Open-Source Prototyping of 5G Wireless Systems for Smart Ag, Autonomous Vehicles and Beyond

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Design Document

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List of figures/tables/symbols/definitions (This should be similar to the project plan)

1 Introduction

1.1 Acknowledgement

Advent of 5G network allows to connect the device to device with extremely low latency and nearly 100% reliability. Autonomous vehicle needs these extreme requirements for the safety issue.

1.2 Problem and Project Statement

This project is designing the 5G network prototype for autonomous vehicle (AV) to fulfill the extreme requirements for the AV has. Conventional network system such as LTE has a practical limitation to meet the requirements: latency less than 1ms, reliability higher than 99%. We will make a prototype network algorithms can fulfill these requirements and implement with the vehicle. There is a practical limitation to achieve latency requirement, so we are more focusing on reliability requirement. With implementation, we are expecting that the AV will receive and perform the commands within the specified requirements.

1.3 Operational Environment

OAI will be the operational Environment for the beginning of the project. It will become the base station for our CPS algorithm. On a different line we will also be designing some code for a raspberry pi. The pi will serve as a sample autonomous vehicle for the project.

1.4 Intended Users and Uses

AV has a huge demand in the U.S. and other countries, most of the motor manufacturers are inventing their own AV and network system. We are expecting that this prototype can be a good reference for those who are actively participating in this field.

1.5 Assumptions and Limitations

We assume autonomous vehicle and IoT industry growing exponentially, the importance of high speed, low latency, and reliable network systems is highlighted. One of the most promising option is 5G network. 5G network provides the 20 times faster data rate than 4G network, and the error rate and latency is near to zero. We are expecting to wirelessly commands the AV with 99% reliability.

Given the fact that we are designing a 5G network prototype, there is a practical limitation to fulfill the latency requirement which is less than 1ms. We decided to leave the latency level as 4G network (100ms) and more focus on reliability.

1.6 Expected End Product and Deliverables

We expect that 5G prototype design can be a good role model for the IoT networks systems and AV industry.

2. Specifications and Analysis

2.1 Proposed Design

We have approached our research by dividing our research into smaller sections and executing the research in parallel. The first item is gaining basic knowledge of 4G LTE, 5G prototyping, Cyber Physical Scheduling (CPS), Unified Cellular Scheduling (UCS), Open Air Interface Software (OAI), and Simulation of Urban MObility (SUMO).

At this point we each have had a section of the book 4G LTE advanced pro and the road to 5G assigned to us. We each have finished our assigned readings, We have summarized each section to a short presentation, and have presented each section to the rest of the project group.

Individually we have read published papers on the topics of CPS, UCS, and effects of latency and reliability.

The biggest promise of 5G to the world is the predictable reliability at at super low latency (1ms). We are currently installing the OAI software into some of our laptops using a Linux virtual machine (VM) to begin our initial development of simulation code. In addition we are exploring the SUMO software so we may understand the behavior of our simulation.

The simulation code will be our main focus we will be modified and refined it as we develop the best simulation we can to represent our 5G network. This process will be repeated multiple times to achieve desired outcome. once we have established a functioning simulation we will begin to apply our simulation to a hardware.

2.2 Design Analysis

We have attempted to install Linux VM's with the required low latency kernel. we have attempted this on two of our computers and did not have the desired results. We are think this is due to our memory levels that are currently to low. We will request a VM with the required specifications from the ETG in the ECprE department building.

3 Testing and Implementation

3.1 Interface Specifications

Our prototype will be working based on the algorithm and codework we are going to design. Simulation will be performed over OAI (Open Air Interface) and SUMO (Suburban Mobility). After the simulation, the hardware implementation will be performed with USRP SDRs. The vehicle will be either RC(Remote Control) car with microprocessor, or the actual vehicle will be provided by the Professor Zhang.

3.2 Hardware and software

Required Hardware:

1. USRP SDRs

2. Vehicle(Either Remote Control car with microprocessor or actual vehicle)

Required Software:

1. OAI (Open Air Interface)
2. SUMO (Suburban Mobility)

3.3 Functional Testing

Latency: 5G is targeting to reach 1ms latency, however, it is expected to have a practical limitation. Latency tolerance will be around 100ms which is similar as 4G network.

Reliability: We set our goal to reach the 99% of reliability of the network systems.

3.4 Non-Functional Testing

The compatibility test with SW simulation and HW implementation will be performed.

3.5 Process

Latency:

Timestamp events (e.g. transmission or reception of a packet) and then calculate the time difference between two events.

Reliability:

Reliability will be tested upon the transmission and reception process. The reliability will be calculated by (Tx / Rx * 100%). The amount of the data packet will be determined by the algorithm.

4 Closing Material

4.1 Conclusion

As a group we have been working hard towards finishing our project. We have researched the basic necessary information for the project. This includes reading several research papers and books. Also we have worked on getting the software OAI running. OAI has proved to be difficult because of how specific its requirements are. Getting OAI up and running with our CPS algorithm is one of the big goals for the project. Another goal is to get it running in the simulation environment SUMO. To succeed in these goals we have broken into two groups and are working on the CPS algorithm and OAI separately to begin with. We will then come back together and get both working together to test in SUMO.

4.2 References

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OpenAirInterface 5G software alliance for democratising wireless innovation
http://www.openairinterface.org/