QoS Provisioning for Vehicular Networks based on X2-HeNBs

Ahmed Salim Chekkouri, Abdellatif Ezzouhairi, Samuel Pierre, Member, IEEE
Mobile Computing and Networking Research Laboratory
Department of Computer Engineering École Polytechnique de Montréal

Introduction

Vehicular Networks
- Vehicular Networks or VANETs use cars as mobile node to form an Adhoc Network. Recently, this kind of MANETs have attracted extensive academic and industrial research to improve safety and efficiency of road traffic.
- DSRC/WAVE or IEEE 802.11p have been specifically designed for automotive use to effectively support vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications.
- Femtocells
  - It refers to a small, low-power cellular base station, typically designed for use in a home or small business.
  - The LTE-Advanced (LTE-A) femtocells also known as HeNBs represent a huge opportunity for connected vehicles.
  - It is proposed as potential solution to offload cellular networks and improve QoS by using a wired X2-based backhaul.

Motivations

- In big cities, 80% of the overall Internet traffic is performed in low mobility.
- LTE-A femtocell deployment is expected to grow up considerably in the near future.
- Although the concept of vehicular networks has been proved in many real-world testbeds, still there is no infrastructure large scale deployment because it needs considerable public investments.
- Given the large scale deployment of LTE-A femtocells and its low latency, they can be used as a supplement for DSRC V2I communications.
- The small coverage of femtocells may lead to frequent handoffs that need permanent support of the core network.
- To ensure seamless handovers through such networks, local mobility management remains an important task to be addressed.
- During rush time femtocells can be used to offload the VANET network and to offer good connexion conditions at low cost.

Hypothesis

- LTE-A femtocells have adequate density to have acceptable coverage in outdoors (with ~7% household femtocells penetration we have a coverage of 80%).
- Vehicles are equipped with DSRC/WAVE (IEEE 802.11p) and LTE-Advanced(E-UTRA-Evolved Universal Terrestrial Radio Access) interfaces.

Contributions

- Proposes a low cost backhaul that integrates LTE-core, vehicular ad hoc networks and HeNB networked femtocells.
- Propose an enhancement to the current LTE-A's mobility scheme. Particularly, our solution uses the X2 interfaces rather than S1. In this way, we uses a wired backhaul for the transported traffic. Furthermore, a smart forwarding mechanism is considered to reduce signaling load relevant to the EPC.

Proposed Scheme

The proposed interworking backhaul using networked femtocells as a supplement for DSRC Roadside units is presented. More specifically, this architecture considers the availability of HeNBs over the road side of highways passing through cities.

To address the aforementioned problems, we propose, in what follow, an interworking architecture as well a mobility scheme that ensures seamless service continuity for VANETs.

Results

To study the effectiveness of the proposed scheme, we developed an analytical model to simulate the vehicular roaming conditions. In what follows, we illustrate the behaviour of the generated signaling load for both the proposed solution as well as the LTE-A standard considered as a benchmark comparison scheme. More specifically, in Fig. 4, we show the impact of mobility on the overall generated signaling cost. Particularly, we notice that when the vehicle speed increases the considered X2-based forwarding scheme contributes to reduce the signaling load.

Conclusion

In this work, a smart X2-based traffic offloading scheme is proposed. The proposed interworking architecture is endowed with a mobility mechanism that allows cars to perform interfemto roaming with minimum signaling load. Based on analytical model, numerical results show the effectiveness of the proposed solution in reducing the signaling load than the benchmark solution.

Smart handoff decision based on vehicle's location
To improve the quality of the handoff decision process considered in the above roaming procedure, as future work, we propose to use vehicle's location to make efficient choice of target femtocell and efficient estimation of the expected time-to-stay in the next femtocell.