COOPERATIVE ADAPTIVE CRUISE CONTROL (CACC) IN THE CONTEXT OF VEHICLE TO VEHICLE COMMUNICATIONS: AN OVERVIEW
Traffic

- On average, a U.S. driver spends 42 hours in traffic congestions which wastes 19 gallons of petrol per person every year

How can traffic congestion be reduced?

- Create intelligent infrastructure to quickly optimize traffic flow
  - Using Coordinated Adaptive Cruise Control (CACC)

What is CACC?

- A combination of Adaptive Cruise control (ACC) and Dedicated Short Range Communications (DSRC)
  - ACC – adaptive cruise control which uses radars, lidars, and cameras to scan the environment ahead and adjust speed, acceleration/deceleration, and relative position accordingly.

What is CACC?

- DSRC – a system of transmitters that are capable of sending information 10 times a second at a distance of 300 meters using a FCC dedicated 5.9 GHz band (similar to WiFi, which uses 2.4 and 5 GHz bands to transmit data)

Source: https://www.researchgate.net/profile/Bernd_Wolfinger/publication/264894205/figure/fig4/AS:272619257724942@1442008904243/Figure-1-General-model-of-vehicular-networks-AP-access-point.png
Benefits

- Extremely detailed traffic data
  - Vehicles constantly communicate position data to a communication network
- Congestion Reduction
- Platooning
  - Vehicle gaps can be minimized, and highway space can be optimally utilized

- Less vehicle hours spent in traffic
- Smoother traffic flow
- Greater fuel efficiency
- Platoons decrease drag through drafting

Source: [http://www.niquette.com/puzzles/denslckp.htm](http://www.niquette.com/puzzles/denslckp.htm)
Gap Regulation

- Establishing a safe following distance that maximizes platoon size and drafting
- National Automated Highway Systems Consortium (NAHSC) established that vehicles must be ordered from longest braking distance to shortest to promote safety
- Constant Clearance/Distance Gap – gap distances are determined by vehicle variables (braking distance, weight, size)
- Constant Time Gap – gap distances are determined by the time it takes for two vehicles to pass through an DSRC equipped piece of road infrastructure
Coordination

- How to get vehicles to create platoons?
  - Local Coordination – vehicles randomly assemble into platoons
    - Requires installation of DSRC equipped infrastructure
  - Global Coordination – Vehicles assemble at a meeting point and then set off to a final destination in a platoon
    - Requires vehicles to wait to assemble platoons
      - Short Trips offset the time/efficiency gains from platooning
Truck Platooning

- Federal Highway Administration (FHWA) study through Exploratory Advanced Research program
  - Phase 1
    - Fleet manager’s responses to CACC adoption
      - 54% had positive to extremely positive responses
      - 39% said that drivers would be willing to adopt the technology
    - Computational Fluid Dynamics (CFD) – platooning increases efficiency at distances lower than 100 feet
  - Phase 2
    - Fleet manager’s responses to specific questions
      - One manager noted that global application of CACC to fleets would result in millions of gallons of fuel being saved
CASE STUDY

- Coordination would not be an issue due to trucks often stopping at pit/fuel stops
- Drivers were willing to adopt CACC assuming veteran drivers were able to get accustomed to the technology and demonstrate them to less experienced drivers
- CFD
  - At an average of 65MPH, gaps of 50 feet or less return significant gains in drag reduction
- Road Test
  - Peterbuilt 579 trucks tested at National Center for Asphalt Technology’s test track (7.5 miles long)
  - Efficiency was maximized at 30 feet for most vehicles in the platoon
Policy
- National Highway Traffic Administration should create more aggressive policy to quickly implement DSRC and ACC in current/future vehicles
- High-Occupancy-Toll lanes
  - Similar to HOV lanes
  - Provide funding mechanism for intelligent infrastructure
    - Intelligent Infrastructure can be fitted with WiFi connection

Technology
- Communication networks using DSRC need to be established
  - Vehicular Ad Hoc Networks create a peer-to-peer network for vehicles to communicate with each other
CACC can provide significant efficiency gains and congestion reduction assuming:

- Policy becomes more aggressive for adoption
- All manufacturers fit current/future cars with ACC and DSRC
- Engineers install infrastructure for communication
- Software developers create robust networks and gap regulation algorithms to promote safety and smooth traffic
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