From VII to Connected Vehicle and the vehicular cloud

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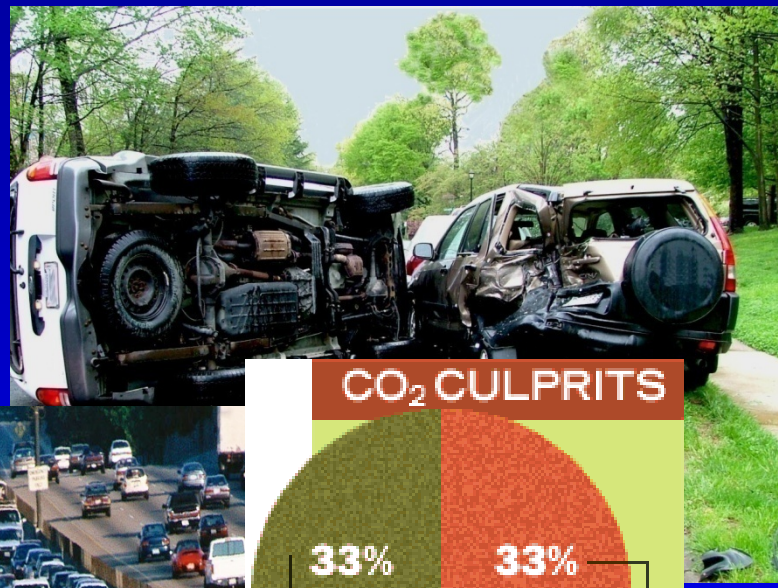
The Vehicle Transport Challenge

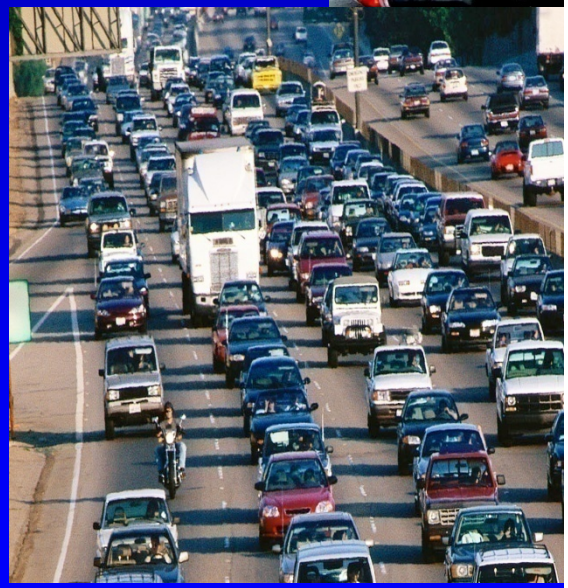
Safety

- 33,963 deaths/year (2003)
- 5,800,000 crashes/year
- **Leading cause of death for ages 4 to 34**



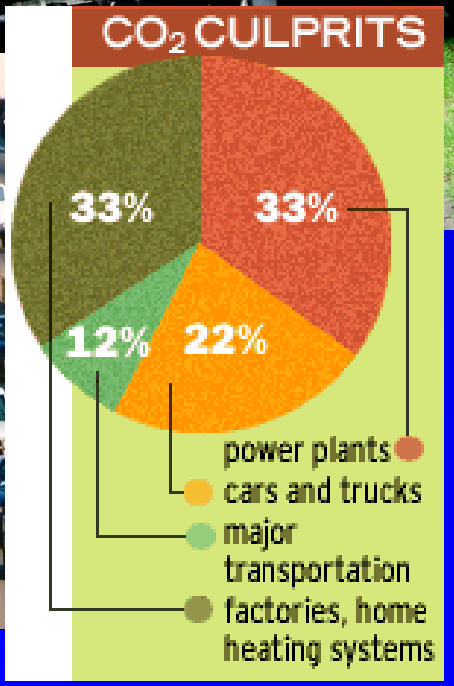
Mobility

- 4.2 billion hours of travel delay
- $78 billion cost of urban congestion



Environment

- 2.9 billion gallons of wasted fuel
- 22% CO_2 from vehicles



From VII to Connected Vehicle

- **In 2003 DOT launches Vehicle Infrastructure Integration (VII) program**
- **VII Consortium: USDOT, automakers, suppliers, ..**
- **Goal: V2V and V2I comms protocols to prevent accidents**
  - Technology validation; Business Model Evaluation,Legal structure, policies;Testbeds (Michigan, Oakland)
- **Major result: DSRC standard was borne**
- **However: 10 year to deploy 300,000 RSUs and to install DSRC on 100% cars**
- **Meanwhile: lots of new developments: 3G, smart phones, on board sensors (cameras, lasers, etc)**

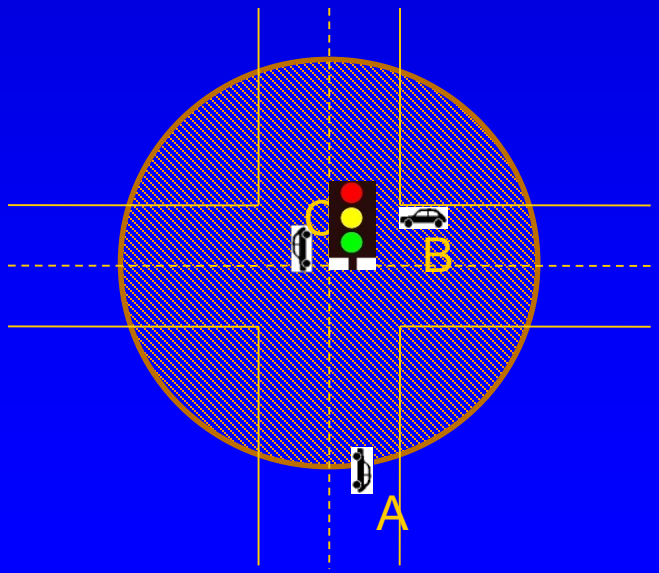
Enter Connected Vehicle (2009-2014)

The Connected Vehicle Program

- **Connected Vehicle Program (2009-2014)**
  - *Safety → DSRC*
    - Aggressively pursue V2V
    - Leverage nomadic devices to accelerate benefits
    - Retrofit when DSRC becomes universally available
  - *Non-safety (mobility, environment)*
    - Leverage existing data sources & communications; include DSRC as it becomes available
- **This is having major impact on vehicle apps:**
  - *Short term deployment*
  - *Long term evolution*

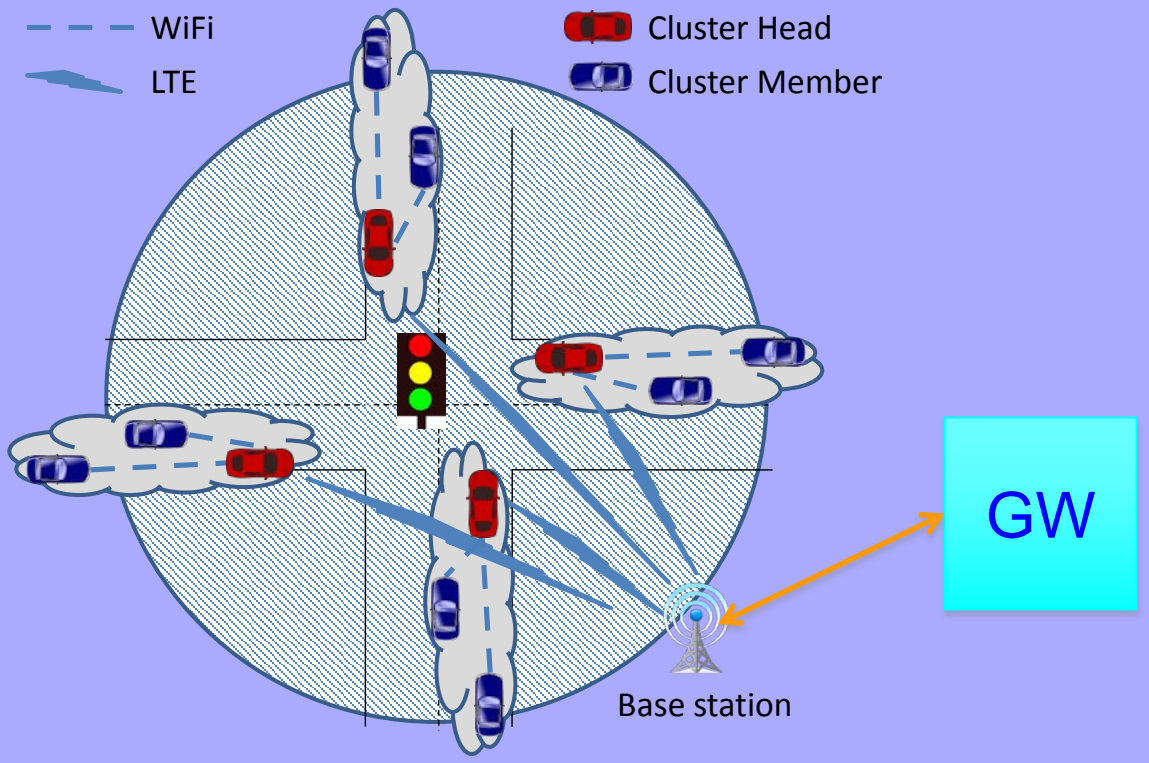
Intersection Collision Avoidance using DSRC

1. **Vehicle A, B and C broadcast DSRC CAMs (Cooperative Awareness Messages) as they approach the intersection**
2. **DSRC RSU installed on traffic light forwards CAMs around the corner**
3. **Problems:**
   1. in the “Connected Vehicle Program” no WiFi AP in Traffic Light nor RSU on road side
   2. Need full DSRC penetration



The LTE Cluster solution

- Clusters and Cluster Heads form on approach to the intersection
- Cluster members communicate own GPS position to CHs via Wi-Fi or DSRC
- CHs connect to the LTE base station
- CHs exchange cluster position information via the GW
- LTE can be replaced by OPEN WIFI when available



Safe Navigation Trends

- **Today:**
  - Neighbor awareness and forward collision avoidance done with lasers and cameras, not DSRC
  - DSRC is not sufficiently secure, not protected from attacks and failures
  - GOOGLE car sets the example for autonomous vehicles
- **In 2020:**
  - Physical channels for short range safety protection; DSRC and WiFI for less critical, longer range awareness
  - Electronic Break Light will use lasers/cameras for short range detection and DSRC (or WiFi) for less critical longer range propagation (eg, standing wave detection)
  - 30% DSRC penetration sufficient for longer range, non time critical apps; DSRC can be replaced by WiFI

Other Applications

- **Content distribution:**
  - V2V communications are emerging as a solution to the Wireless Access Spectrum bottleneck – eg Car Torrent
- **Urban surveillance using vehicles:**
  - Will become increasingly popular (as alternative to fixed cameras and as supplement to urban “drones”)
  - Will heavily relay on V2V – eg Mobeyes
- **Intelligent transport:**
  - Today traffic information is crowd sourced from vehicles (eg Google, NAVTEQ, etc); Traffic management is centralized
  - In 2020, there will be a synergy between centralized and V2V driven traffic management
- **The 2020 outlook:**
  - V2V will play critical role;
  - DSRC nice to have but can be replaced by WIFI

The emerging Vehicular Cloud

Observed trends:

1. Across all Apps, Vehicles will perform complex (sensor) data collection/processing services

road alarms (pedestrian crossing, electr. brake lights, etc)
cooperative content downloading via P2P car- torrent
surveillance (video, mechanical, chemical sensors)
road mapping via “crowd sourcing”
accident, crime witnessing (for forensic investigations, etc)

2. Spectrum is scarce => Internet upload expensive

Enter Vehicular Cloud Computing:

Keep and process data on *vehicle cloud* instead of uploading to *Internet cloud*

Example of Vehicular Cloud

Vehicles in the same geographic domain form a P2P cloud and engage in collaborative activities

P2P communications leveraging spectrum gaps in the urban unlicensed spectrum

Inter-cloud communications via Infrastructure (3G, WiFI)

Related work:

MobiCloud *Dijiang Huang*

Maui – *MSR*

Auton Vehi Clouds-*S. Olariu*

IC Net On Wheels – *Fan Bai GM*

Fog Computing – *CISCO*

The End

Thank You