Project lit review notes

**A Survey on Simulation Efforts of 4G/LTE-based Cellular and Hybrid V2X Communications**

Other papers used:

[2] Research on Resource Scheduling Method Based onLTE-V2X Direct Connect Communication

[3] Multimedia Transmission for V2X Communication over Legacy LTE-A Network Infrastructure - A Performance Evaluation

[4] Impact of VANET-Based V2X Communication Using IEEE 802.11p on Reducing Vehicles Traveling Time in Realistic Large Scale Urban Area

Why V2X?

* increasing number of victims
* Bad weather conditions
* drivers not following the road signs
* careless driving

Types of V2X

* Dedicated Short Range Communication (DSRC)
  + WiFi-based
  + ITS-G5 solutions using IEEE802.11p
* Cellular Communication based technologies
  + LTE-V2X
  + LTE-V
  + Cellular-V2X

LTE-V2X

* Two radio interfaces
  + Cellular interface known as Uu
    - Enables and supports Vehicle-to-infrastructure (V2I) communication
  + PC5 interface
    - Supports Vehicle-to-Vehicle (V2V) communication based on LTE sidelink
    - LTE mode 4 allows vehicles to select radio resources anonymously, allowing V2V communication without needing cellular coverage
* Two operating modes [2]
  + Cellular communication
  + Direct communication
    - Can work inside and outside the network coverage
    - Uses ITS dedicated near 5.9 GHz
    - Communication takes place between terminal devices
    - Low latency
    - Highly reliable
    - Self-organising or base station scheduled resource utilization
* Scheduling methods for resource utilisation[2]
  + Base station scheduling
    - Base station receives data from the on board unit (OBU) or road side unit (RSU)
    - Command centre for global scheduling
    - No collisions, vehicles transmit data independently
    - Optimal when vehicles can connect to the base station
  + Vehicle-based self-organising scheduling
    - Used when there is a lack of base station communication
    - OBU and RSU uses what it knows to which resources to use for scheduling, instead of being given those instructions by a base station
    - Collisions can occur when vehicles use the same resource block to transmit data

Cellular V2X

* Advantages
  + Slicing
  + Edge-computing
  + Integration of V2X into 3GPP cellular ecosystem
  + Wide scale applications
    - Warning other vehicles about road hazards
    - 360 None-Line-of-Sight (NLOS) sensing
    - Situational awareness
    - 3D HD maps
    - Infotainment
    - Diagnostics
  + Will also enable Vehicle-to-Networks (V2N)
    - Used for autonomous driving
    - Collect road tolls
  + Enables Vehicle-to-Pedestrian (V2P)
    - Ensures safety for pedestrians on the road carrying their smartphones

Vehicular Ad-Hoc Network (VANET)

* Temporary network created for communication purposes
* Difficult to implement and test physically, so need to use network simulators in conjunction with a traffic simulator to run close to realistic scenarios

**Network Simulators**

What is the aim of network simulators?

* Firstly, implement networking models and relate protocol stacks
* The networking models will use road data traffic and determined mobility models of nodes from the traffic simulator as input data.
* The network simulator then performs the appropriate routing strategy to transmit data packets.
* It confirms whether the data packets have been successfully sent and received over the radio channel
* Various network simulators available
  + OMNeT++
  + NS-3
  + OPNET
  + JiST/SWANS
  + GloMoSim

OMNeT++

* Object-oriented standard discreet event simulator [3]
* Open source
* Use for modelling wired and wireless communication networks
* Consists of various components (programmed in C++) that can be simulated
* Components can be transformed into larger modules with Network Description Language (NED)

NS-3

* Discrete event network simulator for internet systems
* Written in C++
* Compiled into a set of shared libraries linked by executable programs that that describe the desired simulation topology and configuration
* Requirements for ns-3
  + Computer must have a C++ compiler
  + Python
  + CMake build system
* Simulation Workflow
  + Topology Definition: Use containers and helpers to create basic facilities and define interrelationships
  + Model Development: Add models to simulation, such as UDP, IPv4, etc.
  + Node and link configuration: set default values of models, usually done using the attribute system
  + Execution: Simulation facilities generate event, data requested by the user is logged
  + Performance Analysis: After the simulation, data is available as a time stamped event trace, which can be analysed using R to draw conclusions
  + Graphical Visualization: Raw or processed data can be graphed using gnuplot, matplotlib or xgraph.

**Mediation Frameworks**

* Mediation software is vital in order to ensure desired interaction between the network simulator and traffic simulator. It can also be used to extend the scope of the network simulator to implement simulation models.

Vehicles in Network Simulation - Veins

* TraCI interface
* Open-source framework for running vehicular network simulations
* Based on OMNeT++ and SUMO (Simulation in Urban MObility)
* Uses OMNeT++ for the network simulation and SUMO for the traffic simulation
* Communicates to OMNeT++ via a TCP connection
* Manager module in Veins accountable for synchronization [3]

**Traffic Simulators**

* Purposed with showcasing realistic road traffic and other mobility patterns
* May use real maps to generate road systems to manage mobility patterns

SUMO

* Road network simulator
* Build road environments
* Can be used in two ways
  + Can simulate dynamic route planning using CTT (Current Travelling Time), without the help of any wireless communication
  + Can also be used in conjunction with OMNeT++ to simulate route planning using information gathered from wireless communication networks
* Can import realistic maps and traffic of the selected map for any time within the day.
  + In this study [4], a 400 square-kilometre area of the city of Cologne, Germany, was modelled onto SUMO, with traffic for a period of 24 hours and over 700 000 individual vehicle trips.