Internet of Vehicles (IOV): From Vehicle Grid to Autonomous Cars and Vehicular Clouds

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Evolution of Urban Fleet of Vehicles

▶ From a **collection of sensor platforms**
  - Collect/deliver sensor data to drivers and Internet cloud.

▶ To the **Internet of Vehicles (IOV)**
  - V2V sharing of sensor inputs to optimize local utility functions (e.g., autonomous driving).

▶ In this talk:
  - Unique challenges of IOV as opposed to IOE, say.
  - V2V as IOV enabler
  - Vehicular Cloud as the solution to IOV challenges:
    - Efficient Spectrum Utilization (with 5G and cog radios)
    - Interoperability across devices/platforms

Mobility/V2V Communications Make IOV Unique

▸ **Smart Grid: Objects are hierarchically controlled**.
  ◦ This enormously helps scalability from room to building to city

▸ **Vehicular Grid: Vehicles cannot be hierarchically partitioned and controlled.**
  ◦ Mobility handling & real-time, low latency V2V requirements
    • Many platooning papers stress critical need of V2V.
  ◦ These are not critical concerns in IOE/m-Health IOT apps

Vehicular Cloud

Vehicular cloud

Observed trends/characteristics:
1. Vehicles are powerful sensor platforms
   GPS, video cameras, pollution, radars, acoustic, etc.

2. Spectrum is scarce => Internet upload expensive

3. More local data must be processed on vehicles
   road alarms (pedestrian crossing, electr. brake lights, etc.)
   surveillance (video, mechanical, chemical sensors)
   environment mapping via "crowdsourcing"
   accident, crime witnessing (for forensic investigations, etc.)

⇒ **Vehicular Computing Cloud**

Data storage/processing on vehicles

Vehicle Cloud Challenges and Services

▸ **Challenges**

- Security / Privacy
- Scarce urban spectrum (DSRC spectrum restricted and limited)
- Content dissemination/discovery
- Interoperability across manufacturers/platforms

▸ **Common Cloud Services**

- Uniform solutions across heterogeneous devices
- Efficient spectrum use via cognitive radios and 5G technology

Application : Cloud driven Autonomous Vehicle Control

Interoperability across car makes is essential

Application: Road Surveillance/Monitoring

- ◦ Propagate the "accident" video to upcoming cars
- ◦ Car first learns of the accident from alert messages
- ◦ It then request the video from a car facing the accident
- ◦ **Problem: high video rate; spectrum scarce**
- ◦ **Solution: Cog Radios and 5G**

Conclusions

▸ **Vehicular Grid is evolving to IOV**
  ◦ "connected vehicle" program => V2V critical for safety
  ◦ The emergence of autonomous vehicles (Google Car etc.)

▸ **Emergence of new IOV apps and services**
  ◦ Internal services (safe navigation, intelligent transport, spectrum crowd sourcing, etc.)
  ◦ External services (surveillance, forensic investigation, etc.)

▸ **Vehicular Cloud: a model for the systematic implementation of services in the IOV**

▸ **Byproducts:**
  ◦ **Interoperability across vehicle makes and types**
  ◦ **Aggressive use of scarce spectrum (cog radios, 5G)**