Lecture 1-2: Vehicular Ad-Hoc Networks(VANETs)

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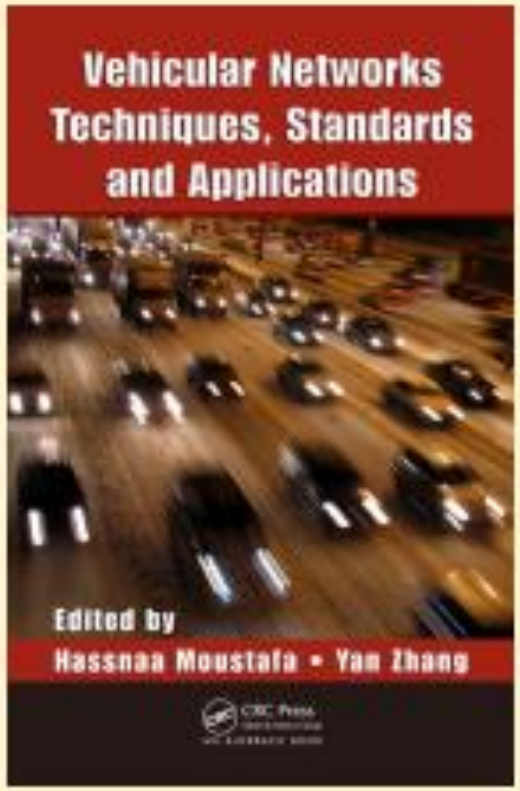
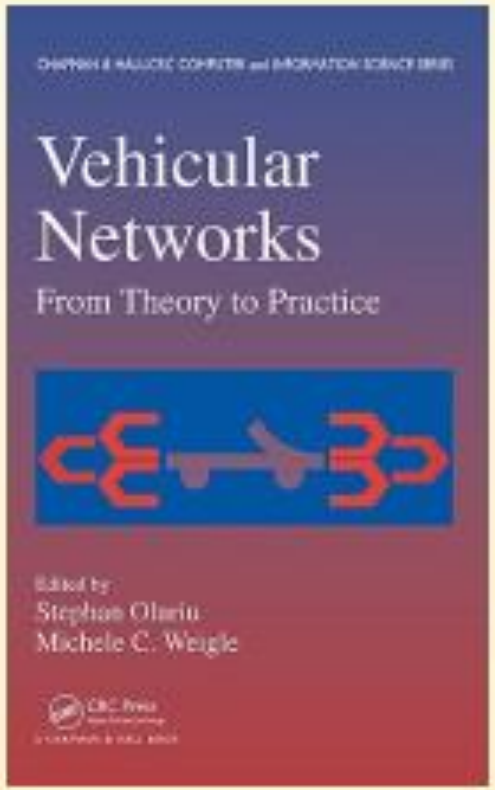
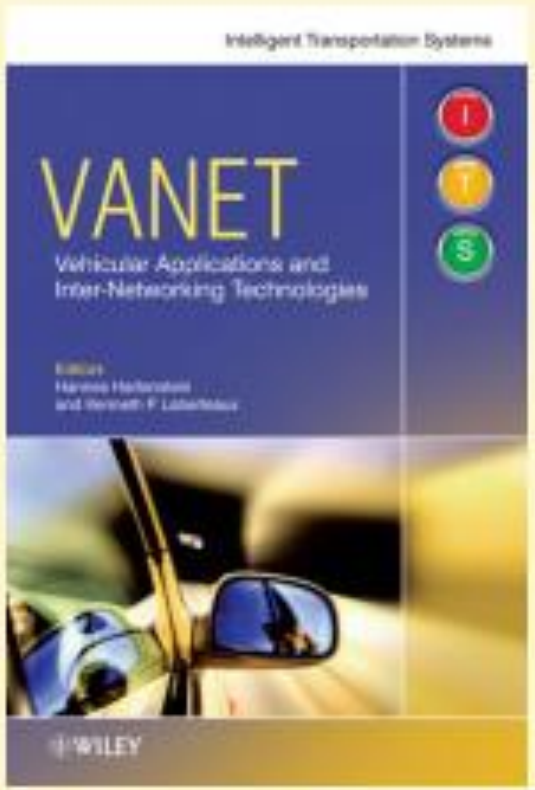
Contents

- **Introduction:** Basic principles and challenges, past and ongoing VANET activities (2 Lectures)
- **Cooperative Vehicular Safety Applications:** Enabling technologies, cooperative system architecture, safety applications (2 lectures)
- **Vehicular Mobility Modeling:** Random models, flow and traffic models, behavioral models, trace and survey based models, joint transport and communication simulations (4 lectures)
- **Physical Layer Considerations for Vehicular Communications:** Signal propagation, Doppler spread and its impact on OFDM systems (4 lectures)
- **MAC Layer of Vehicular Communication Networks:** Proposed MAC approaches and standards, IEEE 802.11p (8 lectures)
- **VANET Routing protocols:** Opportunistic packet forwarding, topology-based routing, geographic routing (8 lectures)
- **Emerging VANET Applications:** Limitations, example applications, communication paradigms, message coding and composition, data aggregation (8 lectures)
- **Standards and Regulations:** Regulations and Standards, DSRC Protocol Stack, Cellular V2X (6 lectures)

Books:


Vehicular Networks
Techniques, Standards
and Applications
Edited by
Hassnaa Moustafa • Yan Zhang


Vehicular
Networks
From Theory to Practice
Edited by
Stephan Olariu
Michele C. Weigle


Intelligent Transportation Systems
VANET
Vehicular Applications and
Inter-Networking Technologies
WILEY

References

- **Textbook**

- Olariu, S., & Weigle, M. C. (2017). Vehicular networks: from theory to practice. Chapman and Hall/CRC.
- Murthy, C. S. R. (2006). Ad hoc wireless networks: Architectures and protocols. Pearson Education India.

- **Reference Books**
- Emmelmann, M., Bochow, B., & Kellum, C. (Eds.). (2010). Vehicular networking: Automotive applications and beyond (Vol. 2). John Wiley & Sons.
- Claudia Campolo , Antonella Molinaro, Riccardo Scopigno(2015). Vehicular ad hoc Networks, Springer.
- Hartenstein, H., & Laberteaux, K. (2010). VANET: vehicular applications and inter-networking technologies (Vol. 1). Chichester: Wiley.
- Sommer, C., & Dressler, F. (2015). Vehicular networking. Cambridge University Press.
- Moustafa, H., & Zhang, Y. (2009). Vehicular networks: techniques, standards, and applications. Auerbach publications.

Objectives

- Introduce the emerging technologies, standards and applications in vehicular communication systems.
- Provide the design considerations and challenges of vehicle-to-infrastructure and vehicle-to-vehicle communications.
- Examples of emerging applications of vehicular communications in Intelligent Transportation Systems will also be studied and discussed.

Learning Outcomes

- Understand and describe the basic theories and principles, technologies, standards, and system architecture of vehicular ad-hoc networks (VANET) or inter-vehicle communication networks.

- Analyze, design, and evaluate vehicular communication platforms for various kinds of safety and infotainment applications.

Attendance Requirements

- A student should have full attendance in each course. Unless the student takes leave of absence for valid reasons, the student has to attend every **lecture, tutorial, or lab session**. The attendance records must be made available to the student after every lecture. Even if the student's attendance falls below **75%,** the student will be allowed to appear for the exams. **Students not meeting attendance criterion of 75% will be required to score C grade to pass a course**. **These students would be awarded F grade if their marks are lower than cut-off for C grade in a course.**

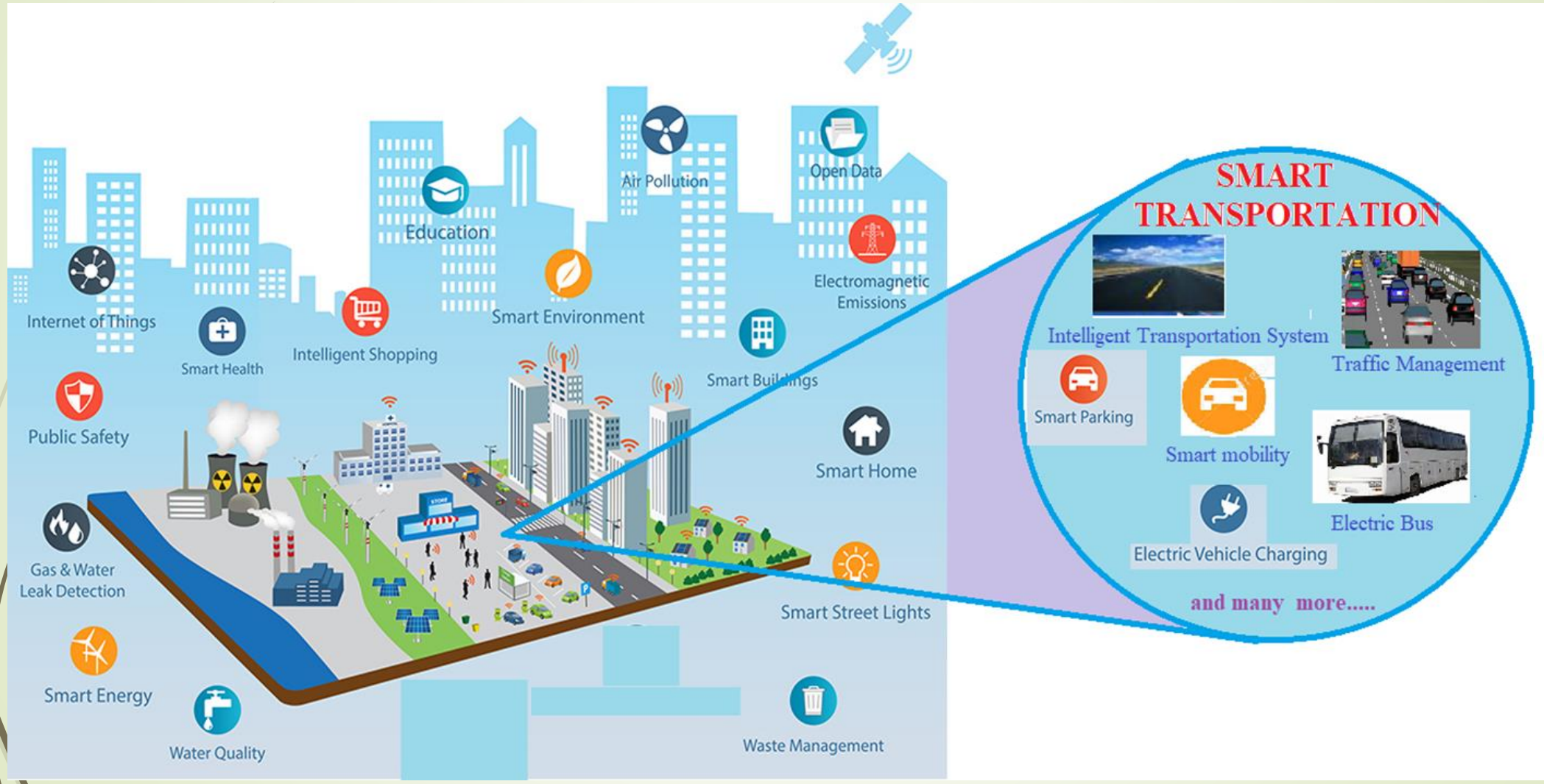
Schedule of Examinations

- A course will have a **60% continuous evaluation and 40% of Major examination** [**Online final exam 20-30% Marks + 10-20% of Marks based on an examination ingroup/project work, special quizzes, etc.].**

Evaluation Scheme

Components	Weightage	
End Sem (Major)	20%	
continuous evaluation	60%	
An examination in group/project work/special quizzes	20%	

Smart Cities



Motivation

- Safety and transport efficiency
  - 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
- Most of these problems can be solved by providing appropriate ***information*** to the driver or to the vehicle

Accidents Reports: WorldWide

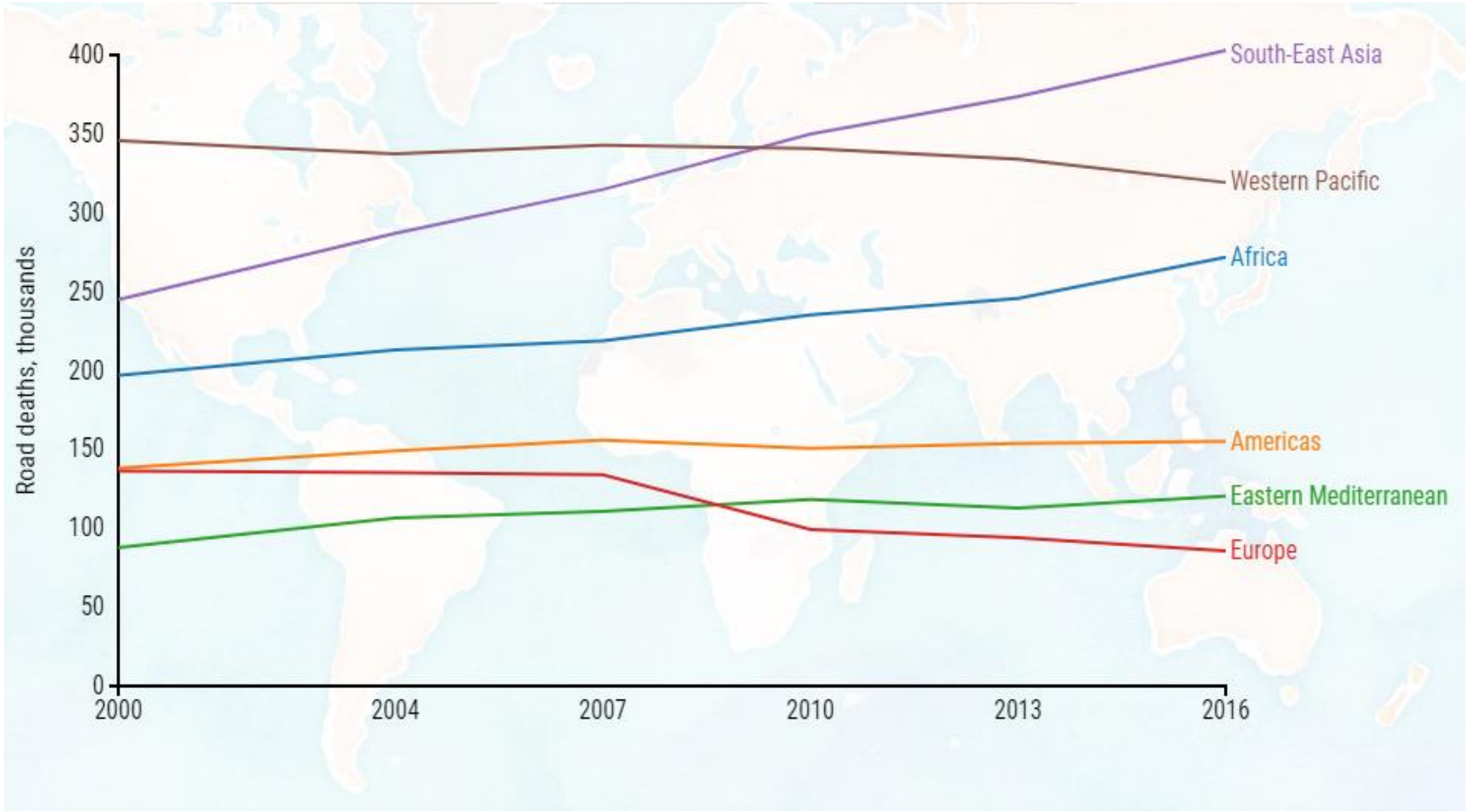


Figure: Total number of road accidents in the world (2019) [1]: 1.35 million

Accidents Reports: India

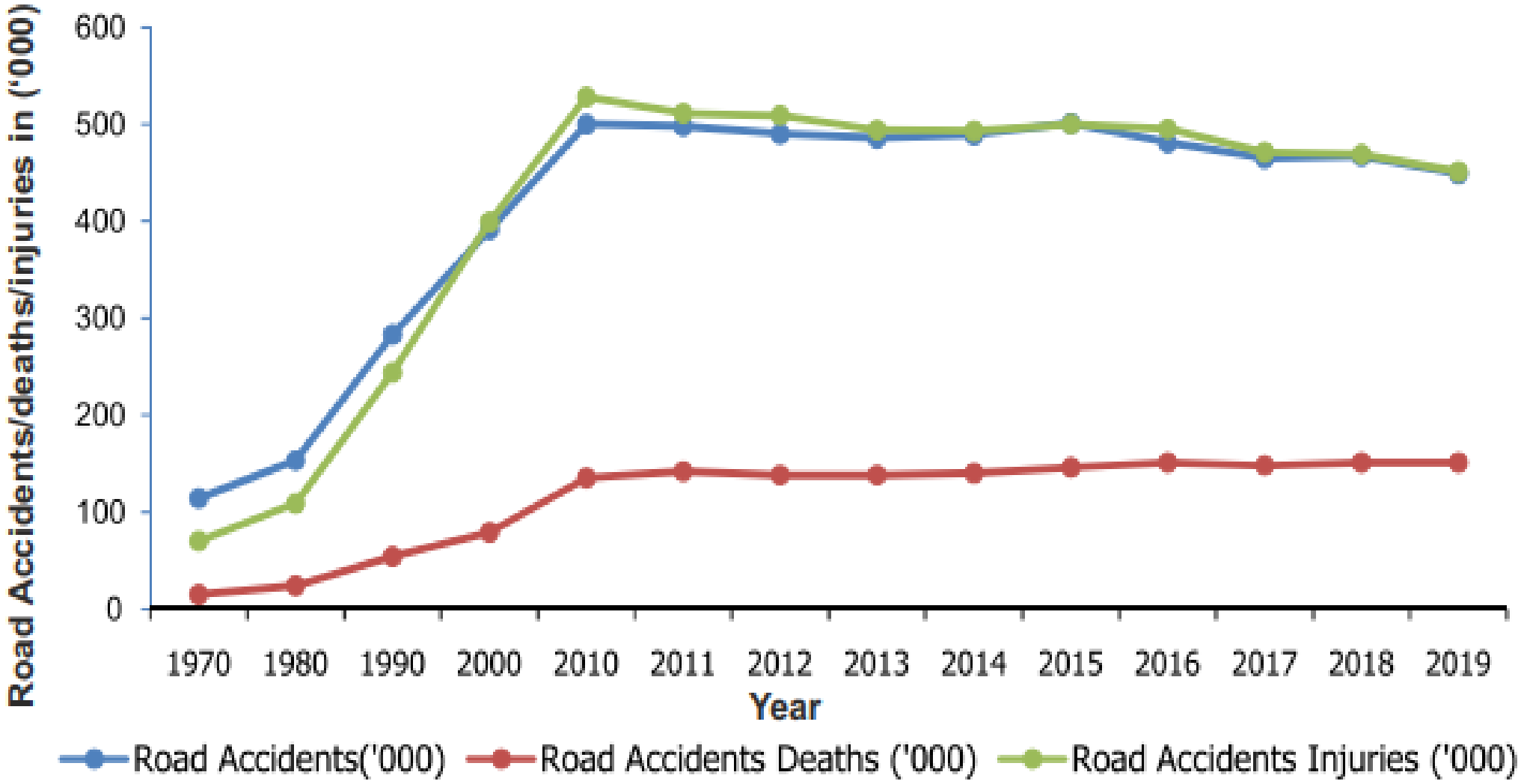
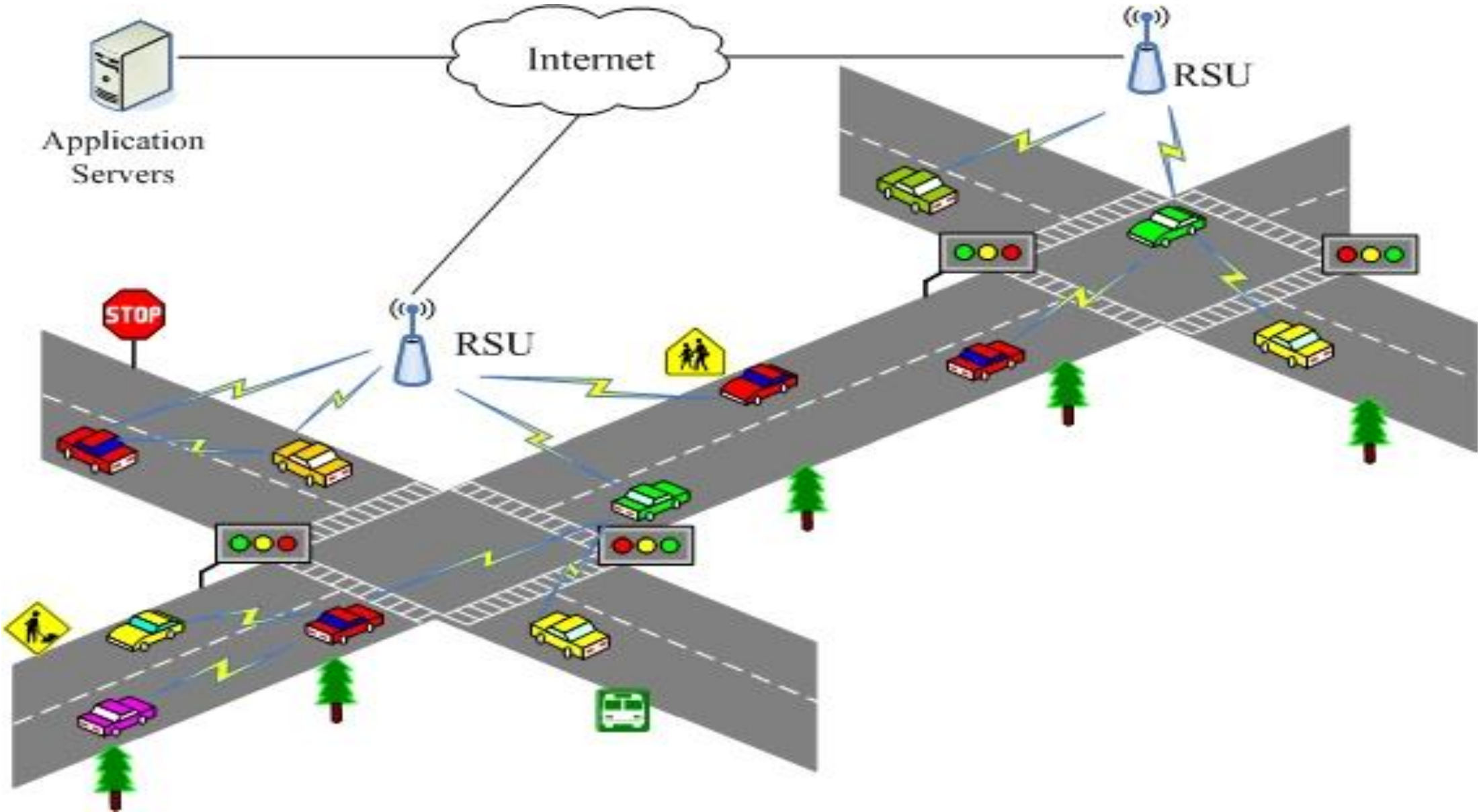
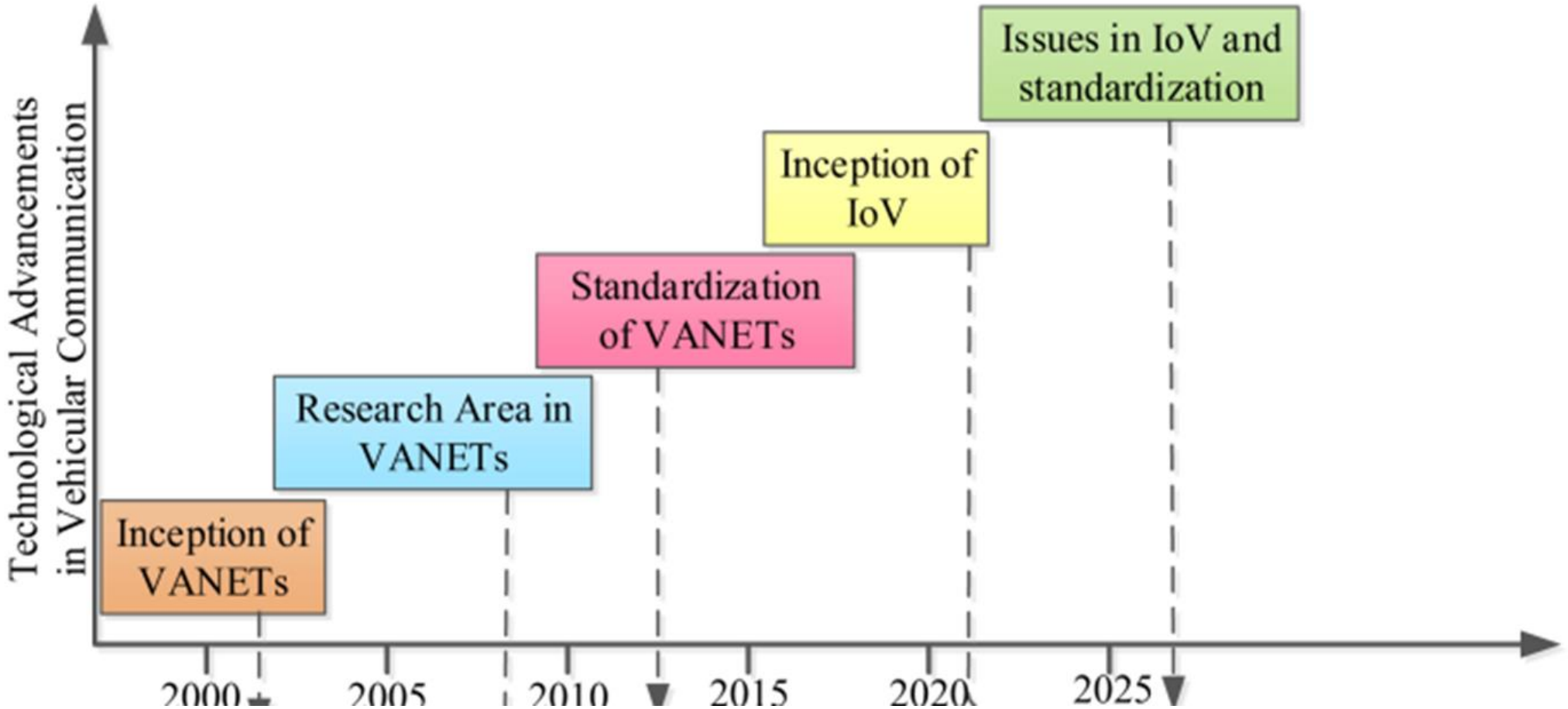


Figure: Total number of road accidents in India (2019) [2]: 4,49,002

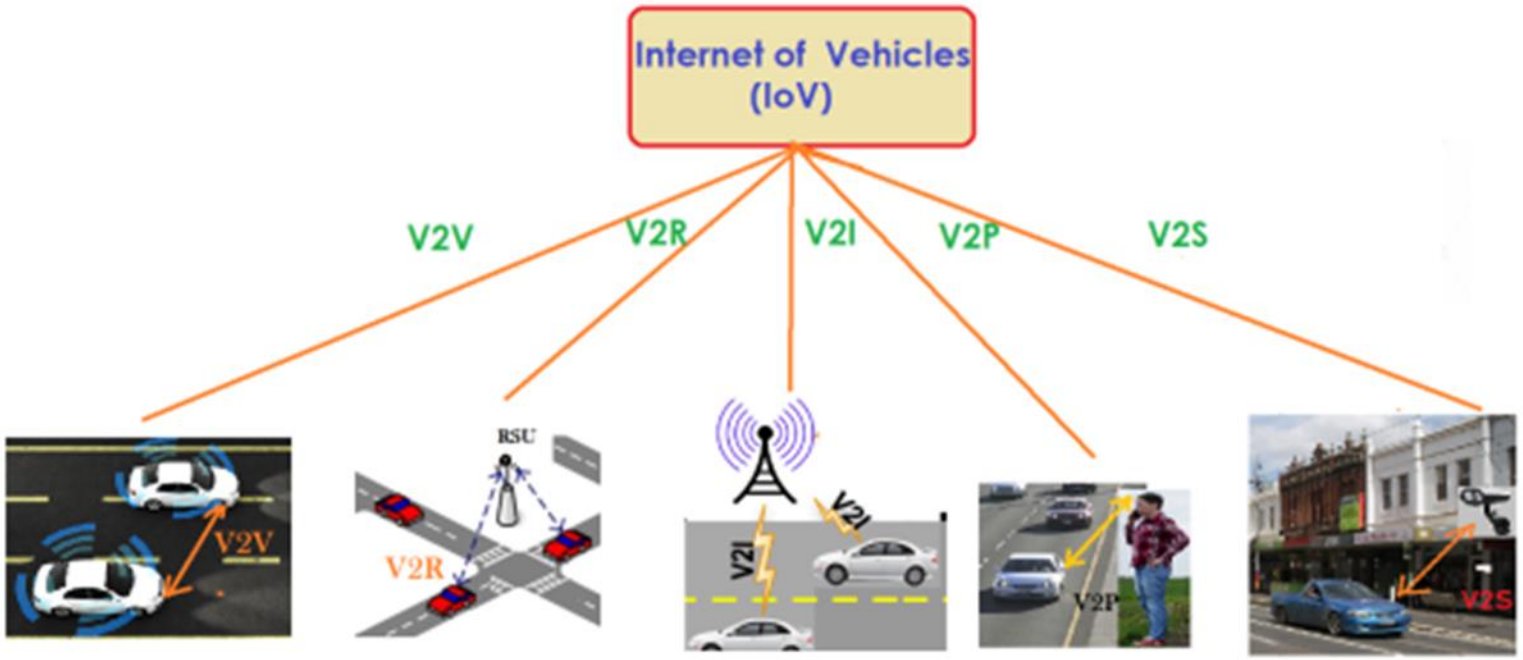
VANETs



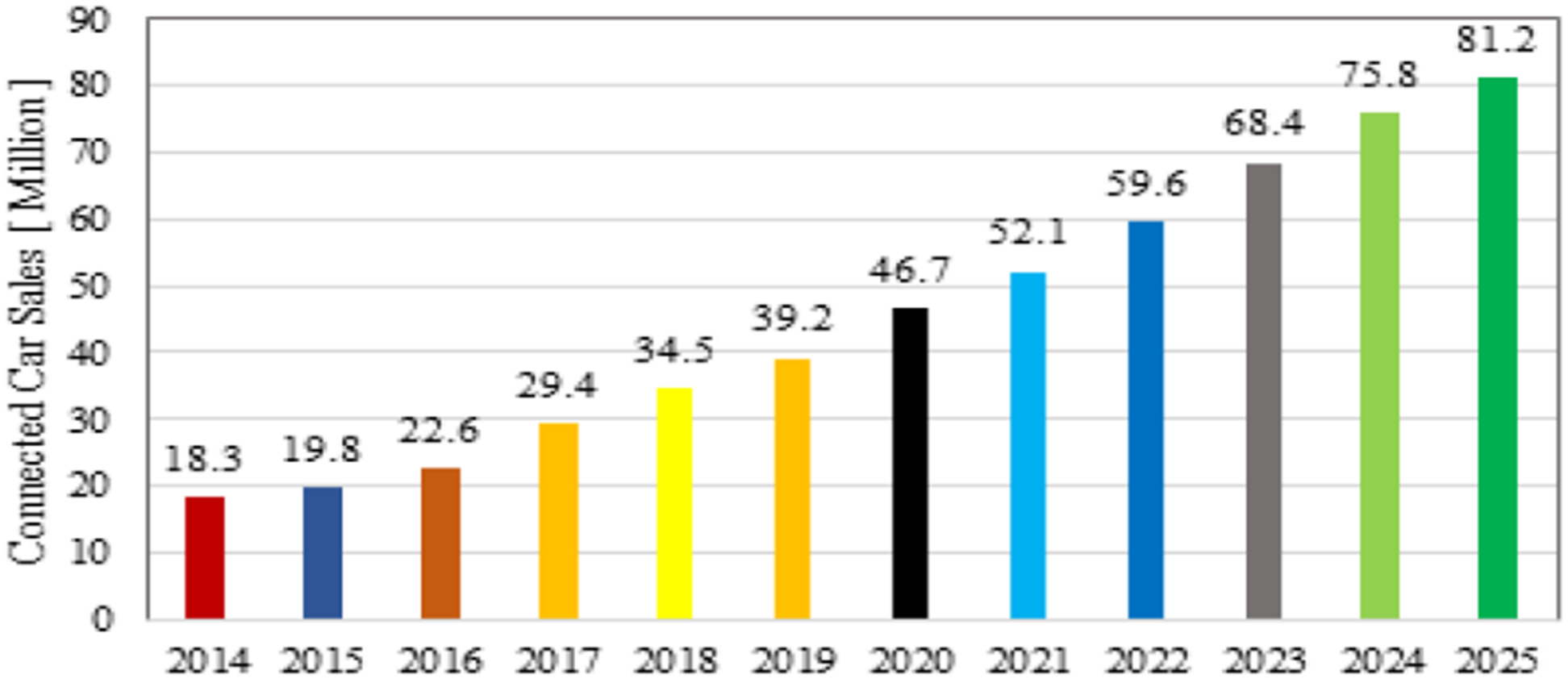
Evolution of vehicular communication from VANETs towards IoV[16]



Internet of Vehicles(IoV) [VANETs + IoT]



The prediction of car sales with some form of connectivity till 2025 [16



Market Opportunities:

- The **VANETs, IoV and VCC** offers huge market opportunity not only for **automobile industry** (like, Ford, Visteon Corporation, Audi, BMW, Maruti etc) , but also for a range of other industries including **IT equipment manufacturer** (like Dell, Intel, Qualcomm, Unex Technology Corporation etc) **software industry**(Like CTS, TCS, Wipro, Amazon, Google, Microsoft, Honeywell etc) and **Internet service providers**(like Vodafone, Airtel, Jeo etc).
- **Academic and Industry Research**
- **Higher Education (MS, Ph.D, Post Doc……)[** MIT, Stanford, UCLS,CMU, NTU, NUS, ……]

Vehicular Ad-Hoc Networks(VANETs)

- Recent advances in **hardware, software, and communication** technologies are enabling the **design and implementation** of a whole range of different types of networks that are being deployed in various environments.
- One such network that has received a lot of interest in the last couple of years is the **Vehicular Ad-Hoc Network (VANET).**
- VANET has become an active area of research, standardization, and development because it has tremendous potential to **improve vehicle and road safety, traffic efficiency, and convenience as well as comfort to both drivers and passengers.**

Introduction

- Vehicular communications are used in various safety and business applications in today's technology world for user benefits. In this, vehicle-to-vehicle (V2V) and V2R communication enables users to exchange meaningful information with nearby vehicles directly.
- In general, vehicles move faster on the highway rather than the intersection road environment, and thus, a robust system is required to communicate efficiently and securely.

Problem Statement

- The number of on-road vehicles has been predicted to increase significantly in the world.
- Due to the higher motorization rate, congestion would result in longer on-road travelling time in coming years.
- Even if 5 minutes of the time wasted in travelling globally is monetized then it is expected to generate Euro 25 billion revenue per year by 2030.
- Automobile industry is expected to increase the profit margin of Euro 54 billion in 2012 to Euro 79 billion by 2020.

Problem Statement

- There is a serious mismatch between the growing traffic volume and the availability of resources to support the traffic.
- Some of the important reasons for this mismatch are rapid development of our economy, increased affordability of our society, multiple vehicles per family, and so on.
- We believe that the mismatch will continue to grow and adversely affect our traffic infrastructure unless efficient traffic management solutions that includes security are developed and deployed

Motivation

- The traditional **Intelligent Transport System (ITS)** has significantly evolved, including **vehicular communication**
  - Main communications: V2V, V2R, V2I→ Vehicular ad-hoc Networks (VANET)
  - VANET – is an important part of the ITS
- VANET (special class of Mobile ad-hoc Network - MANET)
  - has both **technical and business-related limitations**
  - still - **not very large scale deployment in the world**

Objective

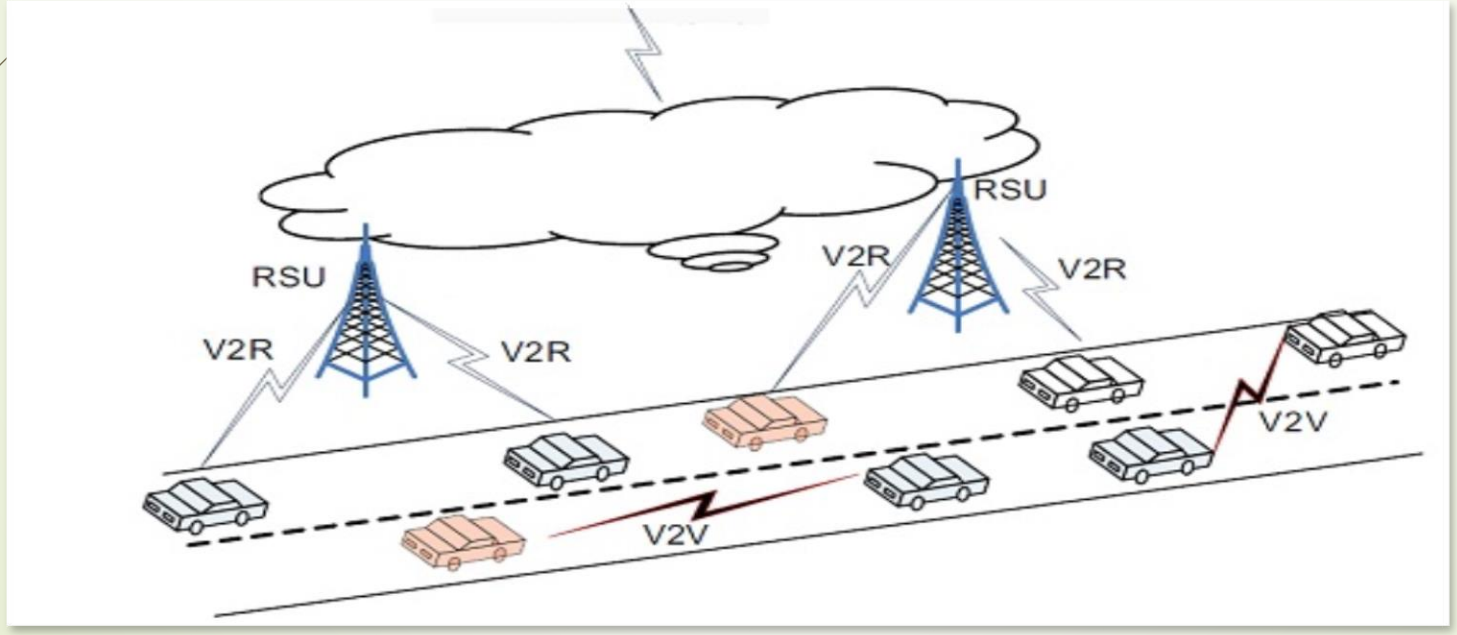
- Optimization of traffic light switching has potential to increase the vehicle carrying capacity of existing roads and can prevent traffic congestions.
- This will provide a number of other advantages to the social fabric and the environment such as reduced traffic jam at city roads, reduce air pollution, reduced traffic accidents, and so on

Introduction

- **Vehicular Ad Hoc Network (VANET) :**

  A vehicular ad hoc network (VANET) uses cars as mobile nodes

- **Vehicle-to-Vehicle (V2V) and**
- **Vehicle-to-Road Side Units(V2R).**



VANET Architecture

Introduction(Cont..)

- **Applications for vehicular networks may require to disseminate information to specific geographical areas.**
- **Communication, Handoff, Security, and Routing are the key research issues in VANETs.**
- **The research challenges for applications of VANETs remains to design of Intelligent algorithms for the Intelligent transportation systems (ITS) to improve safety on the roads.**

Intelligent Transport System (ITS)

- Advanced vehicles and associated transportation infrastructures that use IT&C technology to make driving safer, efficient and comfortable
- Operation of vehicles, manage vehicle traffic, assist drivers with safety and other information, provisioning of convenience applications for passengers
- ITS
  - high interest for companies, operators, government, academia, research; many countries have public and private sector bodies working on ITS
  - Important technologies - implementing many applications related to vehicles, vehicle traffic, drivers, passengers and pedestrians
- **Typical use cases and services/applications**
  - **Active road safety** applications
    - Warnings, notifications, assistance
  - **Traffic efficiency** and management applications
  - **Infotainment** applications

ITS

- **Typical use cases and services/applications**
  - **Active road safety applications**
    - Collision warning: Intersection, Risk, Head on, Rear end, Co-operative forward, Pre-crash
    - Warning on: Overtaking vehicle, Wrong way driving, Stationary vehicle, Traffic condition, Signal violation, Control Loss, Emergency vehicle proximity, etc.
    - Lane change assistance
    - Emergency electronic brake lights
    - Hazardous location notification
    - Co-operative merging assistance

    - **Message types for safety apps**: time-triggered position messages and event-driven hazard warnings

  - **Traffic efficiency and management applications**
    - Speed management and Co-operative navigation
  - **Infotainment applications**
    - Co-operative local services
    - Global Internet services

VANETs

- VANETs are envisaged to provide a communication range of 1000 meters with roadside units and other vehicles, at relative speeds up to 200 km/h, irrespective of the environment.
- Applications for VANETs can be divided into the following broad categories namely, safety related, traffic management and transportation efficiency, user infotainment services and Internet connectivity.
- Safety related applications include lane change assistance, cooperative forward incident warning, intersection collision avoidance, emergency or incident warning.
- Traffic management applications form part of a greater Intelligent Transportation System (ITS) and include toll collection, intersection management, cooperative adaptive cruise control, and detour or delay warning.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