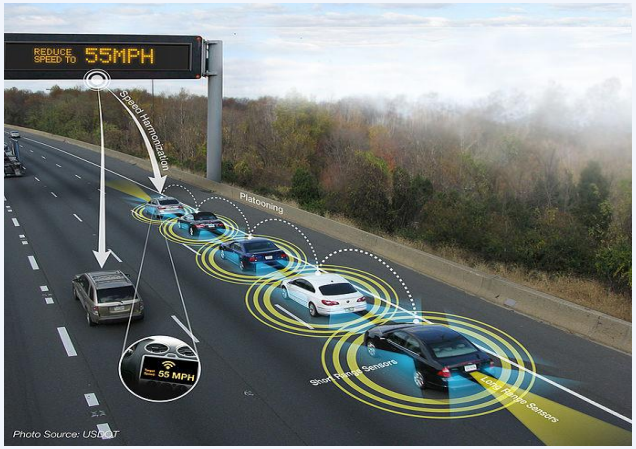
Insights from Some Studies on Control in Traffic Networks



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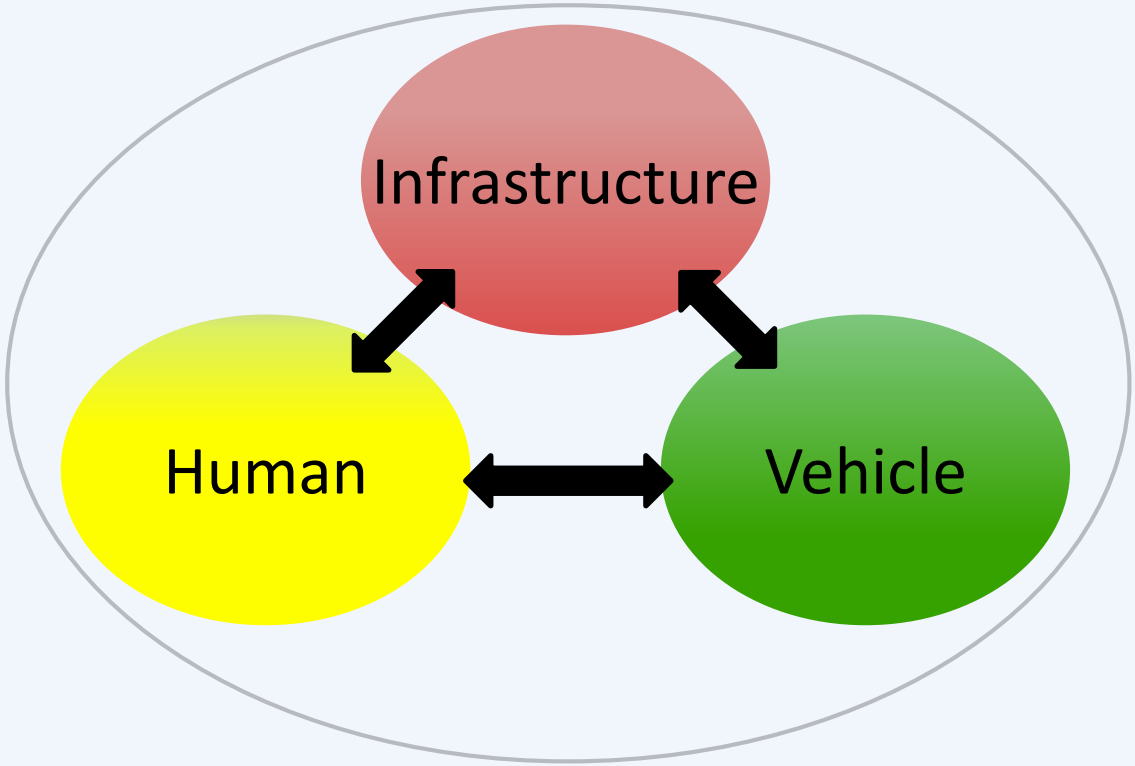
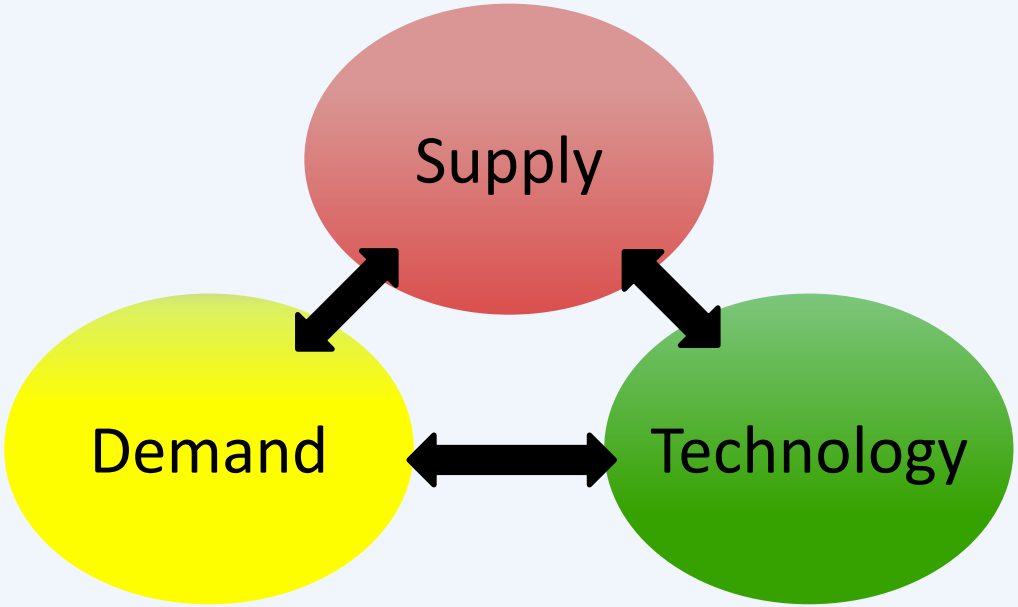
Transportation Ecosystem



Transportation System



Control in Networks: Some Studies

- Real-time dynamic traffic network control
  - Time-dependent conditions
  - Stochasticity: demand, supply
  - Technology: Role of information
  - Traveler behavior
- How information/connectivity can be used to manage networks and their performance
  - Congested traffic networks
  - Disaster response – planning and operations
  - Connected and/or autonomous transportation
  - Collaborative freight networks
  - Organizational networks

Modeling Challenges

- Realism
  - Traffic flow characteristics (analytical, simulation)
  - Travel behavior (departure time/route/mode, learning & evolution, familiarity, risk-taking)
  - Driver behavior (familiarity, experience, aggressiveness)
- Factors
  - Heterogeneity (traveler/driver/human/vehicle)
  - Stochasticity (demand/supply)
  - Time scale (behavior/planning/operations)
  - Interactions (vehicle-human-infrastructure)
- Goals
  - State (description, prediction, evolution)
  - Performance and control

Modeling Challenges

- Mathematical properties
  - Realism in modeling vs mathematical tractability
  - Complexity of traffic flows
  - Traveler behavior and learning
  - Stochasticity, heterogeneity, dynamics
- Computational time
  - Real-time needs
  - Tradeoffs with accuracy
  - Sensitivity issues under emerging technologies

Emerging Technologies

- Connectivity
  - Reliability
  - Congestion
  - Control
  - Security
- Automation
  - Stability
  - Mixed flows
  - Platooning
  - Traffic characteristics
  - Safety and mobility

Needs

- Human-vehicle interactions
  - Transition of control
- In-vehicle interactions
  - In-vehicle devices
  - Mobile apps
- Motion planning
  - Maneuvering
  - Platooning
  - Intersections
- Connectivity-based control
  - In-vehicle/personal devices

Needs

- Transition and mixed traffic flows
  - Level of automation
  - Level of connectivity
  - Vehicle characteristics
  - Asymmetry in human behavior
  - Differences in human and machine approaches to driving
  - Misperception of AV capabilities
- Data
  - What does it reveal?
  - How to connect disparate data?
  - How can it be used to enhance modeling realism?
  - Human in the loop

Insights: Some Problems Addressed

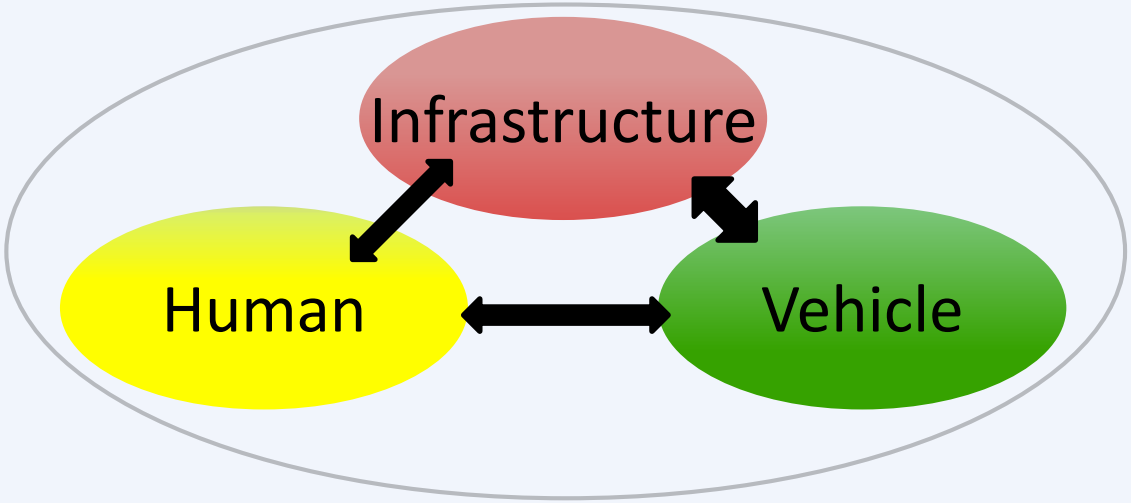
- Platooning
  - Cooperative braking control (CVs)
  - Under V2X communications
  - CV information transmission time delays
- Vehicular traffic flow
  - Sliding mode controller
  - Non-lane discipline
  - Leveraging vehicle characteristics under connecitvity

Insights

- Transportation community
  - Control as a goal enabler
  - Effectiveness, goals (mobility, safety, energy, emissions)
  - Vehicular interactions (behavior, traffic flow theory)
    - Car-following, merge/diverge,
  - Network-level
    - Traffic interactions, traveler/driver behavior, topology/infrastructure effects
- Control community
  - Focus on controller and its properties
  - Convergence, stability, consensus
  - Vehicle as individual agent (inter-vehicle gap, velocity)
    - Negative spacing/velocity, uncomfortable acceleration/deceleration
  - Micro- and corridor-level
    - Lateral control, longitudinal control

Opportunities

- Value in collaboration
  - Increased role of technology, especially automation, as a catalyst
  - Data as enabler (Google, Nvidia, etc.)
  - Focus on realism



Thank you!

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