UNIVERSITATEA TEHNICĂ
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COMMUNICATION TECHNIQUES FOR INTELLIGENT TRANSPORTATION SYSTEMS

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INTRODUCTION

- ITS definition: Directive 2010/40/EU of the European Parliament and of the Council:
  - “Intelligent Transport Systems (ITS) are advanced applications which without embodying intelligence as such aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated and ‘smarter’ use of transport networks.”
  - ITS combines different technologies from the field of telecommunications, electronics, information technology with transport engineering for the planning, operation and management of the transport systems.
- The goal of this course is an introduction in the main communications protocols used by ITS and different modes of transport (road traffic, aeronautics, maritime, railway).

INTRODUCTION

- By using information technology and communications techniques in road traffic and it's interfaces to other transportation modes the following enhancements are possible:
  - Environment performance,
  - Efficiency, including energy efficiency,
  - Road safety and security,
  - Public security,
  - Passenger and freight mobility.
- Service examples:
  - Emergency call in case of accidents
  - Traffic rules enforcement by using cameras (e.g. EDS – Electronic Detection System – Turkey)
  - Intelligent traffic lights, etc.

EVALUATION

- Discipline structure: 2 h course + 2 h laboratory + 1 h project
  - Project is only applicable for TC students
- Final grade
  - TC
    - N = 0.6 E + 0.4 P
      - N – final grade, E – exam grade, P – project grade
      - P = 0.5 semester activity + 0.5 defense/content of the project
    - Pass criteria: E >= 5, N >= 5
  - SICAS
    - N = E
      - N – final grade, E – exam grade
    - Pass criteria: E >= 5, N >= 5

COURSE CONTENT

- LTE
- 5G
- Intelligent transportation systems
- Aeronautics communications protocols
- Automotive communications protocols
- Maritime communications protocols
- Railway communications protocols
- Heterogeneous wireless networks

LABORATORY WORKS

- Adalm Pluto & Matlab
  - FM receiver & transmitter, ADS-B receiver
- Adalm Pluto & GNURadio
  - Spectral analyzer, FM receiver & transmitter
- ADAS systems simulation in Matlab
  - LKS, ACC, EAB, etc.

PROJECTS

- 1. Create a software which allows the comparison between two different empirical radio channel models.
- 2. Create a software which simulates and/or represents graphically at least 4 types of diversity..
- 3. Create a software which represents visually the characteristics of the LTE physical, logical and transport channels.
- 4. Create a simulation of the vertical handover process in wireless heterogeneous networks.
- 5. Create a simulation of the load balancing process in wireless heterogeneous networks.
- 6. Create a software in Matlab for CAN message transmission and reception and message visualization.
- 7. Create a board computer simulation in Matlab including the underlying CAN messages.
- 8. Create a simulation of the ADAS data received from various sensors in Matlab.

PROJECTS

- 9. Implement an automated parking assistant simulation in Matlab.
- 10. Implement automated cruise control simulation in Matlab.
- 11. Implement a lane keeping system simulation in Matlab.
- 12. Implement an automated emergency braking simulation in Matlab.
- 13. Implement a simulation for IEEE 802.11p V2V communication PER study in Matlab.
- 14. Implement a traffic light negotiation system simulation based on V2X communications in Matlab.
- 15. Implement an intersection assistant simulation using V2V communications in Matlab
- 16. Create a vehicle platooning simulation based on V2V in Matlab.

WIRELESS TECHNOLOGIES IN ITS

- In the recent years, many communications technologies were developed for high-speed communications in commercial and military applications:
  - WiFi, WiMAX, cellular networks (4G, 5G), sensor networks, wireless Mesh/Ad hoc networks, mobile IP, smart antenna, cognitive radio, etc.
  - These technologies impact the planning and operation of ITS by offering better safety for vehicles, more efficient traffic management and communications between the vehicles and infrastructure
  - Wireless technologies for ITS refer to:
    - Circuit and physical layer technologies: sensors, channel modelling, intelligent antennas, access control
    - Network layer protocols: routing protocols, data dissemination, handover, security, mesh networks
    - System and application development: traffic estimation, location-based services

WIRELESS TECHNOLOGIES IN ITS

- Any communication system needs the source of the message, the transmitter, the channel, the receiver and the destination of the message
  - In wireless communications the channel is usually uncontrolled or weakly controlled
  - In case of vehicular communications, the channel is usually distorted and lossy
    - The development of efficient V2V (Vehicle-to-Vehicle) and V2I (Vehicle-to-Infrastructure) communications systems faces several challenges
- Most of the V2V and V2I applications have a short range (up to 1 km)
  - Propagation loss can limit the system performance, but this effect can be reduced by increasing the transmission power
    - Buildings and other big obstacles can cause losses, but these are reduced due to the multipath propagation
  - V2V radio channels can be highly dynamic, with double variation rates compared to mobile channels
    - The reduced height of the antenna causes more frequent LOS communications distortions
    - Due to the high variation in time these channels are modelled statistically

WIRELESS TECHNOLOGIES IN ITS

- Intelligent antennas can enhance significantly the performance of mobile communications
  - Intelligent antennas combine multiple antenna elements with signal processing in space and in time to optimize the signal transmission and reception
  - This technology can have a major impact in vehicular communications by increasing the throughput and by enhancing the channels
  - Intelligent antennas can localize the user, so they can contribute to vehicle localization and navigation, and they can launch certain location-based services
- Mobile ad-hoc sensor networks can contribute with supplementary information for vehicles and infrastructure
  - ITS networks need precise and reliable data which cannot be obtained continuously due to the movement of the vehicles

WIRELESS TECHNOLOGIES IN ITS

- Sensor networks can offer precise and up-to-date information and can provide robust communications
- The routing protocols in sensor networks have a major impact on the correct function of these networks

- VANET (Vehicular Ad-hoc NETworks) are critical components of ITS
  - Are a variant of MANET with several differences:
    - High mobility
    - Rapidly changing network topology
    - Unlimited network dimension
    - Time dependent data exchange
  - In VANET information security is essential

WIRELESS TECHNOLOGIES IN ITS

- Emergent wireless technologies contribute significantly to the planning and exploitation of ITS
  - These technologies must be combined with other research areas to offer better services
  - 3 fundamental technologies need to be combined for ITS: wireless communications, geolocation technologies and geographic information systems to develop a system capable of real-time monitoring of moving objects
- The automotive industry offers safer and more intelligent cars
  - The electronic components offer increased comfort and security
  - An important step is connecting the vehicles to the Internet
  - ITS related services can be divided into 2 main categories in passenger vehicles: safety and infotainment, based on the Internet and inter-vehicle communications