# PROTOTYPING S.M.A.R.T. VEHICLE NETWORKING PROTOCOL

**FIRST REVIEW REPORT**

**B.Tech Mechanical Engineering**

*by*

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**[ 14BME0133 ]**

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| **Comments of Reviewer(s)** | |
| **Name and Signature of the Reviewer** | |

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## Abstract.

A novel approach to tackle various inefficiencies of the modern day Vehicle-to-Vehicle communication technology, specifically the modern-day implementation using the Automotive-Grade Linux. The paper begins with sampling the actual hardware and software deployed by the leading manufacturers and industry, highlighting use-cases like the Toyota Prius, Tesla Model S, Reva, etc, employing an ECU approach, and concludes with delivering optimizational remedies.

**Keywords:**

Automotive Communication Networks;

Decentralized Communications;

In-Vehicle Networking;

Hybrid Platooning;

S.M.A.R.T. Automobile Clustering

# CHAPTER –I

# INTRODUCTION & LITERATURE REVIEW

## Introduction

Nowadays , the culture of hybrid, all-electronic S.M.A.R.T. and connected autonomous vehicles is on an ever-peaking demand-curve. This also means an extension of the vehicle-security exploitaions increment we hear about through daily media, about theft, hijacking or simply vandallism. Such an overwhelming need for an automobiles' security and longevity can only be met by the far-reaching, impactful and tailored technology, suited for the respective scenario. Realizing such endeavours could be only possible owing to the O.S.S. collective, and thence garnered resources and source codes.

On account of solving this research conquest, such an approach has been applied, such that in order to be able to cater the needs of almost everyone with a direct contact with a vehicle, or any automobile, public, personal or even private can be realized at the minimal costs of upgradation.

We, through the medium of this project, would aspire to address such vehicle optimization adversing security related tradeoffs, and conclusively suggest remedies.

## Literature Review

A wide variety of scholarly articles have been referrenced to survey the current as well as the previously outdated inter and intra vehicular and network communication and signalling technology. In order to maintain standard universality, all implementations are based using linux kernel 4.1.

### List of Sampled Technology Protocols

- 1: Contoller Area Network (C.A.N.)
- 2: MAC layer Addressing
- 3: IEEE 802.11 (b.g.n/a/c)

### List of Sampled Technology Hardware

- 1: Adafruit's Arduino UNO
- 2: Raspberry Pi's 'Model B+'
- 3: Reannaisance's PorterBoard 2
- 4: Orange Pi's IoT+ Embedded
- 5: Stock Daragonboard410c (QEMU Emulated-VM)

### List of Sampled Software Releases

- 1: Automotive Grade Linux (A.G.L., Linux Kernel 3.9)
- 2: Tyzen Operating System (UNIX Kernel 4.11)
- 3: Qt ( For the Graphical Release, Applications)
- 4: Ubuntu IoT Core (+2.3.26)

### List of Sampled Libraries and Modules:

- 1: AGL
    - 1.1: agl-demo
    - 1.2: agl-appfw-smack
    - 1.3: agl-devel
    - 1.4: agl-netboot
- 2: UNIX
    - 2.1: gawk
    - 2.2: wget
    - 2.3: git-core
    - 2.4: diffstat
    - 2.5: texinfo

    - 2.6: chrpath
    - 2.7: cpip
    - 2.8: socat
- 3: libdll
    - 3.1: libsdl.2-dev
    - 3.2: gcc-multilib
    - 3.3: libhvac
    - 3.4 libssh-dev

## Knowledge gained from the literature:

### List of Sampled Authoring Softwares:

- 1: Reading/Writing a PCB (.gerber format)
- 2: C, PyPi (Writing Functional Code Snippets)
- 3: make, build (C-lang)
- 4: bash (UNIX Scripting)

## Gaps in the Literature

### Brief history of Communication Tehnology used in vehicles:

Most of the projects in IV, V2V and V2I use the standard IEEE 802.11 protocol for communication. But also GSM, UMTS, GPRS protocols are used in some of these projects. Generally WSNs (Wireless Sensor Networks) are deployed uneffectively and thus "platoonong" is inefficient, since the convuluted network is not 'big' enough in terms of the 'no. of nodes' present in the V2V (Vehicle-to-Vehicle) or V2I(Vehicle-to-Infrastructure) network.

Traditionally, IEE standards like the Basic layers have been employed tor the information transmission. Routing inside a low power area network (LoWPAN) might be considered a challenge, as the RPL has to work over lossy radio links, with battery-powered nodes, multihop mesh topologies and frecuent topology changes.

To give a solution several working groups are giving support to the RFC's for this protocol. One of them is the routing over lowpan and lossy networks (ROLL) who is in charge of routing tasks. Meanwhile the "6LoWPAN" is trying to bring the new IPv6 addressing system to these resource-constrained devices. We try to predict the points of failure in such technology from a penetration and security testing point of view and conlclude with instantly applicable remedies via pull requests to the FOSS code repositories.

## Existing  Generic Technologies:

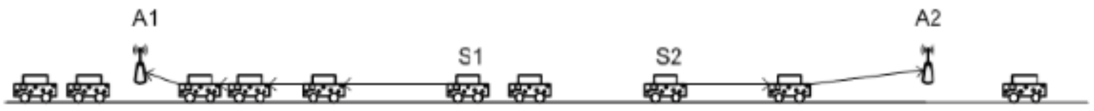
### MAC/PHY layer based communication:

Radio waves and infrared have been studied to give medium support to IVCs. The radio waves include micro, millimeter and VHF waves. The communication with millimeter waves and infrared are usually directional, while VHF is used for broadcast. The typical radio bandwidth used in IVC is 5.9 GHz in US, 5.8 GHz in Japan and 5.8 GHz in Europe. The FleetNet project chose ULTRA TDD due to the availability of the unlicensed frequency band 2010-2020 MHz in Europe. Most projects, however, have adopted the use of infrared (CarTALK, COOPER, JSK, PATH…).

There are two approaches in developing MAC for IVCs. One is using IEEE 802.11 as a radio interface, while the other consists on extended 3G technology, such as CDMA for distributed access.

Both of them have to be modified and adapted to provide an efficient solution for IVCs.

The advantage of using IEEE 802.11 is the inherited support for distributed coordination in ad hoc mode. On the other hand, 3G extensions present high granularity for data transmission.



(Dia. 1.4.1: Vehicle to Infrastructure Communication, schemaic)

## 1.5 Objectives:

- To come up with a neat-networking protocol schema to address inefficient hop-on /ad-hoc communication propogation delays, possibly trying to implement in a decentralized contract.
- To be able to successfully reproduce the hardware based real-time implementation of the AGL release on an ARM based development board.
- To provide an future roadmap for Non-hybrid cum Hybrid on-road network integration in a cheap (feasible), environment-friendly (sustainanble) and energy-efficient (if not, utilitarian) by means of a snap-on dashboard powered by a simple smartphones' sensors, transmitters and transduecers.
- To demonstrate a successful implementation of AGL (improvised fork) during the final review.

### Design Elements included :

| | |
|---|---|
| Engineering Standards* | *Prototype and Fabrication* |
| Design Analysis* | *Experimentation* |
| Modelling and Simulation | *Software Development* |

### Realistic Constraints to be addressed :

| | |
|---|---|
| Economic | *Ethical* |
| Environmental | *Health and Safety* |
| Social | *Manufacturability* |
| Political | *Sustainability* |

# CHAPTER –II

# METHODOLOGY AND EXPERIMENTAL PROCEDURE

## 2.1 Methodology

The AGL is first ported to a VM with a usual DebianOS base kernel.

Next, the images are downloaded and flshed onto a SDHCeMMC Memory Card.

Third, the auxiliary input and output peripherals are serially connected to the used Raspberry Pi, or UNO module.

## 2.2 Experimental Procedure

Hardware Requirements

- Dragonboard410c
- 96Boards Compliant Power Supply
- Linksprite 96Boards Touch Screen
- Sensors Mezzanine
- Audio Mezzanine(Required if using External Arduino)
- Arduino Uno(Optional)
- DC motor with Propellers
- L298 Motor Driver
- 5mm LED's

- 330 ohm resistors
- Connecting wires

## Arduino

Controlling Fan Speed and LED intensity are handled by the Arduino. Sensors Mezzanine has an ATMega328 microcontroller comaptible with Arduino Uno. We use that or any external Arduino Uno for PWM control.

In case of using Sensors Mezzanine, the sketch can be uploaded by using Dragonboard410c itself..

If using Sensors Mezzanine, please follow the below steps on Dragonboard410c running Debian otherwise use Arduino IDE on the host system for programming.

```
$ cd ~/Documents

$ git clone https://github.com/96boards-projects/agl-demo.git

$ cd agl-demo/arduino/hvac
```

Now open the hvac.ino using Arduino IDE and flash it onto the Sensors Mezzanine or Arduino Uno.

## Dragonboard410c

Execution environment: Host PC

Software Dependencies:

```
$ sudo apt-get install gawk wget git-core diffstat unzip texinfo gcc-multilib \

    build-essential chrpath socat libsdl1.2-dev xterm cpio curl
```

## Downloading AGL Source Code

AGL uses repo tool for maintaining repositories. We need to download the source on the host machine and cross compile it for Dragonboard410c.

```
$ export AGL_TOP=$HOME/workspace_agl

$ mkdir -p $AGL_TOP
$ mkdir -p ~/bin

$ export PATH=~/bin:$PATH

$ curl https://storage.googleapis.com/git-repo-downloads/repo > ~/bin/repo

$ chmod a+x ~/bin/repo
```

Next, the stable branch of AGL.

```
$ cd $AGL_TOP

$ repo init -b dab -m dab_4.0.2.xml -u https://gerrit.automotivelinux.org/gerrit/AGL/AGL-
repo

$ repo sync
```

Building AGL

Now,  to build the agl-demo-platform for Dragonboard410c.

```
$ source meta-agl/scripts/aglsetup.sh -m dragonboard-410c agl-demo  agl-appfw-smack
agl-devel  agl-netboot
```

Now to move to the directory:

```
$ cd agl-demo
```

Copying the custom HVAC recipie to AGL source:

```
$ cp hvac_git.bb $(AGL_TOP)/meta-agl-demo/recipes-demo-hmi/hvac/hvac_git.bb
```

Executing bitbake command by moving to the build directory of AGL source.

```
$ cd $(AGL_TOP)/build

$ bitbake agl-demo-platform
```

Flashing AGL onto Dragonboard410c

Once the build has been completed, we have to flash the boot and rootfs images onto Dragonboard410c. Now, boot Dragonboard into fastboot mode by following the instructions here. Then follow the below instructions to flash AGL onto Dragonboard410c.

```
$ cd $AGL_TOP/build/tmp/deploy/images/dragonboard-410c

$ sudo fastboot flash boot boot-dragonboard-410c.img

$ sudo fastboot flash rootfs agl-demo-platform-dragonboard-410c.ext4
```

## Hardware Setupto execute HVAC demo.

Make sure the Dragonboard410c is powered off

Connect DC motor and LEDs to Arduino as per above schematic

Connect LCD to Dragonboard410c via HDMI cable for display and Micro USB cable for touch input

Power on your 96Boards CE with compatible power supply

Dragonboard410c should now boot into AGL and homescreen should be visible.

## HVAC Utilities

Execution environment: Dragonboard410c

Navigate to the HVAC application from the Homescreen.

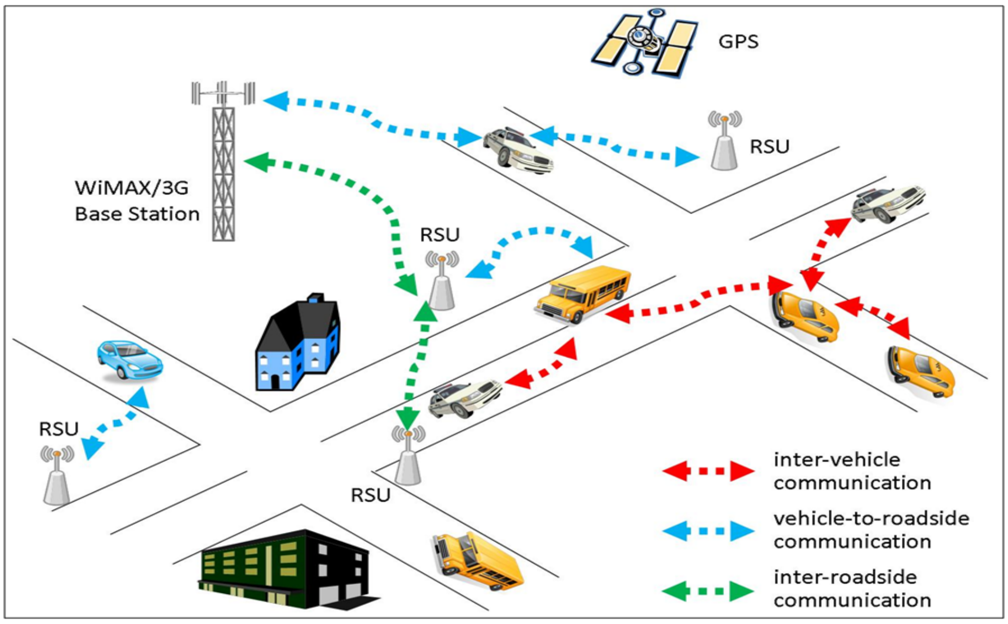
1. To control the Fan speed, change the position of the slider at the top.
2. To control the LED intensities, change the values of L/R temperatures by dragging up the LO box.
3. Turn off power by using the following:

```
$ sudo cd ..

$ poweroff --no-latch
```

## About Network layer based communication:

Almost all routing protocols used by the different IVC projects are position-based. In addition, existing MAC ad hoc protocols could be directly applied. But if an optimal performance is desired taking into account the linear nature of the networks seen in section III, modification of the existing routing protocols must be performed. In addition, the features most of vehicles offer nowadays makes possible to get position information via GPS or GIS, very useful for routing. The protocol uses a forwarding scheme which avoids beacons for impactful transmission and effective sensing.


GPS
WiMAX/3G Base Station
RSU
RSU
RSU
RSU
inter-vehicle communication
vehicle-to-roadside communication
inter-roadside communication

(Fig. 2.4.1: Hybrid or Modern Day Infrastructure)

## eRecurrent Network layer based on-board computation cum signalling:

We aspire to prototype a modular approach to convert existing infrastructure of sensors and wireless telecommunication devices, and perhaps even provide pointers on an improved protocol fabricaion, which could be deployed at scale, feasibly.

# CHAPTER –III

# RESULTS AND DISCUSSION

## PHASE I

### 3.1 Work done so far:

- Successfully studied the architecture of a PCB (printed)  board.
- Gained a deep understanding of remote-sensing and GIS in application-layer deployment.
- Ported AGL unto raspberryPi and successfully emulated on a HDMI-connected monitor.
- Pull Request was successfully merged wih the source at git.automotivelinux.com.
- Cost and Capacity based market economic analysis.

### 3.2 Work to be done

- To come up with a neat-networking protocol schema to address inefficient hop-on /ad-hoc communication propogation delays, possibly trying to implement in a decentralized contract.
- To be able to successfully reproduce the hardware based real-time implementation of the AGL release on an ARM based development board.
- To provide an future roadmap for Non-hybrid cum Hybrid on-road network integration in a cheap (feasible), environment-friendly (sustainanble) and energy-efficient (if not, utilitarian) by means of a snap-on dashboard powered by a simple smartphones' sensors, transmitters and transduecers.
- To demonstrate a successful implementation of AGL (improvised fork) during the final review.

## 3.3 Gantt (Progression / Commits) chart

| Activity/Week | 1 | 2 | 3 | 4 | | 5 | 6 | 7 | 8 | | 9 | 10 | 11 | 12 | | 13 | 14 | 15 | 16 | | 17 | 18 | 19 | 20 | | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Field / Topic | # | # | # | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Literature | | # | # | # | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0th Review | | | | | # | | | | | | | | | | | | | | | | | | | | | | | | |
| Lit. Survey | | | # | # | # | # | # | # | | | | | | | | | | | | | | | | | | | | | |
| Sampling | | | | | # | # | # | # | # | | | | | | | | | | | | | | | | | | | | |
| 1st Review | | | | | | | | | | # | | | | | | | | | | | | | | | | | | | |
| Re-Editting | | | | | | | | | | | ! | ! | | | | | | | | | | | | ! | | | | | |
| Experiments | | | | | | | | | | | | ! | ! | ! | | ! | ! | ! | ! | | ! | | | | | | | | |
| Anlysis | | | | | | | | | | | | | | ! | | ! | ! | ! | | | | | | | | | | | |
| Thesis | | | | | | | | | | | | | | | | | | ! | ! | | ! | ! | ! | ! | | | | | |
| 2 nd Review | | | | | | | | | | | | | | | | | | | | | | | | | ! | | | | |
| Submission | | | | | | | | | | | | | | | | | | | | | | | | | ! | | | | |
| Acceptence | | | | | | | | | | | | | | | | | | | | | | | | | | ! | ! | ! | |
| Result | | | | | | | | | | | | | | | | | | | | | | | | | | | | | # |

! := undone
# := done

Commit history as taken from https://github.com/MEE499/
Code frequency history as taken from https://github.com//14BME0133/

| DATE | DAY | TIME | LOG | | |
|---|---|---|---|---|---|
| | | | | | |
| 21-Dec-2017 | Thu | 1000hrs. | Sampling | | |
| 22-Dec-2017 | Fri | 1000hrs. | Reconcilation | | |
| 23-Dec-2017 | Sat | 1000hrs. | Off | | |
| 24-Dec-2017 | Sun | 1000hrs. | Off | | |
| 25-Dec-2017 | Mon | 1000hrs. | Literature Review | | |
| 26-Dec-2017 | Tue | 1000hrs. | Literature Review | | |
| 27-Dec-2017 | Wed | 1000hrs. | Literature Review | | |
| 28-Dec-2017 | Thu | 1000hrs. | Literature Review | | |
| 29-Dec-2017 | Fri | 1000hrs. | Literature Review | | |
| 30-Dec-2017 | Sat | 1000hrs. | Off | | |
| 31-Dec-2017 | Sun | 1000hrs. | Off | | |
| 1-Jan-2018 | Mon | 1000hrs. | Analysis | | |
| 2-Jan-2018 | Tue | 1000hrs. | Analysis | | |
| 3-Jan-2018 | Wed | 1000hrs. | Analysis | | |
| 4-Jan-2018 | Thu | 1000hrs. | Analysis | | |
| 5-Jan-2018 | Fri | 1000hrs. | Analysis | | |
| 6-Jan-2018 | Sat | 1000hrs. | Off | | |
| 7-Jan-2018 | Sun | 1000hrs. | Off | | |
| 8-Jan-2018 | Mon | 1000hrs. | Hands-On Development | | |
| 9-Jan-2018 | Tue | 1000hrs. | Hands-On Development | | |
| 10-Jan-2018 | Wed | 1000hrs. | Hands-On Development | | |
| 11-Jan-2018 | Thu | 1000hrs. | Hands-On Development | | |
| 12-Jan-2018 | Fri | 1000hrs. | Hands-On Development | | |
| 13-Jan-2018 | Sat | 1000hrs. | Off | | |
| 14-Jan-2018 | Sun | 1000hrs. | Off | | |
| 15-Jan-2018 | Mon | 1000hrs. | Draft I | | |
| 16-Jan-2018 | Tue | 1000hrs. | Feasibility Analysis | | |
| 17-Jan-2018 | Wed | 1000hrs. | Milestone Scheduling | | |
| 18-Jan-2018 | Thu | 1000hrs. | Final Re-editing | | |
| 19-Jan-2018 | Fri | 1000hrs. | Omissions | | |
| 20-Jan-2018 | Sat | 1000hrs. | Off | | |
| 21-Jan-2018 | Sun | 1000hrs. | Off | | |
| 22-Jan-2018 | Mon | 1000hrs. | Review I | | |
| 23-Jan-2018 | Tue | 1000hrs. | Review I | | |
| 24-Jan-2018 | Wed | 1000hrs. | Review I | | |
| 25-Jan-2018 | Thu | 1000hrs. | Review I | | |
| 26-Jan-2018 | Fri | 1000hrs. | Review I | | |

Day-to-Day Activity Ledger: D.D.A.

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## Sources and Code Snips:

https://MEE499.github.io/

https://14BME0133.github.io/MEE499/

https://git.automotivelinux.com

https://MEE499.github.io/agl-7782-0002-0009/