SHORT TERM SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

The STSM applicant submits this report for approval to the STSM coordinator

Action number: CA15127
STSM title: Resilient Internet Provisioning in VANETs
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PURPOSE OF THE STSM/

Drive-thru-Internet is a scenario in Cooperative Intelligent Transportation systems (C-ITS) where a road-side unit (RSU) provides multimedia services to vehicles that pass by. The performance of drive-thru-Internet depends on various factors, like data traffic intensity, vehicle traffic density, and radio-link quality within the coverage of RSU which might experience degradation due to heavy rain fall, fog, etc., and must be evaluated at the stage of system design in order to fulfil Quality of Service requirements of the customers in C-ITS. We are developing an analytical framework that models downlink traffic in a drive-thru-Internet scenario by means of a multidimensional Markov process. Taking into account the state space explosion problem associated with multidimensional Markov processes, we are using iterative perturbation techniques to calculate the stationary distribution of the Markov chain. In this STSM we characterized the connectivity times for Drive-thru-Internet scenario taking into account the multi-channel RSU operation as specified IEEE 1609.4 standard. This collaborative work belongs to WP2.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

The emerging concept of Cooperative Intelligent Transportation Systems (C-ITS) suggests a widespread adoption of information and communication technologies in diverse vehicular applications aimed to increase transport safety, efficiency and comfort. C-ITS vehicles exchange information with each other as well as with roadside infrastructure in a heterogeneous wireless networking environment. There are number of communication technologies currently under development that could support connectivity in a vehicular environment. To enable vehicular communications in the Dedicated Short Range Communications (DSRC) 5.9 GHz band, IEEE 802.11p, which is currently integrated into the recent IEEE 802.11-2012 standard, was introduced by Institute of Electrical and Electronics Engineers (IEEE). The IEEE 802.11p defines two lower layers of the communication stack: the Physical layer and the Medium Access Control layer. IEEE also introduced WAVE (wireless access in vehicular environment), which defines the overall protocol stack for vehicular communications, including management and security planes. At the same time, in Europe, under the European Commission mandate M/453, European Telecommunications Standards Institute (ETSI) developed a C-ITS protocol stack specified in ETSI EN 302 665. The ETSI C-ITS stack consists of three layers: the access, the networking and transport, and the facilities layer, with a number of management and security protocols specified for all three layers. Apart from DSRC, cellular technologies, like LTE (Long Term Evolution) or the currently being developed 5G could become a complementing technology choice. The upcoming 5G communications promises both operation in extremely mobile environments (up to 500 km/h relative speeds) and highly reliable connectivity with low-latency for vehicle to everything (V2X) scenarios. Infotainment services provided to the drivers and passengers are heavily dependent on the connectivity of the vehicles to the Internet. Broadband cellular networks which provide stable vehicle-to-infrastructure communication links are assumed to be available in urban areas. Rural roads, in contrast, might have only intermittent cellular connectivity, which motivates the consideration of a drive-thru scenario where a moving vehicle spends at most a couple of minutes in the coverage area of a roadside unit, an access point or a base station. In this study we consider downlink communications for data downloading by the vehicles from the RSU. There are variety of ITS applications under current consideration, that require such downlink communications in a drive-thru scenario. Some examples include media downloading, map downloading and updating, and vehicle software/data provisioning and updating. All of these scenarios assume infrastructure-to-vehicle (I2V) communications: when in the RSU coverage area, a vehicle should be able to download certain data, e.g. web-page content, map segment update, software update, etc. To provide a certain level of Quality-of-Service (QoS) to users, models to estimate communication performance in drive-thru have been considered in the STSM.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

1. We introduced a Markovian queueing model of an infrastructure vehicular network where an RSU transmits data to vehicles in its coverage area which consists of zones with different channel conditions under realistic assumptions of limited buffer length and limited number of customers in service.
2. We tackled the model numerically despite the large-scale of the queueing system at hand. The solution relies on the Taylor series approximation technique and benefits from the sparsity of the transition rate matrix.
3. We conducted performance evaluation of a drive-thru-Internet scenario and quantitatively characterise the mean queue content, the packet delay and two types of packet loss: discarded packets and rejected packets.

FUTURE COLLABORATIONS (if applicable)

We are planning to continue our work on the "Internet Provisioning in VANETs: Performance Modelling of Drive-Thru Scenarios" for IEEE Transactions on Intelligent Transportation Systems.

We are also planning to analyse the basic tradeoffs in the resilient Internet provisioning in VANETs. First, the more frequently a service is announced, the shorter the service discovery time (i.e., the time necessary to detect a service announcement) will be and the higher the probability to detect the presence of a nearby provider when under its coverage. Second, when the provider has to switch its transceiver from the channel where services are provided to the channel where service advertisement should be delivered, connected vehicles will experience disruption what reduces channels utilization.

Mutual research visits are foreseen in 2018.