المؤتمر الوطني الخامس لكليات الحاسب الآلي بالجامعات السعودية
The Fifth National Conference of Saudi Computers Colleges 2022

21-22 December 2022

Wireless Network Infrastructure for Electric Vehicles Communications: Khobar City as a Case Study

Hassan Ibrahim Mashbi
KFUPM Electrical Engineering Department

Uthman Baroudi
Interdisciplinary Research Center of Smart Mobility and Logistics, Computer Engineering Department

Abstract

As moving to the EVs is essential due to the environmental cues, we need to solve the problems and undertake the challenges of the EVs to expedite this move. One of these challenges is the long recharging time compared to the traditional refueling process and the consequence of this issue is overcrowding in charging stations. To solve this problem, a charging management system is needed. However, an effective charging management system requires efficient communication networks that facilitate the exchange of information between the EVs, charging stations and the management server. In this work, we study the feasibility of exchanging EV's data using V2V and V2I communications infrastructure considering Al-Khobar city in Saudi Arabia as a case study. SUMO GUI and OMNET++ simulators have been used to set up the environment. The simulation results show that the minimum data throughput requirements are 0.83, 1.11, and 59.19 Bytes for V2V, V2I, and I2I respectively. This paper has contributed to finding the minimum requirement of the data throughputs of the communication links in vehicular communication.

Introduction

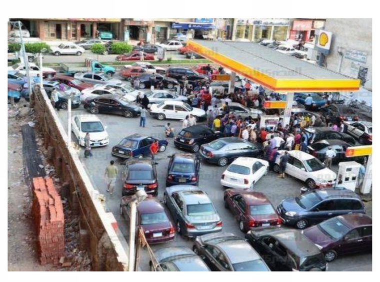
As the global electric vehicles market is expected to reach a value of $823.75 billion in 2030 from just $163.01 billion in 2020, Saudi Arabia is investing heavily in this industry aiming to lead the EV market in the middle east region. It announced that Lucid Motors has started to build the first EV plant in KAEC with plans for 2 more. By 2030, Saudi Arabia aims for at least 30% of the vehicles in its capital to be electric vehicles.

However, EVs have two main drawbacks that limit their spared which are:

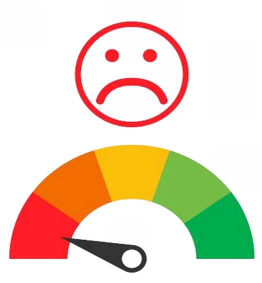
Low Battery Capacities

Long Charging Time

These EV challenges will cause two significant problems which are:

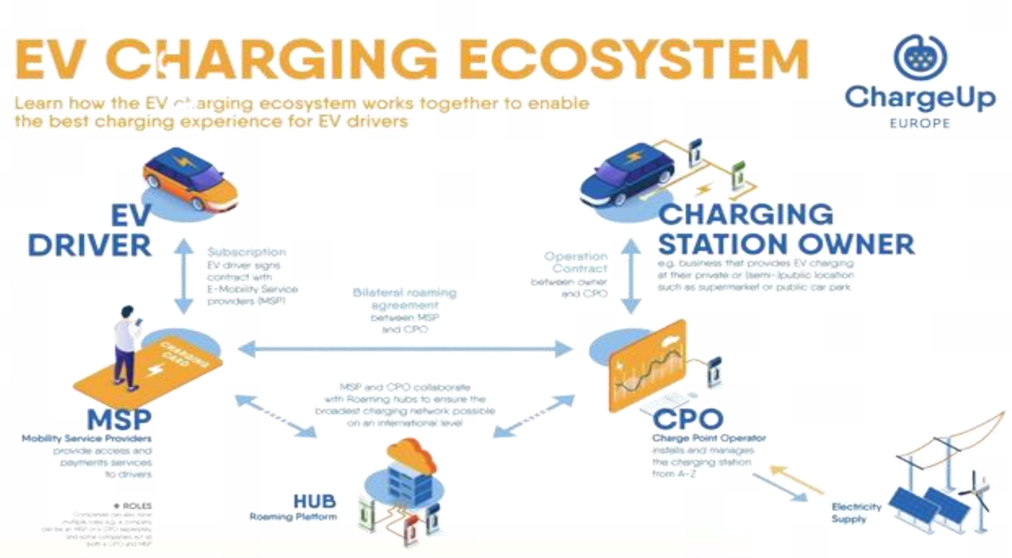


Overcrowding In Charging Stations



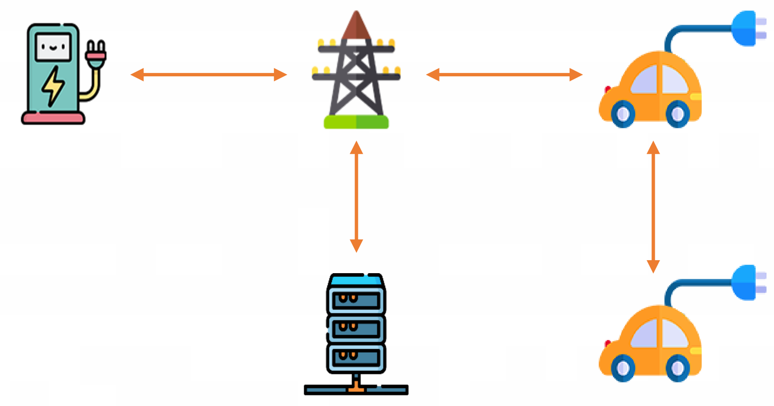
Low Quality Of Service For EV Drivers

The solution for these problems will be a charging coordination system that manages the charging process across the network. However, effective systems need to have a communication network that enables all the components of the system to communicate with each other and share data. A heterogeneous network for vehicular communications and charging coordination systems are needed. The problem is that there are many communication technologies that can be used in the communication network.



Objectives and Proposed Scenario

Investigating the data exchange specifications between the EVs, the infrastructure, and servers, for some scenarios proposed in Khobar city to find the required data thruputs for the communication links which will facilitate the choice of the appropriate communication technologies.

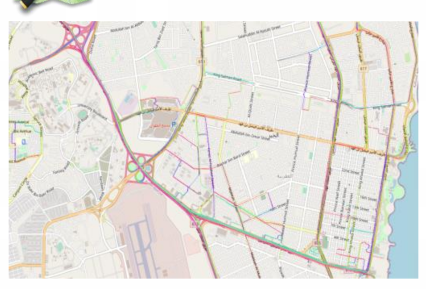


The proposed scenario is to allow an EV to broadcast a message about its state of charge (SoC) when it needs to charge or an accident alert message to other vehicles when it makes an accident. The message will be received by the nearby vehicles and RSUs. RSU will communicate with the aggregator to compute data that is received from EVs, Charging stations (CSs), and the electric grid by the cellular networks and the RSUs. The aggregator collects and analyzes the data and uses it to coordinate the charging process across the network. Once a decision is made, the coordinator conveys these decisions to the corresponding EVs.

Simulation Setup

For the SUMO GUI simulator, **part of Khobar city** was chosen with a total area of **100 Km^2**. Random traffic was generated with different numbers of vehicles to study the communication network in various scenarios which are **250, 300, and 350 vehicles** for the normal hours and **750, 900, and 1050 vehicles** for the rush hour across the network during a period of one hour. For OMNET++, the radio technology that was used is **802.11p** with its default parameters and antennas.**18 RSUs** were distributed across the highways with a **coverage area of 1km**. Vehicles were set to **broadcast SoC packets or Accident packets** with **a size of 250 Bytes**. RSUs were responsible to redirect the packets to the server. The soc packets are generated parodically every **15 secs** and the accident packets every 8 mins and those packets were sent by vehicles that are in random locations in the network.

Open Street Map

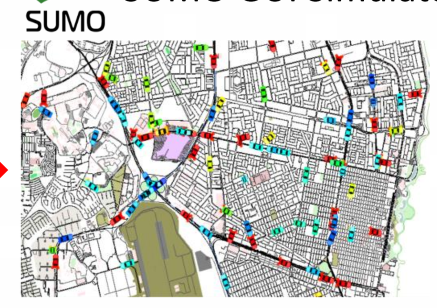


Part of Khobar city with an area equals 100 Km^2

JAVA OSM Editor

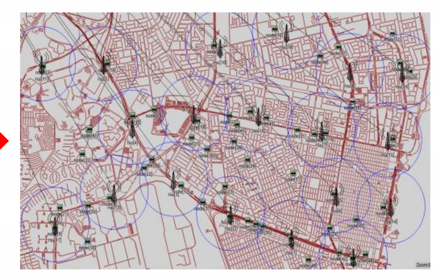
The roads network of Khobar city in JAVA OSM editor

SUMO GUI Simulator



The roads network of Khobar city in SUMO GUI simulator

OMNET++ Simulator



The wireless network infrastructure of Khobar city in OMNET++

Used Frameworks In OMNET++ :

veins

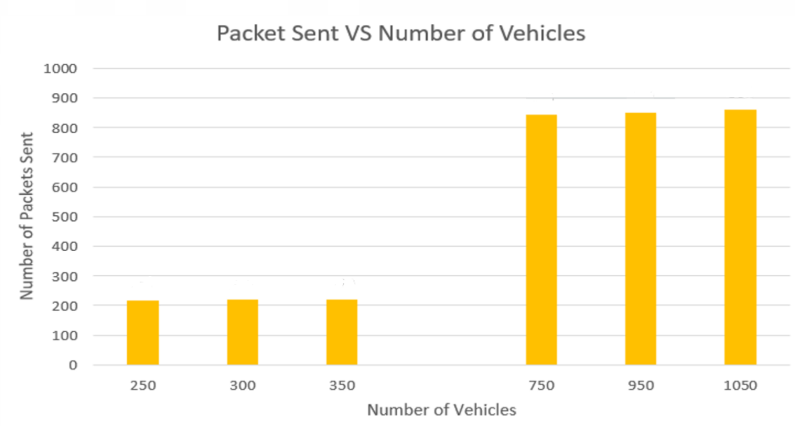
SIMU5G

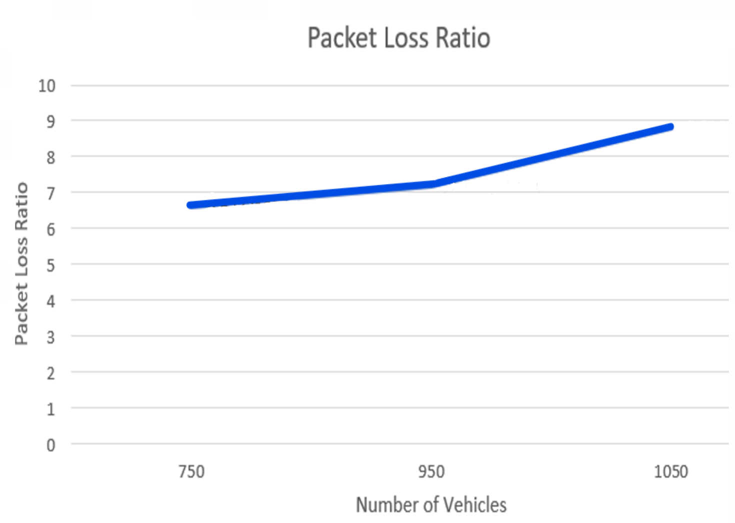
INET FRAMEWORK

Results and Discussion

In order to evaluate the system performance, we have used two metrics: data throughput and packet loss ratio. The data throughput is the amount of successfully transformed data between two nodes during a period of time which is measured in bytes per second. The packet loss ratio is the ratio of the lost packets (amount of unsuccessful transmitted data) to the total number of packets sent (total amount of transmitted data).

It has been found that the maximum number of packets in the network was **862** with an amount of **215500 Bytes** in one hour. Furthermore, as the number of vehicles in the network increases the packet loss ratio increases. the minimum packet loss ratio was equal to **5.07% for the 250** vehicles scenario and it reached **8.82% for the 1050** vehicles scenario. This is considered a vital issue especially for vehicular communications applications.





Furthermore, it has been found that the maximum number of packets received by the RSUs is 6 and 16 for the normal and the dense scenarios respectively and the minimum is 1 and 5. This means that each RSU will receive a number of packets that is between 1 and 16 for all proposed scenarios. As a result, it will receive data from **250 bytes up to 4000 Bytes per hour**. Therefore, it is required for the wireless communication technology in the vehicular communications that is used in the RSUs to provide minimum data throughput that is equal to 4000 Bytes per hour which is about **1.11 Bytes per second**.

Furthermore, it has been found that the maximum number of packets received by any node is 5 and 12 for the normal and the dense scenarios respectively and the minimum is 0 for all scenarios. This means that, each node will receive a maximum number of packets that is equal to 12 for all proposed scenarios. As a result, it will receive data of **3000 Bytes per hour**. Therefore, it is required for the wireless communication technology in vehicular communications that is used in vehicles to provide minimum data throughput that is equal to 3000 Bytes per hour which is about **0.83 Bytes per second**.

The server is supposed to receive an average data throughput of **54667 Bytes per hour** in the normal hours which is equal to **15.185 Bytes per second** and **213083 Bytes per hour** in the rush hours which is equal to **59.19 Bytes per second**. Finally, the research has proven that the data throughput required for the communication links is not an issue, however, the packet loss ratio is rising a real issue.