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A Developed Realistic Urban Road Traffic in Erbil City Using Bi-directionally Coupled Simulations

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ABSTRACT

Internet of Vehicles (IoV) is increasingly brought to light last years. It has an impact to improve the transportation system in smart cities. It is a big umbrella of VANET. IoV has contributed in changing the transportation system since the emergence of smart vehicles. Due to Internet service availability data can smoothly be shared among vehicles. There are three scenarios to utilize the IoV services; these are urban, rural and highway scenarios. One of the main challenges in IoVs is how to simulate Inter Vehicles Communication (IVC) in a realistic simulation. This paper will present a proposed realistic urban traffic simulation in Erbil city using bi-directionally coupled simulations. A real map of the city has been involved to simulate the traffic of vehicles; while the Simulation of Uraban MObility (SUMO) is used to simulate the road traffics, its output would be used as input to the VEhicle In Network Simulation (VEINS) framework to simulate the network under OMNeT++ environment. On the other hand, data is shared between vehicles and roadsides to test the simulation. The results of the simulation have been analyzed in the last stage.

1. INTRODUCTION

NNowadays Internet of Vehicles (IoV) has positively changed the transportation systems. Indeed, Intelligent vehicles that have CPU and transceiver device to communicate with each other are the main components of that system [1]. These intelligent vehicles help in providing safe and smart environment. IoV, is subclass of Internet of Things (IoT) by which transportation system will be more intelligent. IoVs and VANETs are associated terms. While VANETs are used in numerous applications such as automobiles speed monitoring, traffic jam avoidance, best route finding, and outside to vehicles communication [2]. VANET is subclass of IoV, where VANET is local network while vehicles in IoV need to global ID. Internet services might be required in IoV[3]. A large number of vehicles are included in IoVs and some roadside stations that could be deployed in an ad hoc or cellular mode. There are three communication scenarios in IoVs. These are Vehicles to vehicles, vehicles to roadsides and roadsides to roadsides [4].

However, vehicles are severely constrained in terms of mobility, direction and dynamic topology. Therefore, realistic simulation needs to be considered to reduce the non-realism. Numerous methods have been proposed to achieve some of those goals through different strategies. Each strategy can be used to achieve some efficiencies depending on the application for which the VANET is designed. The big challenge is how to simulate realistic vehicular networks because of their constrains [5]. In this event, virtual reality can also be used in increasing the realism of the simulations [6]. Several simulations are available to simulate IoVs or VANETs. Nonetheless, the realistic is not considered in all. This paper will focus on developing urban scenario for Erbil city. This scenario has been proposed, built, promoted, analyzed and discussed in three sequenced stages. The First stage is to prepare a real map which is downloaded from OpenStreetMap website. The second stage will be assigned to design a realistic traffic simulation using SUM0. The last stage is related to link SUMO with VEINS under OMNeT++ environment for building the network. The rest structure of this paper is divided into sixth sections in addition to the 1st section. The second section is to mention the related works that have been done so far. The third section is to discuss the VANET simulations. The proposed system will be investigated in the fourth section. The fifth section will be about discussing the results. Conclusion will be the last section.

2. Related Works

Several mobility models are available to model traffic of vehicles. However, not all of these models take in account specific characteristics of traffic urban scenario. As a result the simulation could be unrealistic [7]. Some of them are unidirectional simulations and others are bidirectional simulations. The latter means that there are two simulations are coupled to achieve the realism. Many unidirectional simulators have been designed for vehicular network [8]. NS2 is used to simulate network of vehicles [9]. However traffic simulation can be achieved through another simulation. GloMoSim is another simulator that has ability to simulate the mobility[10]. It is designed to simulate wired and wireless networks. VanetMobSim is widely used to simulate vehicular networks[11]. It represents an extension of the CanuMobiSim. NetLogo can be also used to simulate the behavior of vehicles [12]. Authors in [13] suggest a road model approach using NetLogo.

On the other hand, bi-directionally coupled simulations have been also proposed to combine two simulations. First one is to simulate road traffic whereas another one is to simulate the network. In [14], SUMO is suggested as a traffic simulation. It is coupled with NS-3 to simulate the network. In [15], authors simulate the road traffic using VanetMobSim simulation and NS-2 as a network simulation. VISSIM is derived from the German sentence "Verkehr In Städten - SIMulationsmodell" (that means "Traffic in cities - simulation model"). It is coupled with NS-2 as a realistic simulation for VANETs [16].

2.1 VANET Simulation

Several tools of Traffic Flow Simulation (TFS) are available. SUMO, VISSIM, Paramics and AIMSUM are examples of road traffic simulations. However, no one can simulate the communication of VANETs. Similarly, the tools of Communication Network Simulation (CNS) are also available (eg. NS2, OMNeT++, Qualnet etc), but they are not able to reflect the interactions between vehicles behaviors and vehicles communication [16]. So there is a need to interactively link TFS with CNS. There are two ways to achieve this task. The first approach is to feed the output of road traffic simulation to the network simulation; while the second approach is to operate both simulations in parallel. The latter is seemed to be more realistic due to the live interactions.

2.1.1 Micro Simulations

Modeling the mobility of vehicles represents a big challenge. Estimating or obtaining a model for the real movement trace of vehicles is not a simple process. Even though it is possible to obtain an approximation to this real movement trace from the real world, it is still not possible to simulate all other scenarios of VANETs. Changing one parameter and keeping others may be not reasonable for all tasks. In this context, researchers have paid their attention to design realistic road traffic simulations that take in account vehicles behaviors [7].

The road traffic simulations can be classified into three classes according to the granularity in which the road traffic will be simulated. These classes are macroscopic, mesoscopic and microscopic [7]. The first two classes have not an offer to simulate the single vehicle behavior and their interactions with other vehicles, whereas the microscopic model can do it. SUMO is microscopic model which is widely used in road traffic simulations. It can send sequence of commands and vehicles' positions to OMNET++ module. The latter can easily react to create new nodes, to delete nodes that reached to the destinations and to move nodes depending on their behaviors in SUMO.

2.1.2 Network Simulations

It has been argued that simulating the network configurations is recommended before nodes are deployed in real world. Indeed, due to the cost and danger environments it is feasible to use

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simulations. Besides, evaluating the behavior of new protocols before real deployment could be more feasible. Several network simulations are available for simulating the network communications. Mostly network protocols are tested using discrete event simulations. Some of them are open source such as NS2, OMNET++, Jist etc., whole others are commercial such as OPNET. This project will use OMNET++ and its VEINS framework.

2.1.3 Bi-directionally Coupled Simulations

For any event in VANET, for example waiting time of vehicles, accident information or obstacle information, needs to make certain interaction between road traffic simulation and network simulation. For this reason bi-directionally coupled simulations have been developed. Two tasks can run concurrently. One is related to the road traffic simulation, where its output will be used as input for the network simulation. The latter will create a node corresponding to each vehicle in road traffic simulation. Both simulations exchange their information such as speed or position of vehicles.

3. Methodology & Implementation

This section will describe the implementation of the realistic simulation. The simulation will be done in two phases. The first phase is to simulate the road traffic in Erbil city (The capital of Iraq's Kurdistan) using SUMO simulator. The second phase is to use the network simulation VEINS framework, which is an OMNET++ framework. Both simulators will be operated in parallel. The proposed bi-directional coupled simulation system in this study is illustrated in figure (1).

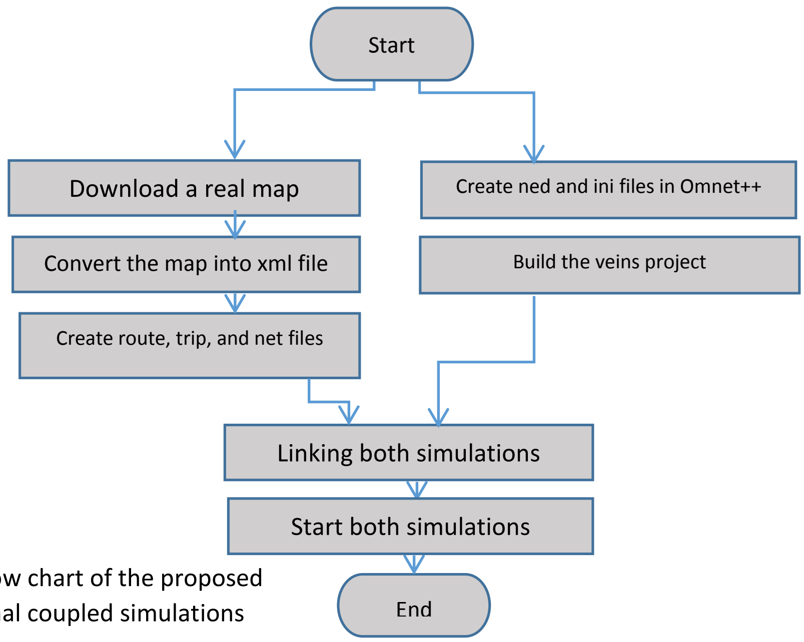

Figure 1 Flow chart of the proposed bi-directional coupled simulations

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3.1 Importing the Real Map

Even though it is possible to create network files manually, these file could be unrealistic. So obtaining realistic simulation requires a real map. The openstreetmap web site provides such this real map as .osm file [17]. This map is converted into net.xml file using SUMO using netconvert command.. Figure (2) shows the Erbil city map in (a) and the network file in (b).

a. Erbil city map .osm file

b. Network map net.xml file

Figure 2 Erbil city map

The network file defines all edges that link the start points and the end points of roads.

3.2 Road traffic Simulation (SUMO)

SUMO is an open source traffic simulator. Microscopic and mobility model are used in SUMO. It has been developed by the German Aerospace Center (Institute of Transportation Systems) [7]. Each vehicle has a unique path defining its source and its destination. There are four main files should be created in SUMO. These are network file to define the road network, trip file to define the start and end point for each vehicle, route file to define vehicles and their routes, and configuration file to control all the mentioned previously files. As the network file is mentioned in the previous section, the rest of files will be discussed in the next sections.

- **Creating trip file:** As it is discussed previously the network file defines all edges in the network. However, vehicles' paths are still not defined. For this reason trip file is responsible to define a path for each vehicle. As it is seen trip file has parameters like route id, departure vehicle id, and starting and ending lane.
- **Creating route file:** The route file defines the information of the route a vehicle would travel through. Since each vehicle should have the route and it may have many lanes, it is not possible to define this file manually. So SUMO provides a facility to generate this file from the network file and trip file which are defined previously.
- **Creating configuration file:** Creating a configuration file is a necessary step to link all the created files.

3.3 Network Simulation (VEINS)

There are many network available simulators. Some of them are open source whereas others are commercial. Due to extensive cost of testing the network in real world, network simulation is used. Most of the previous projects use the open source simulator OMNET++ and its framework VEINS to simulate the vehicles network. It contains two main types of files. They are .ned files and .ini file.

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The former is to describe the network whereas the latter is to include the configuration of the network. The output of SUMO will be used as input to VEINS in parallel [18].

3.4 Linking SUMO and VEINS

SUMO contains Traffic Control Inteface (TraCI) module for OMNET++. This module contains a small daemon, sumo-lunched, which makes running of coupled simulations easier and simpler. The sumo-lunched daemon is listening for each incoming request. For this process TCP connection is needed. In this connection SUMO will operate as server and OMNET as client. To achieve such that connection opening port is also required.

At this stage, both simulators are ready to start in parallel as illustrated in figure (3).

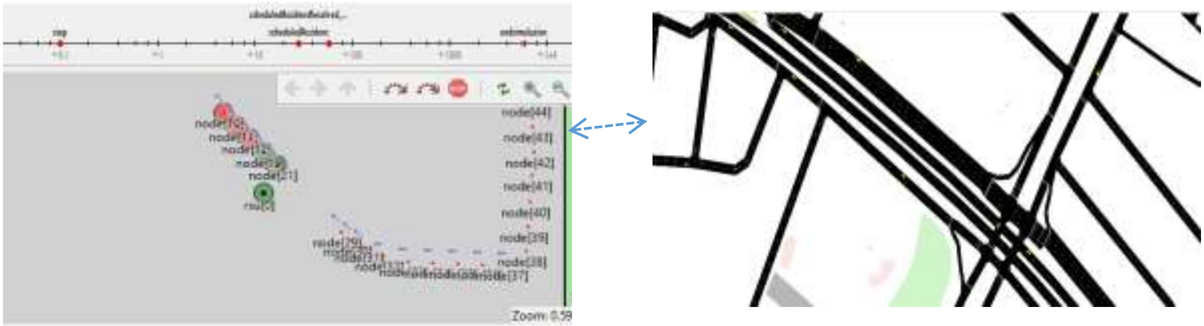

Figure 3 SUMO and VEINS in parallel

4. Results and Analysis

1000 vehicles are used in the road traffic simulation (SUMO). However, 200 vehicles along 4 km road are traced in the network simulation (VEINS). 1026.4 s is elapsed time for the network simulation. In VEINS, 40448 events have occurred ranging from packet sending, waiting time and changing positions. Figures (4 &5) show the start and end time for each vehicle.

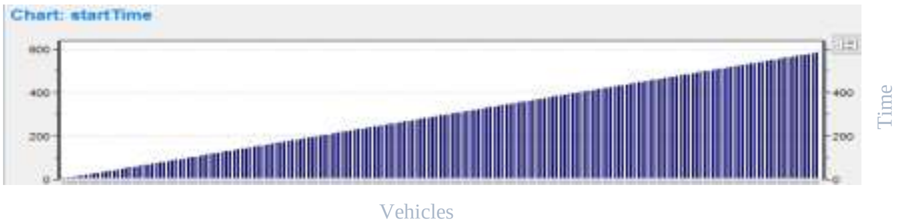

Figure 4 Start time of vehicles

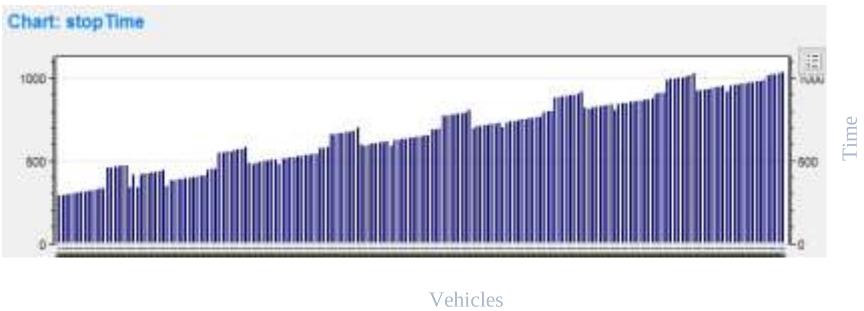

Figure 5 end time of vehicles

Busy time for each vehicle is collected and shown in figure (6).

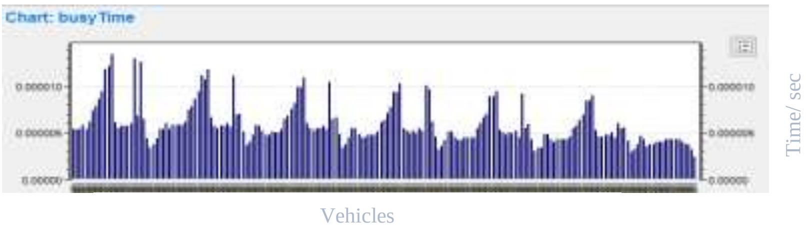

Figure 6 busy time of vehicles

Each vehicle changes its behavior according to the behavior of others and traffic conditions. So each vehicle may change its speed. Where Max speed is setup to 60km/h in this project.

As it could happen in any network, some packets may be lost. If there is one packet sent by every vehicle, there will be 199 packets should be received by each vehicle. According to these results, decreasing the lost packets is recommended to increase the reliability of the system. So figure (7) shows the number of lost packets in the network.

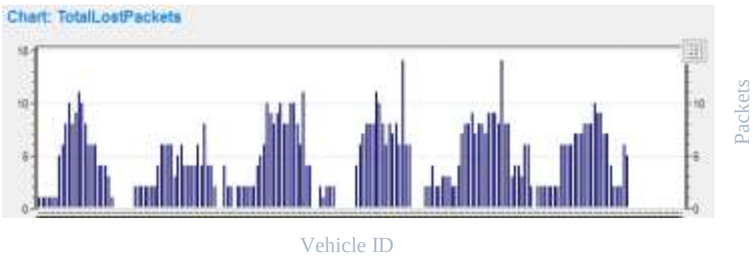

Figure 7 lost packets of vehicles

5. Conclusion

Internet of vehicles IoVs are networks of distributed autonomous vehicles and roadside stations that can cooperate together for sharing physical or traffic conditions. It has been regarded that the transportation systems have a significant impact in many countries. On the other side, using advance technology to improve intelligent traffic has been available. This encourages researchers to pay their attention to develop the transportation systems. As long as simulation of road traffic system is a considerable issue due to high mobility that characterizes this system. So there is a need to realistic simulation to achieve some realism. This paper presents an example of realistic simulation to investigate the road traffic in Erbil city by combining the road traffic simulator (SUMO) and the network simulator (VEINS). The behavior of vehicles can be enhanced according to some results of bi-directionally coupled simulations. This project will also contribute in investigating the important cases and challenges of the transportation system. It will also contribute in decreasing the cost and the time of studying such those cases. In fact, the real world experiments could be risky, costly and time consuming. Moreover, this project may help in developing Erbil city. Extending roads and predicting challenges can be investigated before the costly real world experiments. Besides, in term of future work, the road traffic simulations can be brought to life by using Virtual reality tools. These tools may give more realism to the simulations.

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