Sustainable Transportation

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Why US & China?

- Leaders in vehicle ownership
- Largest producers of greenhouse gases
- Major issues with urban congestion and pollution
- Both considering alternative vehicle technologies
- Both have the capability to implement technology-rich solutions

Summary of Challenges

	Electricity pricing	Battery Storage	Charging Network Design	Charging Service & Scheduling	Smart Routing	Ride Sharing
Mechanism design	●	●		◐	●	●
Optimization	◐	◐	●	○	●	◐
Machine Learning	◐	◐	○	○	◐	◐
Queueing			○	●	◐	◐
Privacy	◐	◐		◐	◐	◐

Some Recurring CS Themes

- Many aspects of transportation are inherently “behavioral”
  - Good behavior can be incentivized through mechanism design
- Transportation consumes resources (electricity, highway infrastructure, time)
  - Optimization, machine learning, and queueing can improve efficiency
- Efficient transportation can benefit from information
  - Data networking, information sharing and social networking can all play a role
- Transportation services will need to access personal location information
  - Privacy issues will need to be addressed
- Intelligent vehicles and services will need
  - A seamless and intuitive human interface
  - Well-validated software and software engineering practices

Applications: Electricity

- Pricing electricity for electric vehicles (EVs)
  - Smart charging: better pricing to smooth grid demand
- Battery Storage
  - Using EV batteries as a “distributed capacitor”
    - Lots of stored electricity could add storage/resilience to grid
    - How to price electricity “take backs”?
    - What protocols and controls are needed?

Applications: EV Infrastructure

- Charging network design
  - Need to avoid overloading grid
  - Where do you put Level 3 charging stations?
    - Need to service vehicle demand, especially for long haul travel
  - Where do you put Level 2 charging?
    - Could be part of a “smart city” design
    - Mostly short haul or longer-stay travel
  - Is battery swapping a viable option?

Applications: Charging Stations

- The range for an all-electric vehicle is currently under 100 miles
- A “fast charge” (Level-3 charge) takes 20+ minutes
- When you are on a long trip, when and where do you stop to recharge?
  - Long charge times create the need for a “smart charge” service
  - Cars communicate with charging stations within range to negotiate a charging reservation
  - Trade time spent queueing against:
    - Price (pay more for a shorter line)
    - Routing (travel further for shorter line)
    - Charge level (agree to less charge to reduce service time)

Applications: Smart Routing & the Automated Highway

- Routing to prevent congestion
- Routing to prevent excess pollution in certain areas
- Pricing/rewards to incent non-shortest path routing
- Cede some level of control to network
  - “Cars as packets”
- Create an information rich road system
  - Traffic lights send updates for very localized information

Application: Transportation Sharing

- Information and networking for more efficient use of taxis, car pools, ride shares
- “Craig’s List” for ride sharing
  - Could be especially effective for commutes to/from urban areas
  - Ad an hoc carpool within a community group (e.g Rutgers people needing rides to NYC)
- Locating (and relocating) fleets for zip-car-like services or bicycles
- Transportation ecosystems
  - One transportation mode feeds another
    - e.g. Park and Ride near DC Metro