of all types
- Among vehicles and roadway infrastructure
- Among vehicles, infrastructure, and wireless consumer devices

Connected SYSTEMS: Add
 USERS (Travelers)
 OPERATORS
EXAMPLE APPLICATIONS
V to I and V to V

INFLO: Network Flow Optimization
   Speed Harmonization
   Coordinated Advanced Cruise Control (CACC)
   Advance Queue Warning

AERIS: User Information Systems for Environment-related Objectives (Eco-driving, Green choices)

DMA: Dynamic Mobility Applications

Intersections without Traffic Lights
Simultaneous *traffic* microscopic modeling and *telecommunication* system performance: Clustering algorithm for ad hoc network configuration
Objective: Reduce variance of speeds

Benefits: Avoid flow breakdown, maintain throughput
Reduce delay
Improve safety, reduce crashes
Study Segment

I-290 eastbound
5 miles length
7 on-ramps
6 off-ramps
Input data from DYNASMART ALINEA
Simulation Results

Effects of Compliance with the Speed Limit

- Once certain number of vehicles slow down to the posted speed limit, the rest of traffic should automatically slow down

(\textcolor{red}{Red: Speed}; \textcolor{blue}{Blue: Flow})
Simulation Results

Effects of Compliance with the Speed Limit (Continued)

- Once certain number of vehicles slow down to the posted speed limit, the emissions stay at reasonable values.

No Compliance  
10% Compliance  
90% Compliance
Smoothed Speed Variations in Time-Space Diagram for Simulation without and with Active Speed Harmonization
Coordinated Advanced Cruise Control (CACC)

Without CACC:
- Irregular braking and acceleration
- Longer headways
- Lower throughput
- Risk of rear-end collisions

CACC Enabled:
- Coordinated speeds
- Minimized headways
- Higher throughput
- Reduced rear-end collisions
- Fuel economy savings/emissions reductions

1. Lead Vehicle broadcasts location, heading, and speed
2. CACC-enabled following vehicles automatically adjust speed, acceleration, and following distance
3. Any speed or acceleration perturbations by Lead Vehicle can be instantly accounted for by following vehicles utilizing V2V communication
4. TMC observes traffic flow and adjusts gap policy to manage road capacity
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ITS: LOCAL OR GLOBAL?

Technologies: global; no need to reinvent the wheel

Systems/platforms: must be adapted and customized to local conditions

Applications: local intelligence, context expertise, channels for creativity
ITS: LOCAL OR GLOBAL?

Q: LOCAL OR GLOBAL?

A: LOCAL FOR GLOBAL

Locally developed, globally deployed
Concluding Thoughts: Smart Cities

• Smart Cities will not happen by fiat, through top-down big plan
• System is too complex, too fragmented, too many owners, jurisdictions, etc...
• System is too dynamic, will not wait for the final design to materialize, be tested, revised, stabilized, etc...
• It will happen through more or less loose coupling of smart apps, developed by entrepreneurial entities, and/or offices with specific needs
• Opportunity is in facilitating data sharing, transparency, access across apps—this is as much culture as it is technology
• Integration will happen over time, just as new apps appear and others disappear— as marginal effort to leverage data decreases.
THANK YOU!

QUESTIONS?

masmah@northwestern.edu