Enabling Intelligent Transportation Systems (ITS) through programmable networks

Level of qualifications required: Bachelor's degree or equivalent

Fonction: PhD Position

About the research centre or Inria department

The Inria Sophia Antipolis - Méditerranée center counts 37 research teams and 9 support departments. The center's staff (about 600 people including 400 Inria employees) is composed of scientists of different nationalities (250 foreigners of 50 nationalities), engineers, technicians and administrators. 1/3 of the staff are civil servants, the others are contractual. The majority of the research teams at the center are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Six teams are based in Montpellier and a team is hosted by the computer science department of the University of Bologna in Italy. The Center is a member of the University and Institution Community (ComUE) "Université Côte d'Azur (UCA)".

Assignment

voir sujet ci-dessous

Main activities

Context

Transportation systems are a key component of our society's critical infrastructure and are expected to experience major changes during the current "information age". A noteworthy example is the automotive industry that has been disrupted by technologies such as vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication. Vehicular communication is expected to be one of the key technological enablers of next-generation transportation systems, also known as Intelligent Transport Systems (ITS). In ITS, vehicles exchange information to self-drive, coordinate road traffic, communicate road conditions, avoid accidents, as well as support infotainment services.

ITS services and applications pose significant challenges due to their stringent low latency, reliability, scalability, and geographic decentralization requirements. Leveraging the emergence of programmable networks with the Software-Defined Networking (SDN) [1] paradigm, Software-Defined Vehicular Ad hoc NETwork (SD-VANET) architectures have been proposed as a way to address such requirements [2,3]. SD-VANETs rely on the separation between network control and data planes, resulting in increased network programmability that enables vehicles to react and adjust to dynamically changing environmental- and networking conditions. They have demonstrated the benefits of using SDN's decoupling of network control from data forwarding when compared to "traditional" VANET architectures (e.g., employing multi-hop ad hoc network routing [2]). However, SD-VANETs and other existing solutions either rely on logically centralized control plane [3,4,5,6], or use a static control distribution approach [7], both of which are not compatible with ITS' QoS needs.

We contend that ITS' stringent scalability, latency, reliability, and decentralization requirements call for a distributed and flexible network control plane, decoupled from the data plane, that can automatically and dynamically adjust to current environment and network conditions [8].

Objectives and challenges

The main objective of this work is to design such a distributed network control plane and demonstrate its performance benefits in a variety of ITS services and applications.

We anticipate a wide range of research challenges. For instance, decoupling the Virtual Network Functions (VNFs) from underlying hardware presents multiple management challenges, including the mapping of services to chains of VNF (aka...
service function chaining), instantiating VNFs, allocating and scaling resources to VNFs, monitoring VNFs, support of physical/software resources. Control decentralization will require maintaining flow and controller state consistency, dynamically establishing the control hierarchy within- and across administrative domains, and defining control delegation policies and mechanisms. The question of how to adapt to network dynamics while preventing oscillations also needs to be addressed. Furthermore, providing security services as an integral part of our framework while trying to mitigate the impact on performance will be critical. Finally, applying our framework to use cases related to existing and emerging applications will raise a variety of challenges ranging from providing required functionality to using realistic testbeds and creating scenarios that are as close as possible to real-world characteristics and conditions.

This work aims at addressing the above challenges by: (1) developing a programmable network control plane that will dynamically adjust to current environment conditions and network characteristics to support ITS' scalability, quality of service (QoS), and decentralization requirements, and (2) applying the proposed distributed network control plane framework to ITS services and applications, such as road hazard warning, autonomous- and self-driving vehicles, and passenger-centric services (e.g., infotainment and video streaming). The performance of the proposed algorithms and protocols will be assessed analytically and using network emulation such as mininet-wifi[9], and reproducible experimentation using testbeds such as R2lab[10].

The PhD work will be carried out in the context of an international collaboration between Inria, the State University of Campinas (UNICAMP), Brazil and the University of California, Santa Cruz (UCSC). The outputs of this work are expected to be shared with standardization bodies such as ETSI and the CAR-2-CAR Communication Consortium.

Required skills and background

- Strong mathematical background
- Good programming skills in Python and the ability to quickly learn and master other programming languages and simulators
- Excellent verbal and written skills in English

Contact

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References


[10] FIT R2lab Reproducible Research Lab: http://fit-r2lab.inria.fr/

Skills

- Strong mathematical background
- Good programming skills in Python and the ability to quickly learn and master other programming languages and simulators
- Excellent verbal and written skills in English

Benefits package

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

Remuneration

Duration: 36 months
Location: Sophia Antipolis, France
Gross Salary per month: 1982€ brut per month (year 1 & 2) and 2085€ brut/month (year 3)