Cloud-Integrated Infrastructure for Automotive Cyber-Physical Systems (ACPN)

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Introduction

- As a vehicle to infrastructure (V2I) service, cloud computational resources can be used to virtually represent the automotive systems for monitoring, actuating, and navigation purposes in an efficient and reliable manner.
- By adding this new dimension, vehicles will become service-based mobile cyber-physical platforms that can be informative about their surroundings, and can be optimally controlled via the available models and data-bases in the cloud service.

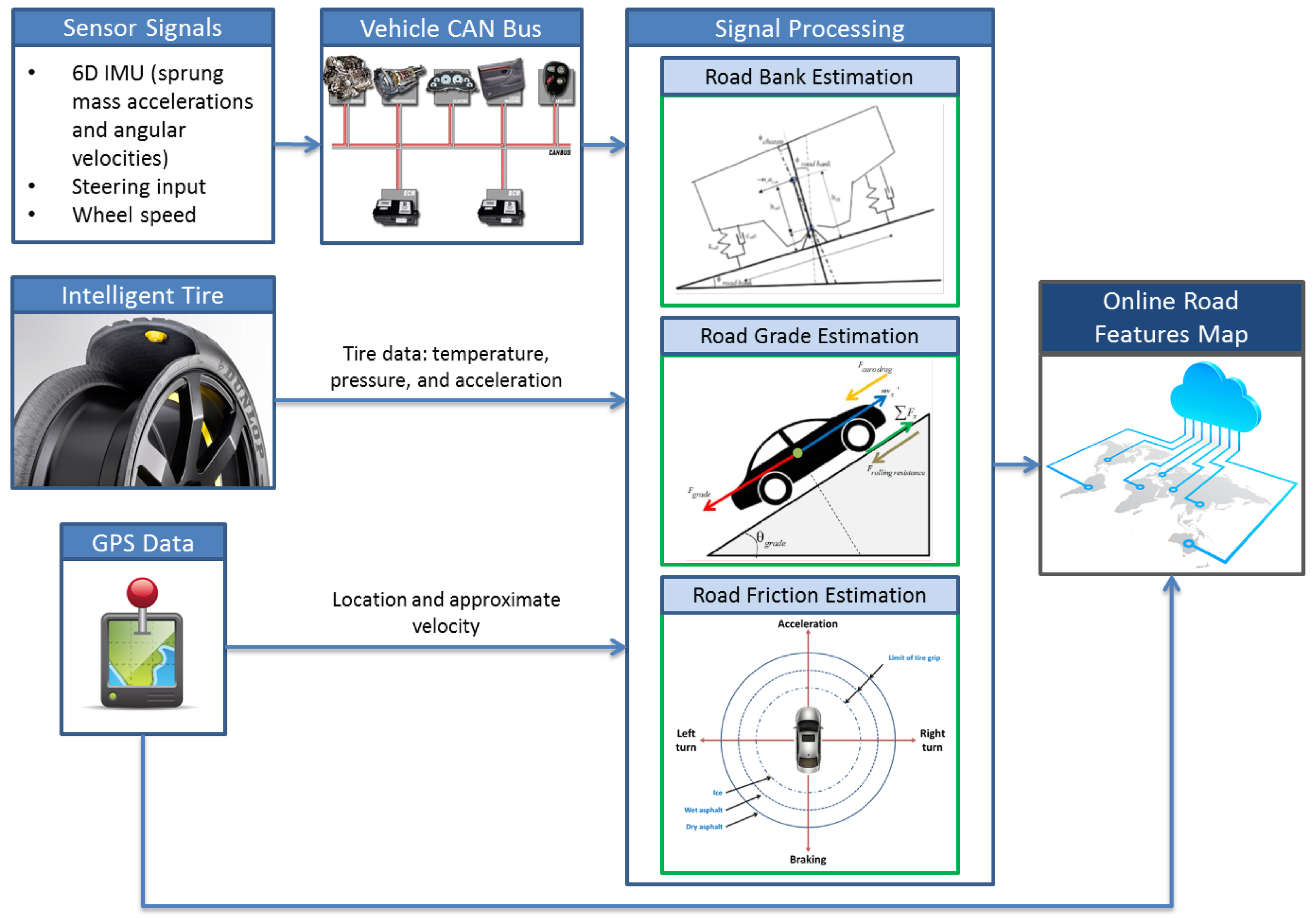
Cloud Framework

- Platform-as-a-Service (PaaS) is proposed as a viable cloud framework option. In this case, a platform hosts multiple instances of an application (e.g., vehicle models or road databases), and handles infrastructure (hardware), security, and scalability of the application.

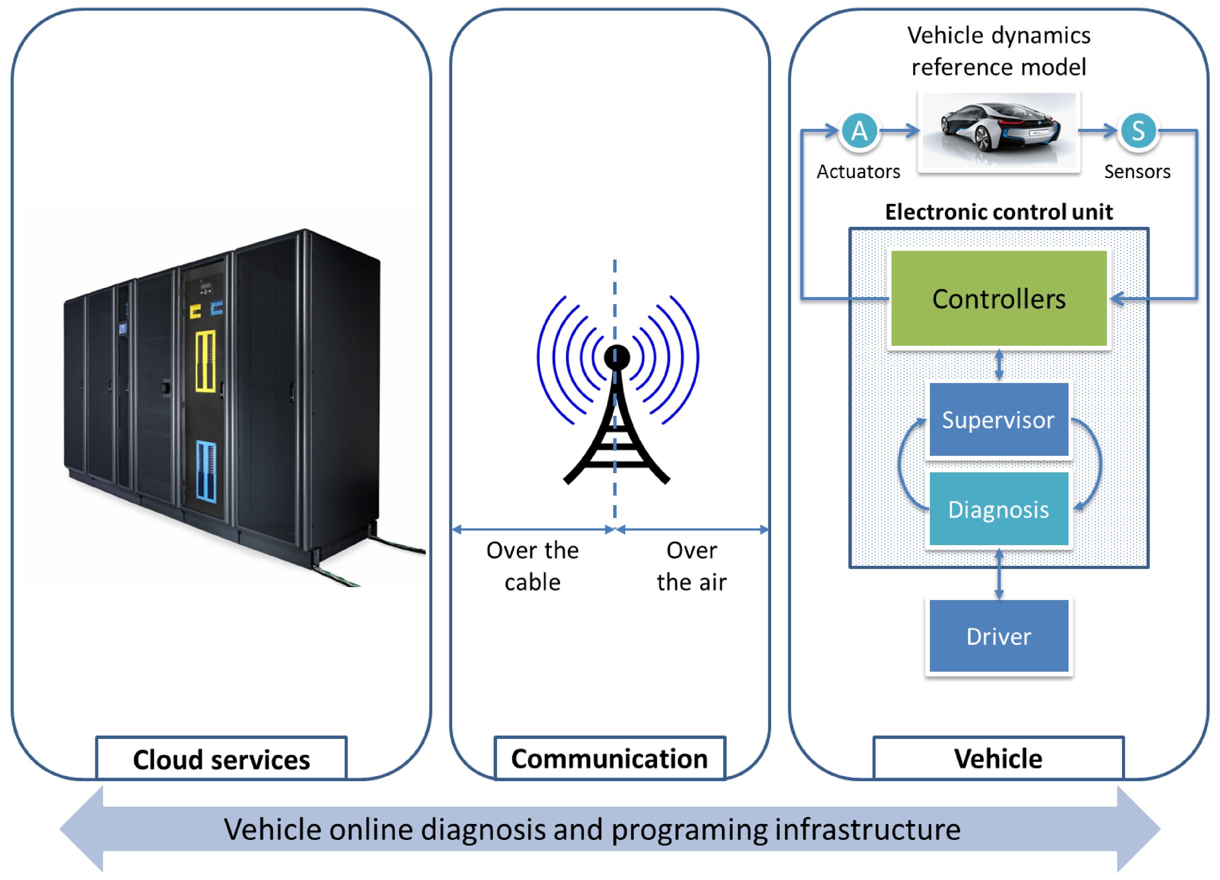
Road Health Monitoring

- Aggregate the vehicle sensor readings and GPS data in order to construct a comprehensive real-time road map, which helps identifying and locating road hazards
- Ex.: Pass the car suspension acceleration data through a wavelet feature extraction filter and classify the results to identify the location of potholes
- Ex.: Incorporate cameras behind the rearview mirror and process the images to find unclear road signs and markings

Road Feature Database



Remote Diagnosis and Programming



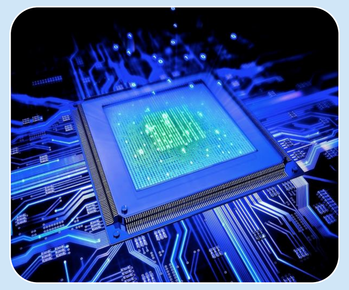
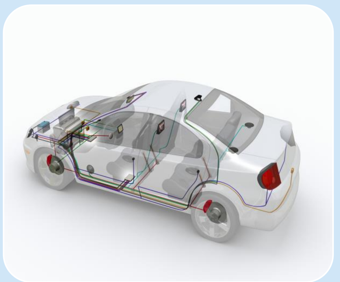
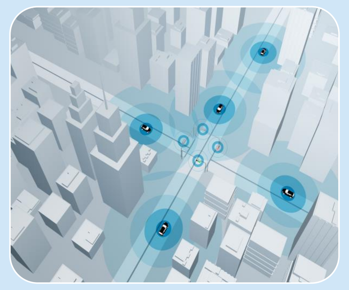
Efficiency and Safety

- The road inclination is used in the adaptive cruise control systems to adjust the vehicle speed and gear before encountering the high gradient road profiles, which, in turn, helps avoiding unnecessary gear changes.
- Local friction coefficient, local speed limit, road curvature, and road banking are used in the vehicle stability program as a-priori to help the associated controller converge faster.
- Instead of using simplified models (e.g., bicycle model) in these adaptive control systems, full vehicle models can be incorporated into the cloud system, and the realistic results are generated promptly via the parallel computational resources.

Environmental Analysis

- Environmental analysis requires high density observation networks as well as many radar and satellite estimations.
- The available sensors in a modern vehicle can be exploited for improving the estimations in the environmental studies.
- Ex.: Measurements from the optical sensors used in the automatic windshield wipers can be used to construct a model that correlates the wiper's frequency and vehicle speed (at multiple network nodes) to the rainfall patterns.
- Ex.: Readings from other sensors, such as temperature, oxygen, and carbon monoxide sensors are useful for evaluating the weather conditions, as well the urban air quality.

Project Outline

Step 1
- Requirement specification
- Identify the available infrastructure
- Literature survey

Step 2
- Model-based development
- Software development
- Cloud integration
- co-simulation

Step 3
- ECU code building
- Hardware in the loop
- System calibration

Step 4
- System validation
- Infrastructure development

Challenges

Data Communication and Timing

- **Vehicle to Infrastructure Communication:**
  - It can be established by cellular or wireless communication links.
- **Connectivity Limitations**
  - It can be improved by improving infrastructure with inner-vehicular sub-wireless connections (e.g., IEEE 802.11p/Wave protocol), and applying loss anticipation rules (e.g., slowing down the vehicles in case of a connectivity problem)
- **Timing Requirements**
  - Strategies to avoid real-time faults such as jitter, delay, and incorrect sampling rate

Security and Failure Semantic

- **Failure Identification**
  - Partial failures due to aleatory uncertainties
  - Unanticipated failures (epistemic failures)
- **Failures paradigm**
  - Intricate paradigm for estimating the probability of the failures.
- **Cyber attacks**
  - Prevention: Information holes
  - Detection: Incorrect information propagation
  - Mitigation

Verification and Validation (V&V)

- **Closing the Loop**
  - Testing the intelligent ACPN with complex human interaction models developed using neural network and fuzzy logic algorithms
- **System Dimension**
  - V&V architectures should be scalable both in dimension and complexity
- **Realistic Real-Time Model Based Controller Design Verification**
  - By integrating multiple motion based vehicle simulators in a V2X framework