



ERCIM "ALAIN BENSOUSSAN"
FELLOWSHIP PROGRAMME



Scientific Report

First name / Family name

Khaleel Husain

Nationality

Indian

Name of the *Host Organisation*

Fraunhofer Institute for Integrated Circuits IIS

First Name / family name
of the *Scientific Coordinator*

Dr. Stefan Eck

Period of the fellowship

01/11/2021 to 31/08/2022

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

The scientific activity at Fraunhofer Institute for Integrated Circuits IIS involved the investigation of the use of artificial intelligence algorithms for quality of service prediction to support 5G vehicular applications.

1. **Review Article Preparation:** Since the topic was relatively new, the aim was to gather as much literature regarding the topic as possible. In this regard, a review article on the topic was prepared. Specifically, the contents covered by the review article are as follows. Firstly, information on the existing review work relevant to the topic and their contributions were presented. Use cases defined by 5GAA and 5Gcroco are categorized into seven applications and all the use cases are then listed according to their categories. Furthermore, the service level requirement definitions of the use cases are also provided. One of the key features in 5G release 16 named "QoS Sustainability Analytics" that enables the QoS prediction is then explained. A brief introduction about commonly used machine learning and deep learning algorithms was then followed by a literature review of existing ML/DL algorithms utilized for the prediction of various QoS metrics (throughput, latency, data rate, etc.). Finally, various challenges and open issues encountered

at different steps of QoS prediction process are highlighted.

2. **Initial Network Simulator Setup and Scenario Setup:** The network simulator used to perform the simulations was the OMNeT++ network simulator. The initial setup included installation and compatibility checking of key packages such as INET, SIMU5G, and Veins. The simulation of urban mobility (SUMO) open source software was further integrated with OMNeT++ through the veins package and was utilized for map generation. Specifically, an urban Manhattan grid model with an area of 1299 m x 750 m was utilized for simulations. Other simulation parameters (transmission power, noise figure, antenna height, etc.) are set according to the 3GPP specification guidelines. As for the simulation scenario variation, several scenario variations were considered. Specifically, scenario variation included source transmission rate variation (1 Mbps, 2 Mbps, and 3 Mbps), channel model variation (urban macrocell, rural macrocell, and urban microcell), and variation in number of background vehicles (0, 10, 25 and 50). Also, each condition involves four different simulation runs that are obtained by changing the random seed and mobility patterns.

3. **Dataset Preparation:** Different features were recorded at the physical and application layers of the network simulator during simulations. Specifically, signal-to-interference-plus-noise ratio (SINR), other channel quality indicators, and serving cell ID were recorded at the physical layer while position coordinates, mobility information, and individual end-to-end packet delays were recorded at the application layer. Since the features were recorded at different layers, there were slight time differences that needed to be adjusted. To address this issue, data pre-processing was carried out to make the dataset ready to be used by prediction algorithms.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

The article entitled “A Survey on AI-based Predictive QoS for 5G V2X Communication: Use Cases, Techniques, Challenges and Open Issues” was prepared and submitted to *IEEE Transactions on Intelligent Vehicles* journal. We have received comments from the journal and currently, the manuscript is being revised for further submissions.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

Although, so far, there has been no conference submission, the plan is to extend collaboration with Fraunhofer IIS and attempt to submit for conference once the prediction results for the prepared datasets is ready.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

The Research Exchange Programme was carried out at *the institute for high performance computing and networking (ICAR-CNR)*, Napoli, Italy from 29th May, 2022 until 10th June, 2022. The collaboration was with Mr. Antonio Coronato’s team and information regarding AI algorithms that could be used for QoS prediction was discussed.