Demonstration of a Vehicle-to-Infrastructure (V2I) Communication Network featuring Heterogeneous Sensors and Delay Tolerant Network Capabilities*

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Abstract. The development of applications based over vehicular networks, such as road safety, environmental information etc. require a complete testbed platform for research and evaluation. Such a platform will be provided by NITOS[1] testbed, that will include nodes mounted on cars and fixed nodes of the testbed operating as road side units (RSU). Besides the wireless infrastructure, there will be several sensors regarding the environmental conditions and the vehicle. These will gather measurements about air conditions and GPS data such as position and speed and will be collected in a central database, where the experimenter will be able to depict them in a Google map.

Key words: Vehicular Network, Delay Tolerant Network, 802.11p, Sensors, Testbed, NITOS, NITlab, Wireless

1 Introduction

Todays wireless communications testbeds, tend to expand their infrastructure to dynamic deployments, such as mobile and vehicular environments. In the presence of this scope, NITOS is being extended to incorporate nodes mounted on vehicles. Furthermore, we enhance the nodes' capabilities with a sensors framework, based on microcontroller boards. Testbed's users will be able to collect measurements regarding the environmental conditions, the vehicle's trajectory and the vehicle's internal status (e.g. fuel consumption, velocity etc.). These measurements include temperature, humidity and CO2 indications. Measurement points will be localized according to the GPS coordinates and they will consist of data, concerning the vehicle's speed, elevation and position.

The methodology that will be used to collect sensors measurements, will be incorporated into an OML framework[2], which is currently available in NITOS testbed to the experimenters, as a framework that collects measurements. The data collected from the sensors will be initially stored locally on the car-mounted node and afterwards, it will be uploaded to the testbed's central database through an RSU.

The above implies a delay tolerant network (DTN), which is achieved through an OML module, named OML-Proxy-Server[3] and acts as local buffer before the measurements are being sent to the central OML server of the testbed.

Finally the experimenter will be able to retrieve the database file during the experiment, so he can evaluate the received measurements as soon as they are collected and injected into the database. The network scheme is shown in Figure 1.

2 Network Components

The main components of the vehicular network are listed below and contain the hardware parts, which are the sensors and the nodes. However, besides the necessary hardware, a bunch of software programs are used to collect measurements using OML. Additionally a web interface will be available to the experimenter to evaluate the car's route and measurements.

2.1 Communication

The connection between the car mounted node and the RSU is achieved through a WiFi interface. The communication protocol used for this set up is the 802.11p, which implies the following modifications to the well known 802.11a,b/g protocol.

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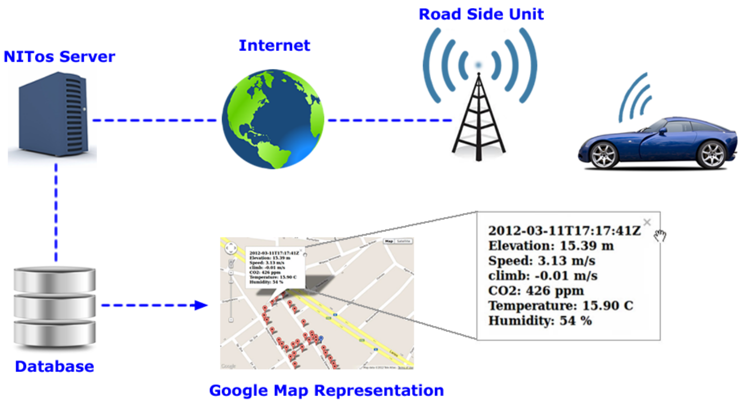


Fig. 1. The big picture.

– Operation in the band of 5.9 GHz
– 10 MHz channel bandwidth instead of 20 MHz that is used in 802.11a,b/g

We meet the above requirements by using Mikrotik R52 wireless cards, which feature atheros chipsets that are capable of transmitting up to 6.1 GHz with a step size of 5MHz and configurable width channel. The above requirements wouldn't have been feasible without the presence of open source drivers just as the ath5k[4] in our case.

The RSU will be a static node of NITOS testbed. However, any access point that is capable of sharing internet access, can play the role of an RSU. Nevertheless, the RSU will be only responsible to forward the received measurements, from the car to the testbed's server, where the data will be stored in a sqlite3[5] database. The last one implies that the car node will send the measurements through internet infrastructure to NITOS server.

2.2 Sensors

Regarding the sensors infrastructure, we exploit Arduino Uno[6] potential, which is a programmable micro-controller board and let us feature the car's node with CO2 2(a), temperature and humidity 2(b) sensors. Additional, a GPS module is connected to the car node and enables the following measurements:

1. Current Latitude - Longitude
2. Altitude
3. Speed
4. Vertical speed
5. Direction

2.3 OML

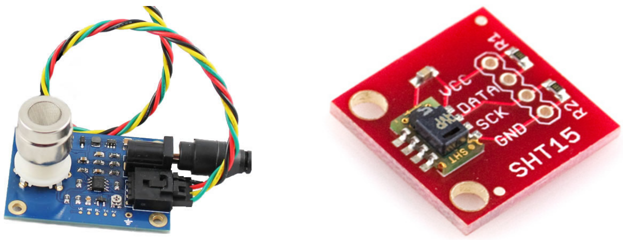
As mentioned earlier, a current framework called OML will be exploited for collecting the measurements from the sensors to a central database in testbed's server. An OML application has been developed for each of the three different types of sensors. More specifically, on the car mounted node an instance of oml-proxy-server will be serving as an intermediate buffer between the OML applications and the central OML-Server. Whenever there is connectivity between the car mounted node and the RSU, the proxy server will forward all the measurements collected so far, to the main OML server. When connectivity fades away, the measurements will be cached locally in proxy's buffers.

2.4 Web interface

Finally, for demonstration purposes a web interface based on Google maps API[8] has been developed. A ruby script on server side produces dynamically an XML file, with the measurements that sqlite3 file contains up to this point. JavaScript language is used to parse the XML file, in order to create several markers, which are depicting the measurements collected from the car yet. By clicking on a marker, further information is revealed regarding sensors' measurements at this point.

3 Conclusions and Future Work

In this demo, a vehicular network with multiple sensors and DTN capability is presented as part of the NITOS testbed. Temperature, humidity, CO2 and GPS measurements are collected through an OML framework and stored in a central database. During the experiment a dynamic Google map is created, depicting all the available data contained in the database so far. For future work, we plan to control the network's resources with the OMF[7] framework, which is featured on NITOS testbed for conducting experiments. Furthermore we will investigate a more elegant and sophisticated way to provide the Google map directly on experimenter's browser without the necessity of the server's browser.



(a) CO2 (b) Temperature and humidity

Fig. 2. Sensors

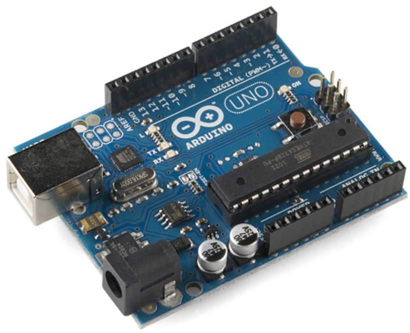


Fig. 3. Arduino Uno board

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