Vehicular Ad hoc Network and Its Challenges

Overview

- **Motivation of VANET**

- **Current DSRC/WAVE Technology**
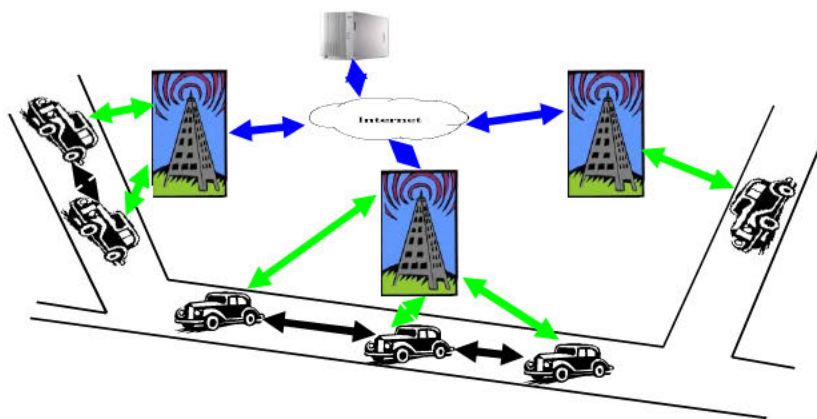
- **Research and Technical Challenges**

Disclaimer: This presentation only represents the panelist's personal opinion from a researcher's perspective.

When Two New Worlds Encounter

Key: Integrate information gathering, aggregation, sharing, processing and entity control/action into a single paradigm

Vehicular Ad Hoc Network (VANET)

Vehicle-to-Vehicle (v2v)

Vehicle-to-Infrastructure (v2i)

Vehicle-to-Portable (v2p)

Vehicular Sensor Network

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Vehicles (and their information) are an important component of ubiquitous computing platform.

Today, this part has been ignored in the existing equation of Internet architecture

Application-Driven Technology Development

■ Two Perspectives to Classify VANET Applications

Application Benefit Perspective

1. Safety
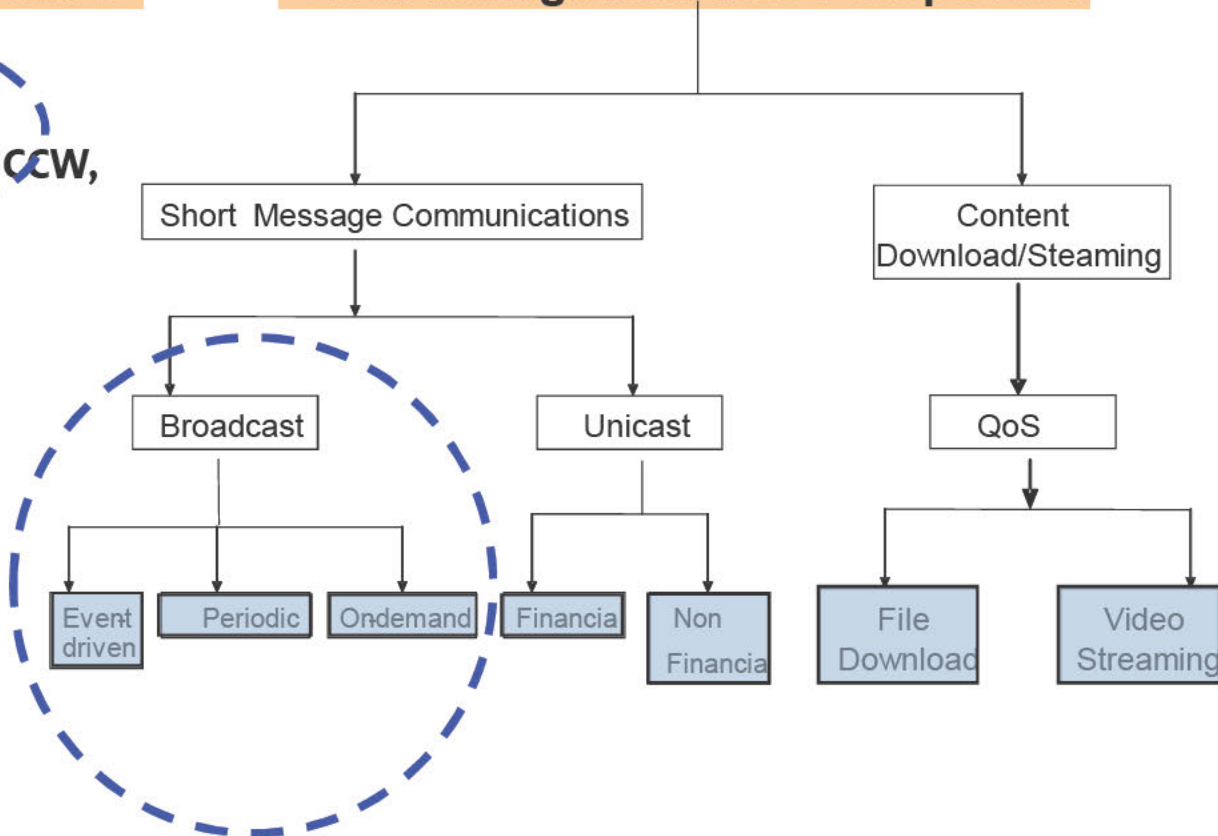- SVA, EEBL, PCN, RHCN, RFN, CCW, CVW

2. Convenience
- CRN, TP, TOLL, PAN, PSL

3. Commercial
- RVP/D, SA, GMDD, RTVR

Networking Attributes Perspective

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                    Short Message Communications          Content Download/Steaming

        Broadcast              Unicast                    QoS

  Event    Periodic  Ondemand   Financia   Non           File        Video
  driven                                   Financia      Download    Streaming
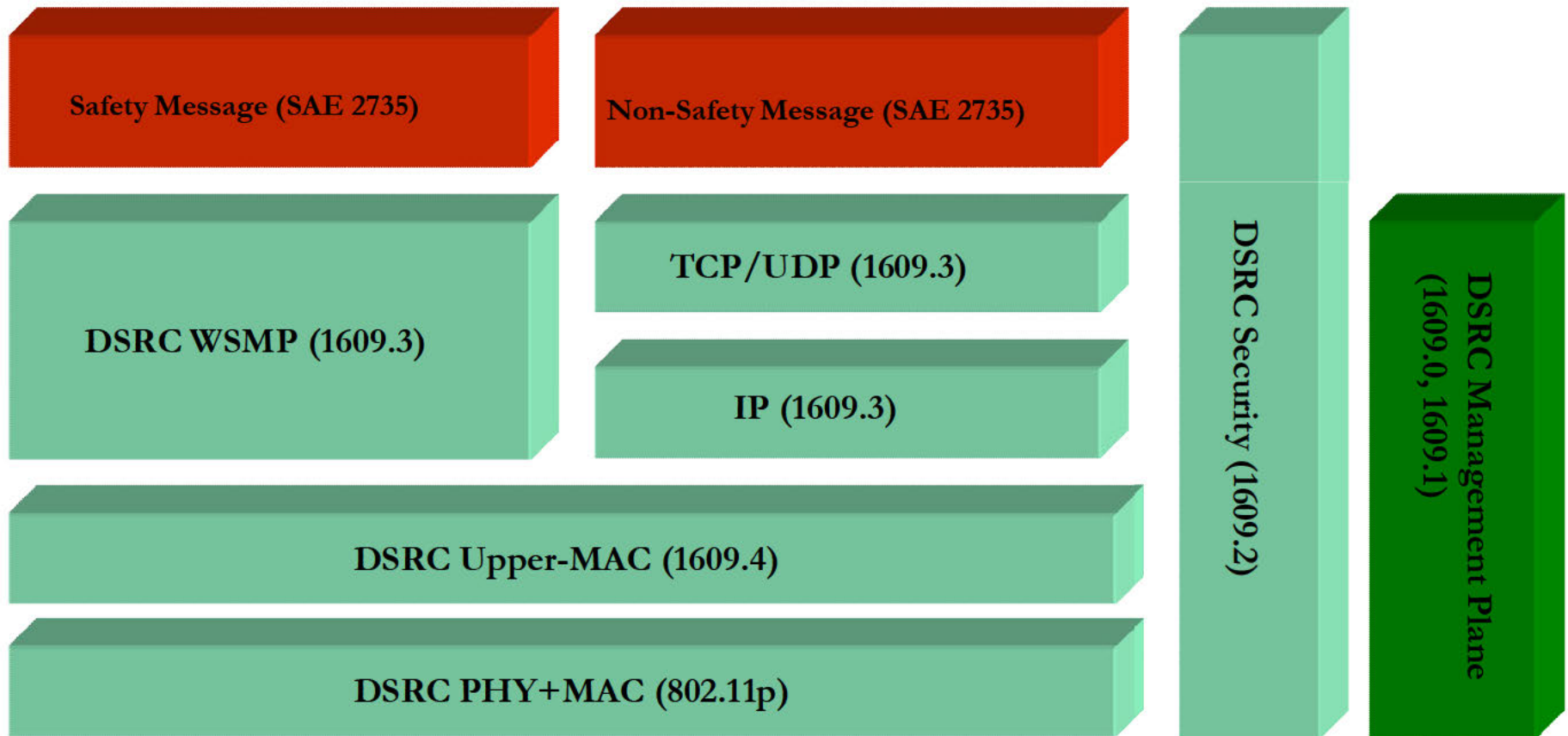```

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# Ubiquitous Computing, Communication and Control

- Single ubiquitous computing/communication/control platform providing information sensing, gathering, aggregation, sharing, processing and action control in the real-world environment
  - (1) Sensing; (2) Information Sharing and Processing; (3) Control
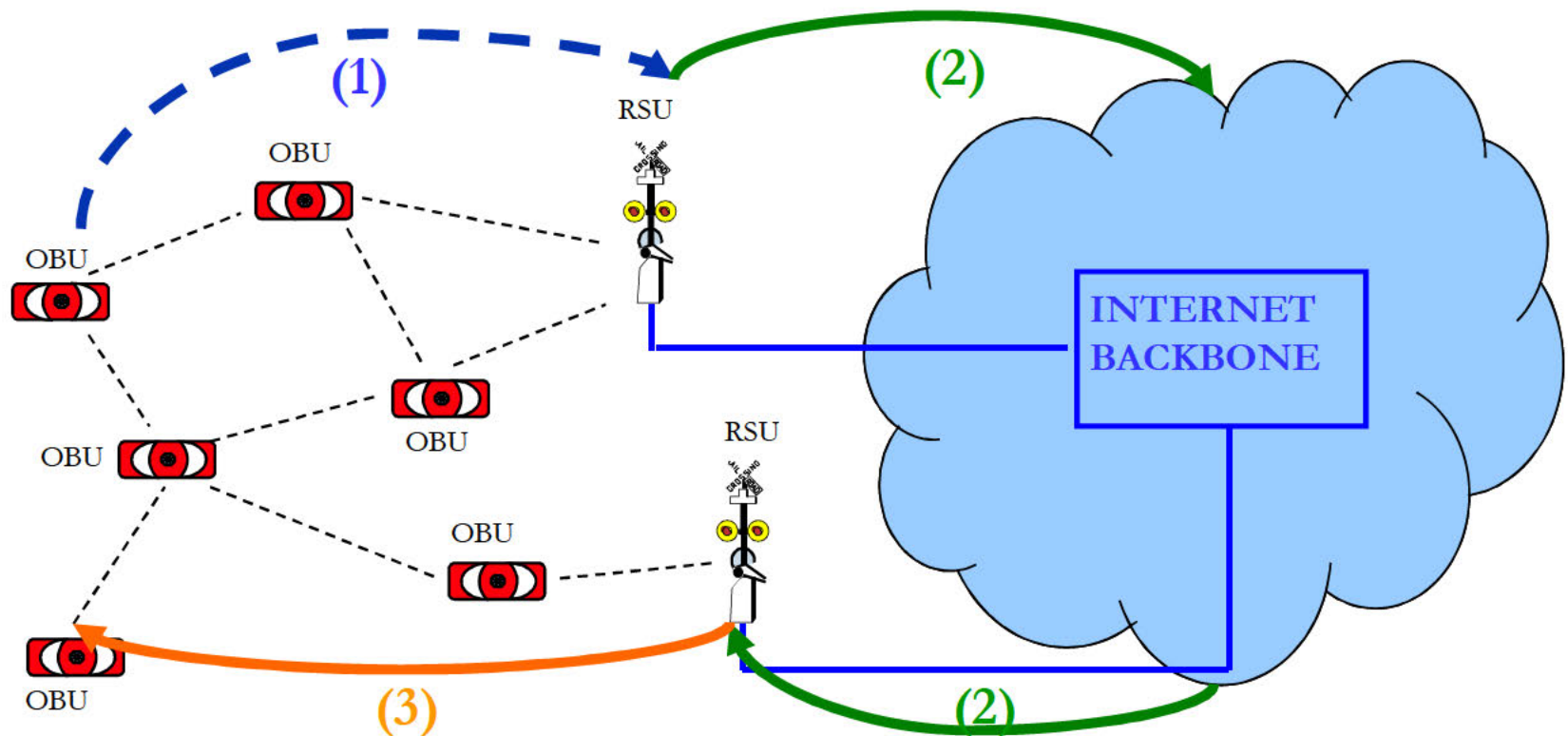
# DSRC/WAVE Protocol Stack (Standards)

■ DSRC Standard Stack: Since early stage, DSRC/WAVE technology development has been closely coupled with industry standard development

| Safety Message (SAE 2735) | Non-Safety Message (SAE 2735) |
|---|---|

| DSRC WSMP (1609.3) | TCP/UDP (1609.3) |
|---|---|
| | IP (1609.3) |

DSRC Upper-MAC (1609.4)

DSRC PHY+MAC (802.11p)

DSRC Security (1609.2)

DSRC Management Plane (1609.0, 1609.1)

# DSRC/WAVE Technology Status: PHY/MAC

- **PHY layer is a variant of OFDM-based IEEE 802.11a**

  - Channel bandwidth is halved from 20MHz into 10MHz. Consequently, channel guard interval is doubled

  - In order to adapt to the severe fading with longer delay spread

- **MAC is a variant of CSMA/CA without ACK**

  - In order to avoid the broadcast storm of ACK caused by unreliable transmission

- **Network-layer WSMP (Wave Short Message Protocol) is a variant of simplified IP protocol**

  - In order to reduce the unnecessary overhead introduced by packet header, boosting system efficiency
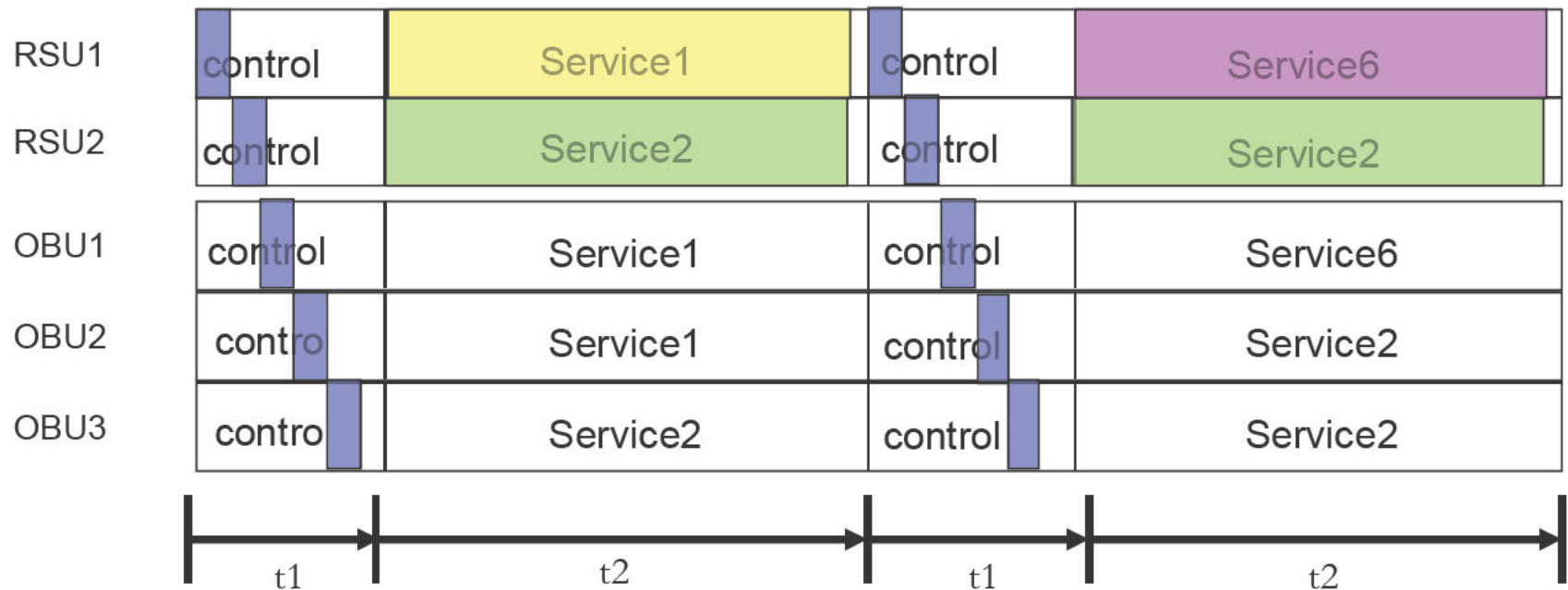
# DSRC/WAVE Status: WAVE BSS

- WBSS (WAVE BSS) is a variant of generic BSS, which is adjusted for automotive environment

  - WAVE Announcement at RSU

  - Channel selection scheme with priority consideration at OBU
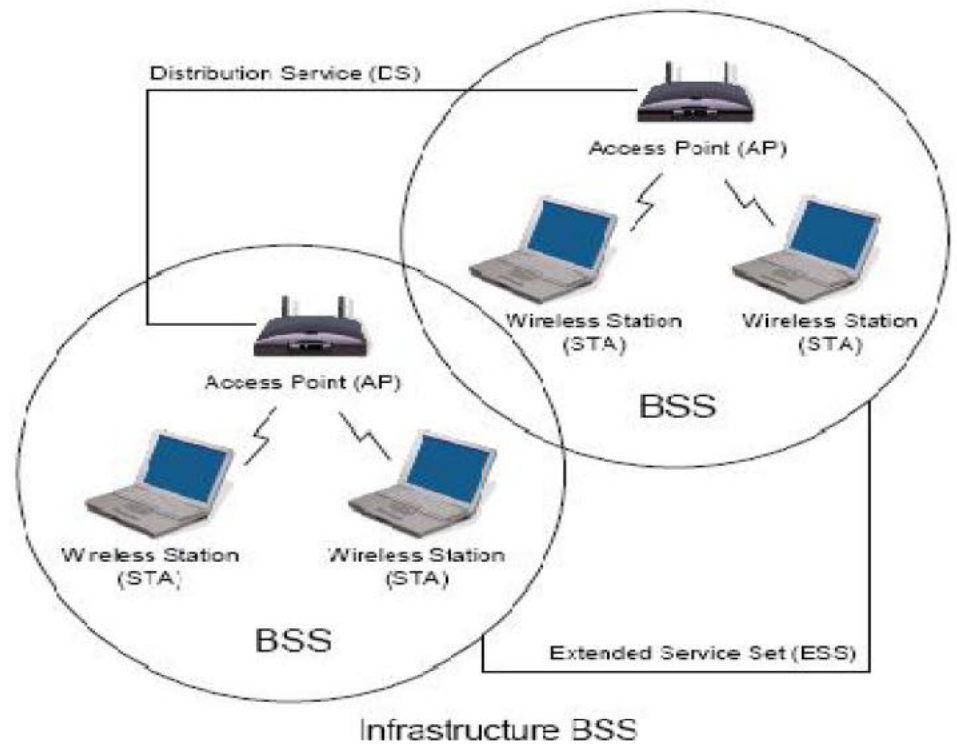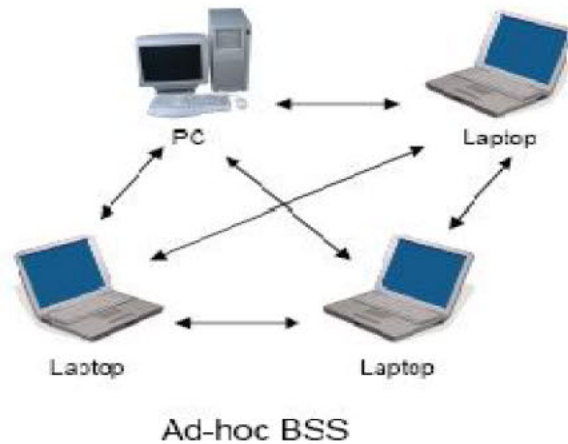
# DSRC/WAVE Status: Multi-Channel MAC

■ **To support both safety and non-safety applications simultaneously, DSRC radio device constantly switches among DSRC physical channels according to a predefined scheme**

- For the channel switching, all DSRC radio devices need to be synchronized with the external assistance (i.e., GPS)

| | | | | | |
|---|---|---|---|---|---|
| RSU1 | control | Service1 | control | | Service6 |
| RSU2 | control | Service2 | control | | Service2 |
| OBU1 | control | Service1 | control | | Service6 |
| OBU2 | control | Service1 | control | | Service2 |
| OBU3 | control | Service2 | control | | Service2 |

t1   t2   t1   t2

# VANET Research Challenges

■ **Reliability**: How to improve reliability of DSRC communication and VANET system?

- OFDM enhancement adjusted for high mobility and fading environment?

- MAC-layer broadcast reliability compensation and transportation-layer error control?

■ **Efficiency**: How to improve the efficiency of contention-based CSMA/CA MAC?

- Reduce data traffic intensity (power control and rate control)?

- CSMA/CA enhancement to reduce chaotic and organized contention?

■ **Scalability**: How scalable is the VANET system and V2V/V2I application? How to improve it?

- Theoretical analysis on network capacity?

- What kind of applications (data traffic) can be supported in such a network?

- Scalable network support for a large-scale VANET system (Hierarchical or P2P)?
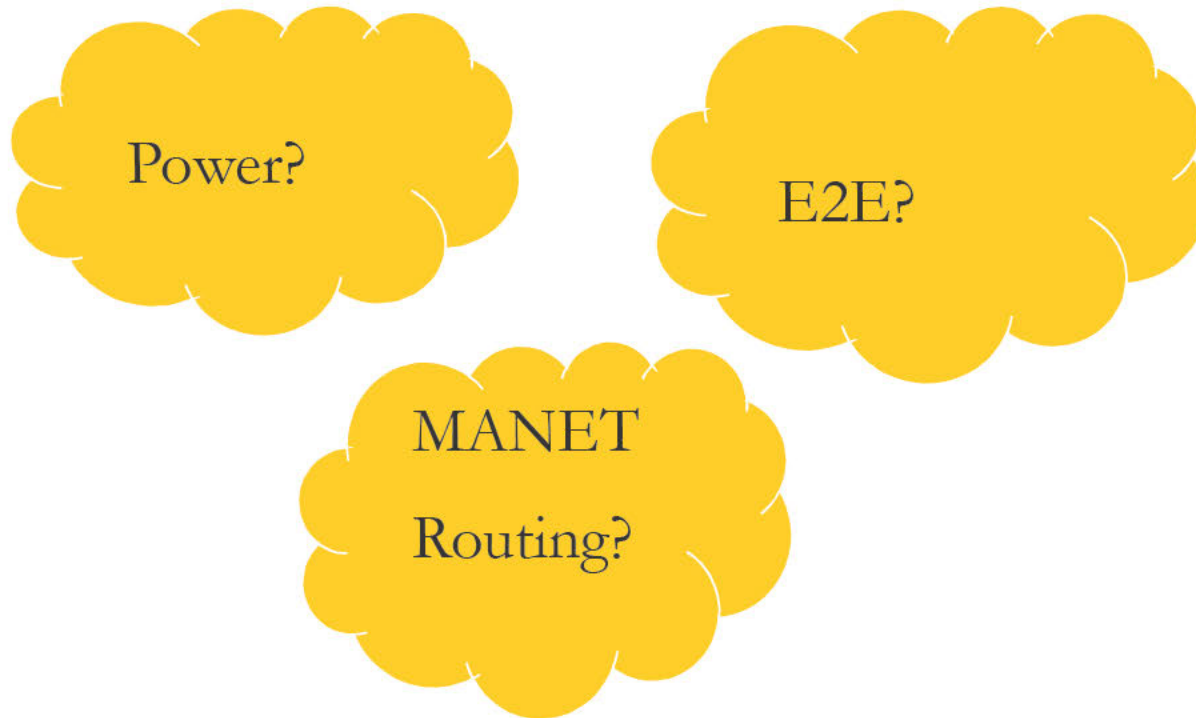
# VANET Research Challenges

- **Flexibility/Compatibility**: How to support both safety applications and non-safety application simultaneously?

  - Multi-channel switch scheme to allow time-sharing among safety and non-safety application?

  - Generic tech solution (protocol stack) to enable various applications?

  - Magic common interface to glue all protocols across layers together?

- **Adaptability**: How to adapt to various underlying environments?

  - How to adapt to various fading/propagation environments?

  - How to adapt to different kinds of network topology?

- **Security**: How to protect the wireless security and driver's privacy?

  - Enhanced security mechanisms to protect both safety and non-safety applications?

  - Privacy solution providing anonymity and untraceability ?

# Research Theme of VANET?

- **Many open issues need to be answered and analyzed**
  - Identification of a single research theme might help to focus our research effort

Power?

E2E?

MANET

Routing?

# Research Theme of VANET?
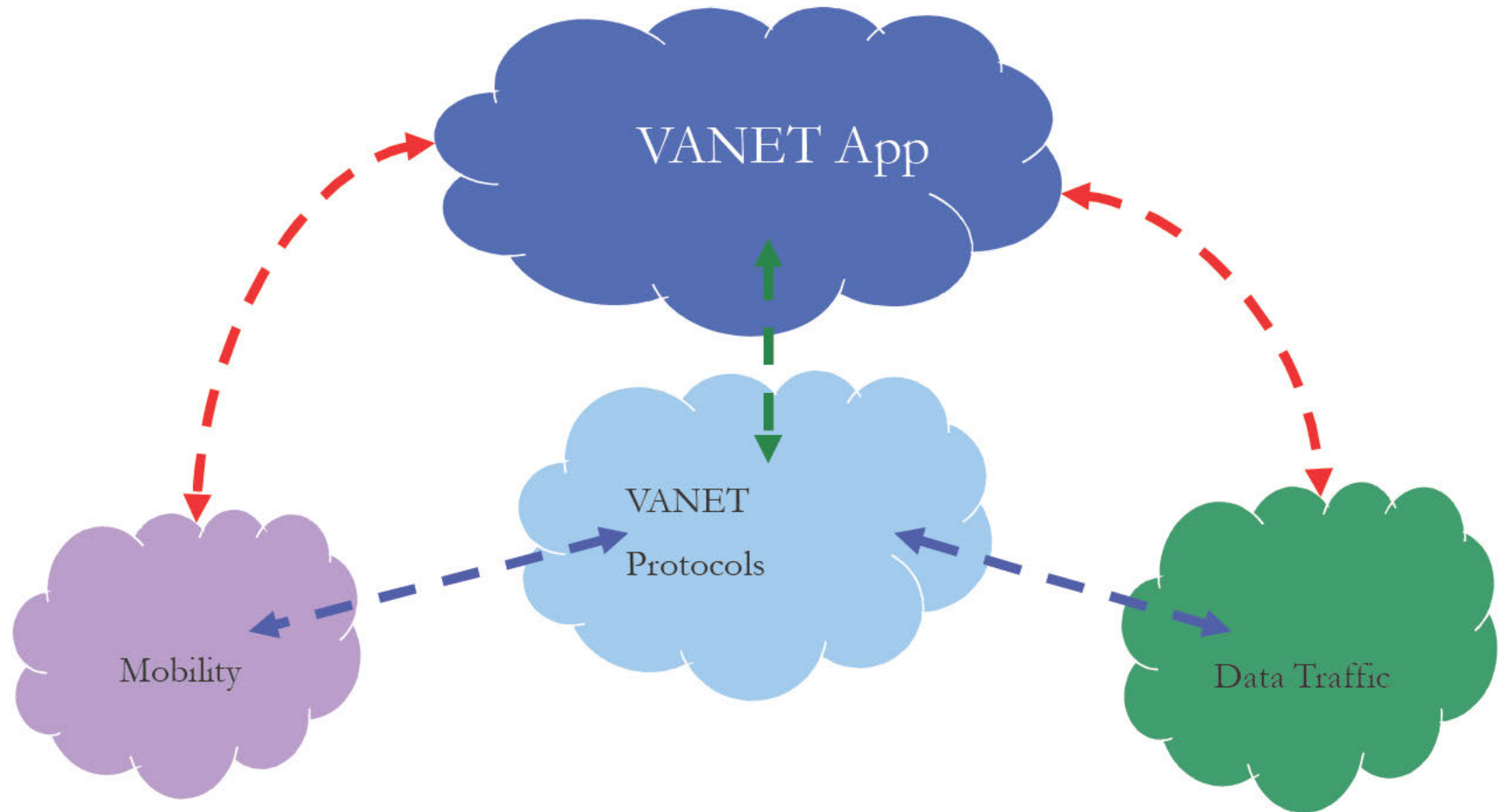
# Challenges on Economics Incentive

- **Catch-22: Market Penetration vs. Value Proposition**
  - VANET's value to customers is not obvious until widely deployed
  - VANET is not widely sought unless performance of VANET system is good
- Potential Solutions
  - "Killer applications" demonstrating values even with low market penetration phase
  - Infrastructure-assisted VANET system also helps to populate market penetration
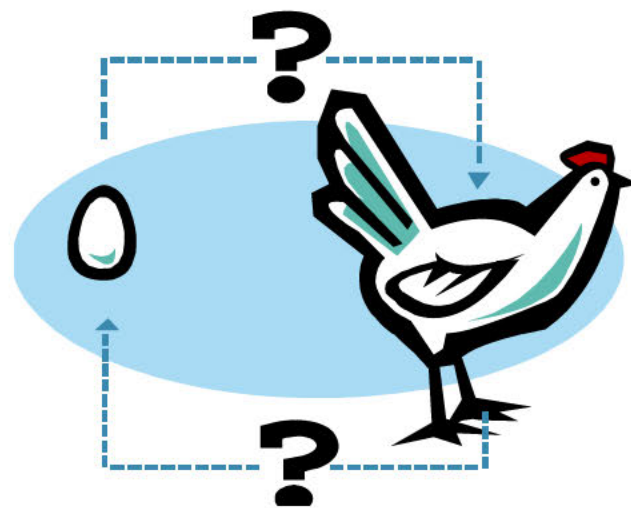
# Challenges on Technology Evolvement

- **Catch-22: Standard vs. Technology Maturity**
  - Early adoption of standard facilitates the wide deployment of VANET
  - The compatibility between existing technology/standard and the new technology/standard is an issue, since car's lifetime is about 10-15 years
- Potential Solutions
  - Carefully defined standard evolvement strategy to enable back/future compatibility
  - Module-oriented design philosophy in system engineering

# Summary

- Telecommunication/wireless/networking society and automotive society both offer revolutionary opportunity toward each other

- Eventually, a generic framework can be formed to guide the development of both technology and application, by integrating various perspectives
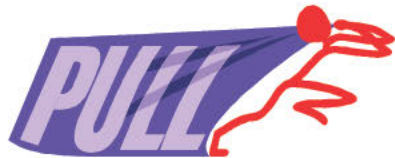
**Application**

**Pull**

**Technology**

**Push**