Open-Source Prototyping of 5G Wireless Systems for Smart Ag, Autonomous Vehicles and Beyond

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Anthony Benson, Hye-Sung Moon, Jaime Zetina, Jared Gorton, Khanh Luu, Theodore Miller

Client: Dr. Hongwei Zhang

Adviser: Dr. Hongwei Zhang

Problem Statement

Current wireless network technology does not provide a suitable environment to support reliable Vehicle to Vehicle (V2V) communication given the complexities of uncertainty and the dynamics of a mobile network.

Solution

Geometric Cellular Scheduling (GCS) is a scheduling algorithm that will use a vehicle's geographical location to schedule communication between itself and other vehicles that may fall in its interference area for reduced interference and predictable reliability.

Simulation of Urban Mobility (SUMO)

- An open source simulator from the Institute of Transportation Systems at the German Aerospace Center.
- Generating real-road conditions and vehicle's data (location, speed, etc).

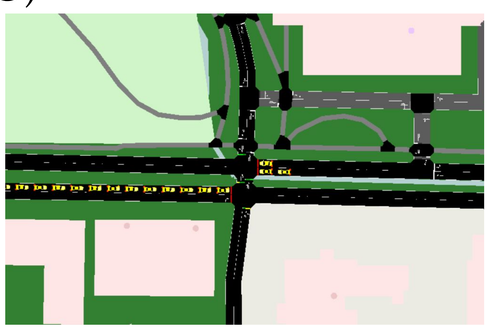

Figure 1. SUMO simulation, map rendition Iowa State University campus area.

OpenAirInterface (OAI)

- Open source software and hardware development for the core network (EPC), access network and user equipment (EUTRAN) of 3GPP cellular networks.

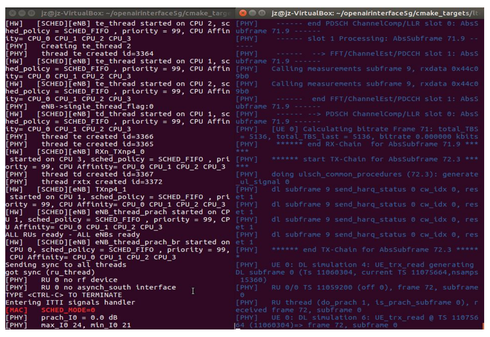

Figure 2. OAI simulation, One User Equipment and one Base Station.

GCS Algorithm

- Estimate the future positions of vehicles.
  - Using Adaptive Cruise Control and Unscented Kalman Filter.
- Interact with SUMO to get vehicle information.
- Use predicted vehicle information to find interference.

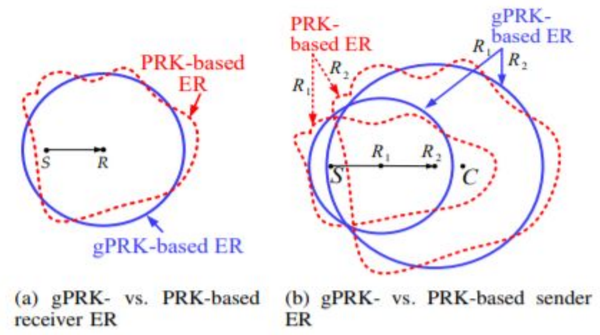

Figure 3: GCS Algorithm Cyber-Physical Scheduling for Predictable Reliability of Inter-Vehicle Communications Hongwei Zhang et. al.

Functional Requirements

- Interference Identification
  Mark nodes with the potential to interfere in communications and correctly schedule these nodes with respect to time and frequency such that they will not cause any interference.

Non-Functional Requirements

- Reliability
  Ratio of data packets sent to data packets successfully received with an expected rate as high as 90%.
- Latency
  Expect the latency to be at 4G capability.
- Concurrency
  Number of simultaneous non-interfering transmissions successfully transmitted in the same time slot.
- Throughput
  The rate of successful packets transmission with respect to time.

Design Analysis

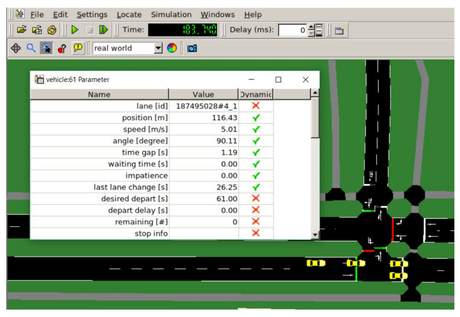

Figure 4: Iowa State Campus on Sumo and Data Extraction

- Iowa State Campus map on SUMO.
- Extracted vehicle data (speed, location, and acceleration)

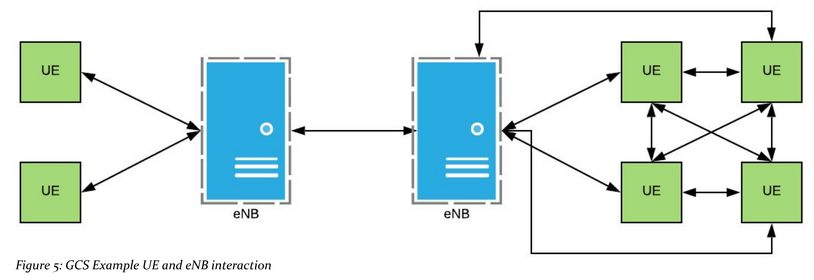

Figure 5: GCS Example UE and eNB interaction

- Example of the interaction between UEs and eNBs necessary for the GCS algorithm to function correctly.

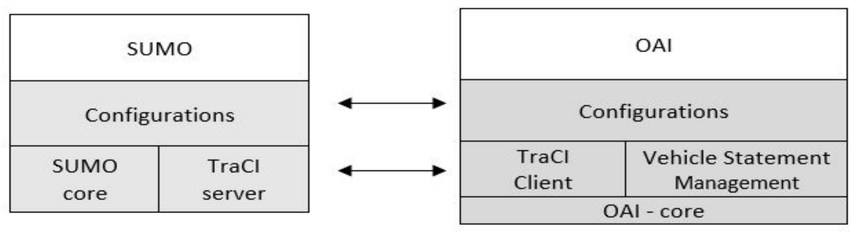

Figure 6: Schematic of SUMO and OAI Integration

- Integration of SUMO and OAI to simulate real world movement of smart vehicles.
- Client sub-system of OAI connects to the SUMO TraCI server to control simulation and retrieve vehicle information at each time step.

Testing

- Testing Environment

Type	OS	Kernel	OAI Version	SUMO Version
Linux Virtual Machine	Ubuntu 16.04.02	Low-Latency 4.8	1.0.0	0.25.0

Table 1: Testing Environment

- Testing Strategy

OAI Stress Testing	Number of UEs	2
	Number of eNBs	1
SUMO Simulation	Number of Vehicles	3600
	Testing Area	Iowa State Campus
GCS a_ACC	Tested without Kalman Filter. Outputs expected results as defined by the algorithm formulas	
GCS Approximation	Outputs similar latitude and longitude to future SUMO data	

Table 2: Testing Strategy

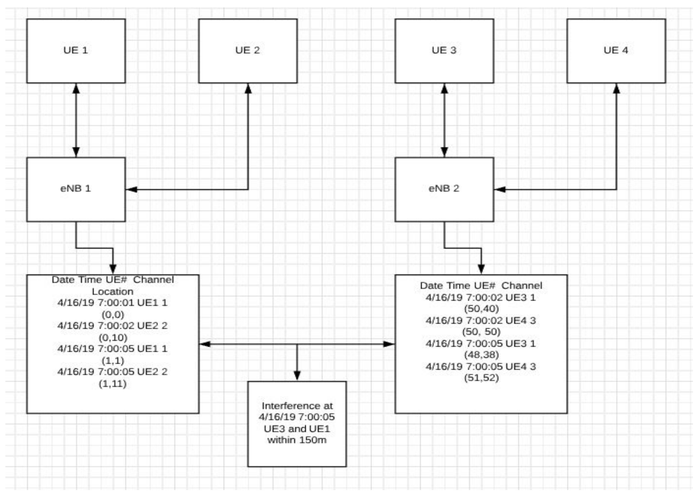

Figure 7: Example of Timestamp of events