From VII to Connected Vehicle and the vehicular cloud

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Mario Gerla
UCLA, Computer Science Dept
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% CO₂ 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 $\rightarrow$ 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