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SUBJECT: Wireless Communication and Applications

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Outline

Introduction

Introduction

- Rapid advances in wireless technologies provide opportunities to utilize these technologies in support of advanced vehicle safety applications.
- Dedicated Short Range Communication (DSRC) offers the potential to effectively support vehicle-to vehicle and vehicle-to-roadside safety communications, which has become known as Vehicle Safety Communication (VSC) technologies.
- DSRC enables a new class of communication applications that will increase the overall safety and efficiency of the transportation system.

Motivation

- Safety and transport efficiency
- Congestion costs the U.S. economy over 100 billion dollar per year.
- Vehicle occupancy has dropped 7
- In Europe around 40,000 people die and more than 1.5 millions are injured every year on the roads
- Traffic jams generate a tremendous waste of time and of fuel

What is VANET?

Vehicular Ad Hoc Networks

- Vehicular Ad Hoc Networks (VANETs) are autonomous and self-configurable wireless ad hoc networks and considered as a subset of Mobile Ad Hoc Networks (MANETs).
- MANET is composed of self-organizing mobile nodes which communicate through a wireless link without any network infrastructure.
- A VANET uses vehicles as mobile nodes for creating a network within a range of 100 to 1000 meters.
- VANET is developed for improving road safety and for providing the latest services of intelligent transport system (ITS).
- The development and designing of efficient, self-organizing, and reliable VANET are a challenge because the nodes mobility is highly dynamic which results in frequent network disconnections and partitioning.

What is VANET?

Vehicular Ad Hoc Networks...

- VANET protocols reduce the power consumption, transmission overhead, and network partitioning successfully by using multicast routing schemes.
- In multicasting, the messages are sent to multiple specified nodes from a single source. The novel aspect of this paper is that it categorizes all VANET multicast routing protocols into geocast and cluster-based routing.

What is VANET?

Dedicated Short Range Communication (DSRC)

- Dedicated Short Range Communications (DSRC) is a short to medium range communications service that was developed to support vehicle to vehicle and vehicle to road side communications.
- DSRC is meant to be a complement to cellular communications by providing very high data transfer rates in circumstances where minimizing latency in the communication link and isolating relatively small communication zones are important.
- DSRC is also known as WAVE (Wireless Access in Vehicular Environments). It operates at 915 MHz Transmission rate of 0.5 Mb/s.

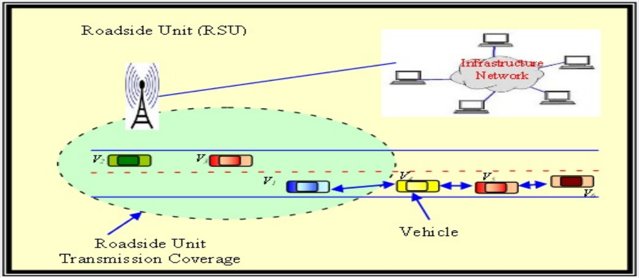
What is VANET?

Categories of applications of DSRC

- Vehicle-to-Vehicle
  Applications transmit messages from one vehicle to another.
- Vehicle-to/from-Infrastructure
  Applications in which messages are sent either to or from vehicle to a Road Side Unit (RSU).
- Vehicle-to-Home
  Application that is used when a vehicle is parked at the drivers residence, for purposes such as transferring data to the vehicle.
- Routing Based
  Applications are used when the intended recipient is greater than one-hop away.

VANET Architecture?

Architecture of Vehicular Networking



- A Vehicular Ad hoc Network (VANET) is a kind of wireless ad hoc network to provide communications among vehicles and nearby roadside equipments. VANET consists of vehicles with on board sensors and roadside units (RSUs) deployed along highways/sidewalks, which provides communications between vehicle to vehicle (V2V) and communications between vehicles to infrastructure (V2I).

VANET Architecture?

Architecture

- Main Components
  Introduce the main components of VANETs architecture from a domain view.
  1. Mobile domain
  2. Infrastructure domain
  3. Generic domain

VANET Architecture?

Architecture

Mobile Domain

- Mobile domain consists of two parts. The vehicle domain comprises all kinds of vehicles such as cars and buses.
- The mobile device domain comprises all kinds of portable devices like personal navigation devices and smartphones.

VANET Architecture?

Architecture

Infrastructure domain

- There are two domains:
  1. The roadside infrastructure domain
  2. The central infrastructure domain.
- The roadside infrastructure domain contains:
  1. Roadside unit entities like traffic lights.
  2. The central infrastructure domain contains infrastructure management centers such as traffic management centers (TMCs) and vehicle management centers

VANET Architecture?

Architecture

Infrastructure domain

- Development of VANET architecture varies from region to region
- In the CAR-2-X communication system which is pursued by the CAR-2-CAR communication consortium, the reference architecture is a little different.
- This system architecture comprises three domains:
  1. In-vehicle.
  2. Ad hoc.
  3. Infrastructure domain.

VANET Architecture?

Architecture

Infrastructure domain

- In-vehicle domain is composed; an on-board unit (OBU) one or multiple application units (AUs).
  1. The connections between them are
  2. usually wired and sometimes wireless.
- Ad hoc domain is composed:
  1. vehicles equipped with OBUs.
  2. roadside units(RSUs).
- An OBU can be seen as a mobile node of an ad hoc network and RSU is a static node likewise. An RSU can be connected to the Internet via the gateway; RSUs can communicate with each other directly or via multihop as well.

VANET Architecture?

Architecture

Infrastructure domain

- Infrastructure domain access:
  1. RSUs and
  2. Hot spots (HSs).
- OBUs may communicate with Internet via RSUs or HSs. In the absence of RSUs and HSs, OBUs can also communicate with each other by using cellular radio networks (GSM, GPRS, UMTS,WiMAX, and 4G)

VANET Architecture?

Architecture

Communication Architecture

- Communication Architecture. Communication types in VANETs can be categorized into four types. Describes the key functions of each communication type
  1. *In-vehicle communication,*
     which is more and more necessary and important in VANETs research, refers to the in-vehicle domain. In-vehicle communication system can detect a vehicles performance and especially drivers fatigue and drowsiness, which is critical for driver and public safety.
  2. *Vehicle-to-vehicle (V2V)*
     communication can provide a data exchange platform for the drivers to share information and warning messages, so as to expand driver assistance.

VANET Architecture?

Architecture

Communication Architecture .....

- Communication Architecture. Communication types in VANETs can be categorized into four types. Describes the key functions of each communication type
  1. *Vehicle-to-road infrastructure (V2I) communication*
     is another useful research field in VANETs. V2I communication enables real-time traffic/weather updates for drivers and provides environmental sensing and monitoring.
  2. *Vehicle-to-broadband cloud (V2B) communication*
     means that vehicles may communicate via wireless broadband mechanisms such as 3G/4G. As the broadband cloud may include more traffic information and monitoring data as well as infotainment, this type of communication will be useful for active driver assistance and vehicle tracking.

VANET Architecture?

Architecture

VANETs system domains

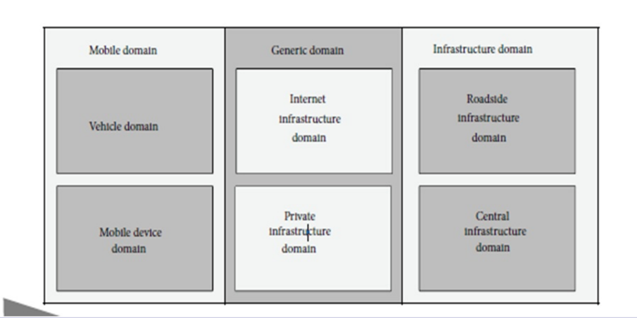


Figure: Main components Architecture

VANET Architecture?

Architecture

Research Issues

- Routing
- Security
- Privacy
- Applications

VANET Architecture?

Architecture

Routing

- In VANETs, wireless communication has been a critical technology to support the achievement of many applications and services.
- However, due to the characteristics of VANETs such as high dynamic topology and intermittent connectivity, the existing routing algorithms in MANETs are not available for most application scenarios in VANETs. There are three types of routing approaches
- There are three types of routing approaches
  1. Geocast/broadcast
  2. Multicast
  3. Unicast

VANET Architecture?

Routing

- *Geocast/Broadcast:*
  With the requirement of distributing messages to unknown/unspecified destinations, the geocast/broadcast protocols are necessary in VANETs.
- *Multicast*:
  is necessary to communications among a group of vehicles in some vehicular situations, such as intersections, roadblocks, high traffic density, accidents, and dangerous road surface conditions
- *Unicast:*
  Researchers investigate the unicast communication protocols for VANETs in three ways: (1) Greedy: nodes forward the packets to their farthest neighbors towards the destination, like improved greedy traffic-aware routing (GyTAR); (2) Opportunistic: nodes employ the carry-toward technique in order to opportunistically deliver the data to the destination, like topology-assist geo-opportunistic routing; (3)

VANET Architecture?

Security and Privacy

- Nowadays more and more intelligent on-board applications may store lots of personal information and vehicular trajectory data, which can disclose individuals activities, habits, and traces. These threats have to be overcome before communication architecture in VANETs is deployed.

What is VANET?

VANET Characteristics

- Rapid but some what predictable changing topology.
- Fragmentation of the network.
- Effective network diameter of a VANET is small.
- Redundancy is limited both temporally and functionally.
- It poses a number of unique security challenges.

Application

Where can it be Applicable?

- Applications in vehicular environment usually can increase the road safety, improve traffic efficiency, and provide entertainment to passengers. In most cases, VANETs applications can be roughly organized into two major classes: safety applications non safety applications

    1. *safety applications*
       Traditionally the intention of safety applications is accident prevention, and thus this kind of applications is also the main motivation for developing vehicular ad hoc networks. Such applications like crash avoidance have a great requirement for the communication between vehicles or between vehicles and infrastructure.
    2. *non safety applications*
       With respect to their specific intended purpose, nonsafety applications usually provide drivers or passengers with some useful information, such as weather or traffic information and the location of restaurants or hotels nearby.

Research Issues

Challenges and Future Trends

- *Fundament Limits and Opportunities.*– Surprisingly little is known about the fundamental limitations and opportunities of VANETs communication from a more theoretical perspective. It is believe that avoiding accidents and minimizing resource usage are both important theoretical research challenges.
- *Standards.*– The original IEEE 802.11 standard cannot well meet the requirement of robust network connectivity, and the current MAC parameters of the IEEE 802.11p protocol are not efficiently configured for a potential large number of vehicles.
- *Routing Protocols.*– Although researchers have been presenting many effective routing protocols and algorithms such as CMV (cognitive MAC for VANET) and GyTAR (greedy traffic-aware routing), the critical challenge is to design good routing protocols for VANETs communication with high mobility of vehicles and high dynamic topology

Research Issues

Challenges and Future Trends ....

- *Connectivity*. The management and control of network connections among vehicles and between vehicles and network infrastructures is the most important issue of VANETs communication. Primary challenge in designing vehicular communication is to provide good delay performance under the constraints of vehicular speeds, high dynamic topology, and channel bandwidths
- *Cross-Layer*.– In order to support real-time and multimedia applications, an available solution is to design cross-layer among original layers. In general, cross-layer protocols that operate in multiple layers are used to provide priorities among different flows and applications.
- *Cooperative Communication*.– VANETs as a type of cloud called mobile computing cloud (MCC), and present a broadband cloud in vehicular communication. Thus, the cooperation between vehicular clouds and the Internet clouds in the context of vehicular

Challenges and Future Trends ....

- *Mobility*.– Mobility that is the norm for vehicular networks makes the topology change quickly. Besides, the mobility patterns of vehicles on the same road will exhibit strong correlations. Address the idea that mobility plays a key role in vehicular protocol design and modeling.
- *Security and Privacy*.– Presents many solutions that come at significant drawbacks and the mainstream solution still relies on key pair/certificate/signature. For example, key distribution is a key solution for security protocols, but key distribution poses several challenges, such as different manufacturing companies and violating driver privacy. Besides, tradeoff of the security and privacy is the biggest challenge under the requirement of efficiency.

Research Issues

Challenges and Future Trends ....

- *Validation.*– It is necessary not only to assess the performance of VANETs in a real scenario but also to discover previously unknown and critical system properties. Besides, validation has become more and more difficult under the wider range of scenarios.
- *Generally The key challanges on VANET are*– VANET supports diverse range of on road applications and hence requires efficient and effective radio resource management strategies. This includes QoS control, capacity enhancement, interference control, call admission control (CAC), bandwidth reservation, packet loss reduction, packet scheduling and fairness assurance

Conclusion

- *The convergence of computing*,– telecommunications (fixed and mobile), and various kinds of services are enabling the deployment of different kinds of VANET technologies. Several VANET standards have been developed to improve vehicle-to-vehicle or vehicle-to-infrastructure communications. Challenges that still need to be addressed in order to enable the deployment of VANET technologies, infrastructures, and services cost-effectively, securely, and reliably.

The End