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Cloud based Internet of Vehicle development using SDR platform towards URLLC system

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Abstract

The present decade has witnessed a revolutionized progress towards the development of Smart Cities. A Smart City will provide a plethora of Cloud-Controlled end-Node services to its citizens and in turn the data collected from those devices and assets is processed and analyzed to monitor and manage tra□c and transportation systems, electricity distribution systems and other community services. With such an ever growing population and hence the number of vehicles, the rate of road accidents are expected to increase manifold. Ultra reliable Low latency Communication (URLLC) going to be an important part of Internet of vehicle (IoV) which can reduce the probability of road accident. This paper tried to design Cloud Controlled Internet of Vehicles (IoV) based service on a laboratory scale which is focused towards URLLC systems and is capable of sensing and avoiding accidents.

1. Introduction

The extent of urbanization has been exponential since the Industrial Revolution. This has led to the development of Mega Cities such as Tokyo, Shanghai, Dubai and many more since the beginning of 21st century. But the rapid population growth in these cities is driving ideas for judicious consumption of resources and better management for Sustainable Development. [1] One of the major areas of concern is the traffic management in these cities. The booming number of vehicles makes the transport services more prone to accidents. The future looks for autonomous driverless vehicles that can steer by themselves. This technology is popularly known as Internet of Vehicles.

To achieving driverless automated car, the main criteria is one car should connected to another and every car should be connected with the next one, in another view every living and non living things should connected to each other to avoid collisions, which required the most successful connecting media Internet. But not only internet will help, another main requirement is an ultra stable and ultra fast computations to take decisions. In this context 5G communication is targeted toward Ultra reliable Low Latency Communication (URLLC) which may be the backbone of future automated and connected cars. The URLLC based Vehicle to Vehicle (V2V) communication can be achieved by analysis End to End delay between transmitted and received signals. Channel delay between the Transmitter and receiver is also a part of it. This work concentrated on Channel delay which can be mapped on to distance also and that data is communicated to the Global Cloud Server which will makes it available for all nearby vehicles and a decision can be taken to avoid collisions. All the vehicles will act as an end-node device to the Global Cloud and hence they will share a common reference signal.

The challenges to such a system are many:

1. **Fuel E□cient**: Their movement must be tracked by the Cloud and as such they should be started andstopped as and only when required and must take the shortest route in order to
2. **High Reliability and Low Delays**: Since the end node devices dealt here are mobile vehicles, the communication must be reliable such that no data gets corrupted in the process. Simultaneously, the communication should be free from latency that is less than 1ms.
3. **Synchronization**: All the vehicles must be clock synchronized with respect to the transmitted signals.

Several works are going on in this domain, and the whole world is culturing and incorporating this technologies in future transportation system [2] [3].

In this paper, we have tried to overcome the above challenges on an experimental laboratory platform.

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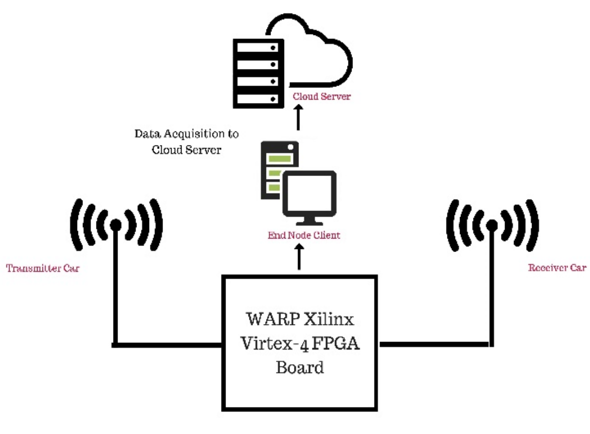

Figure 1: Schematic of IoV Service

2. Layout

2.1 Concepts

A Communication established between two cars by sending some code, and pulsed compression based correlation technique is used to identify the car at the receiver side. This technology is the heart of today's RADAR Communications has been used for the IoV service [4]. A polyphase code is selected as baseband code for its better correlation gain property at the receiver. There is bound to have channel delay between transmitter and receiver placed in two different toy cars, and hence the correlation sample changes in accordance with the distance between the transmitter reference and received signal. The signal bandwidth is defining the range resolution between two cars which is around 8 meter in this case. All this received data and correlation outcomes is transferred to the cloud server where a threshold is set according to our range resolution, now it is the duty of the cloud to generate and sends a stop signal to the vehicle if distance is less than the threshold. The stop signal hence generated can be used to drive the engine of the vehicle.

Personal Desktop Computers is set up as Cloud Server and Client are connected in a Local Area Network (LAN). The Received signal is sent to the Cloud. The cloud server is working mainly for three purposes [5]:

- Acquisition & Storage of Data
- Analysis of the data and returning the output
- Generate some intelligent control signals based on the analysis

Afterwards, the data is acquired from the system and hosted on to a Web Server so that the same data can be accessed by the Global Cloud Server for Internet of Vehicles.

2.2 Hardware

The hardware used for the purpose is WARP SDR board having Xilinx Virtex-4 FPGA [6], along with 2 WARP radio daughter cards, used for transmission and receiving respectively. At the heart of this Board is a Xilinx Virtex-II Pro FPGA which provides the processing abilities. The sampling frequency of the board is 40MHz which means that the communication cell dimensions will be small providing us more precision in setting up the threshold.

$$\text{Cell distance}_{\text{Threshold}} = c^* (1/\beta) \qquad (1)$$

Where c= speed of EM Wave (m/s) & β = Sampling Frequency (Hz).

The transmission and receiving of the signal is achieved by means of Horn Antennas.

Figure 2 : WARP Xilinx Virtex-4 FPGA Board, popularly known as Mango Board

2.3 Methodology

The Vehicular Communication was achieved by means of the FPGA board. The board was configured and programmed with the help of Xilinx iMPACT software [7]. The data transfer from the board to the Client system was done through LAN connectivity. Data generation and Radio parameters controls can be done by MATLAB programming. P4 code with 40 MHz of Bandwidth is generated in MATLAB and transmitted received and processed using same MATLAB programming.

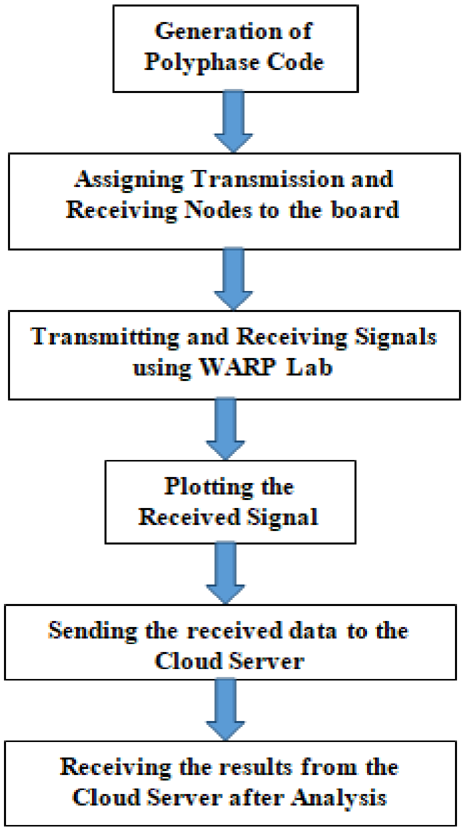

Figure 1 Flow chart of the Client Processes

The data was transferred to the Cloud Server. Since the board has a Sampling frequency of 40MHz, applying equation (1), we get each cell length to be 7.56

meter. So in the server, code was written to check if the transmitter and receiver are in the same cell (i.e. the distance is less than 7.56m threshold), a control signal was generated by the Server to the client that makes an alert sound. The entire codes were run in an infinite while loop so that the system runs in real time continuously. The Server-Client communications were done in MATLAB.
By providing specific IP address and port number to each of the devices in the Local Area Network. The Cloud Server here performed three main functions –

- Storage and display of data in real time by plotting the signals
- Calculation of Signal Delay (Latency) and Bit Error (Reliability) and sending the results back to the Client
- Taking decisions to stop the vehicle by generating and sending control signal

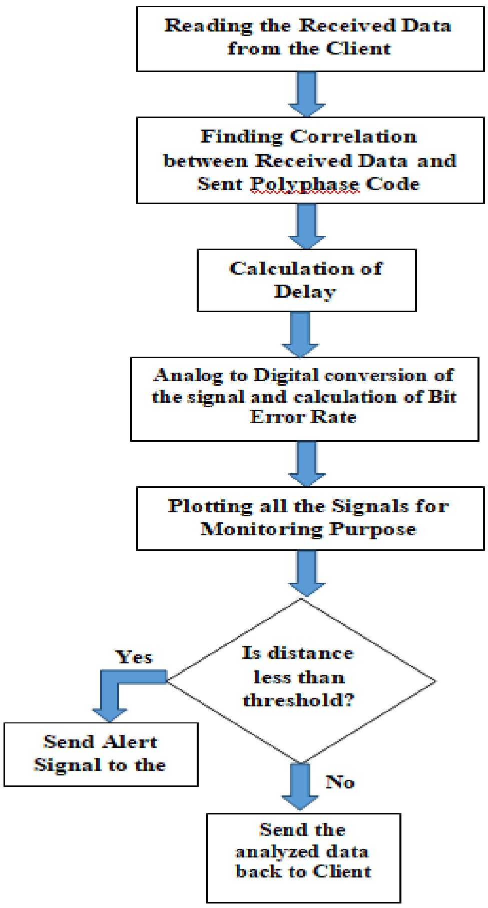

Figure: 2 Flowchart showing Cloud Server processes

The Local Cloud Server runs a web server so that the service can be extended globally hence creating a Global Cloud Server. The data received by the Local Server is written on a file using MATLAB. These are in turn read by the Web Server dynamically for display of the data, graph and alert signals, if any. The Web Server also sets a correlation threshold index based on the test bed environment. If index is less than threshold, the web server alerts that the vehicles are nearing each other. This SDR hardware, PC and cloud communication is designed based on TCP/IP protocol, which providing a fast and reliable communication which may be a backbone of future URLLC system.

3. Results:

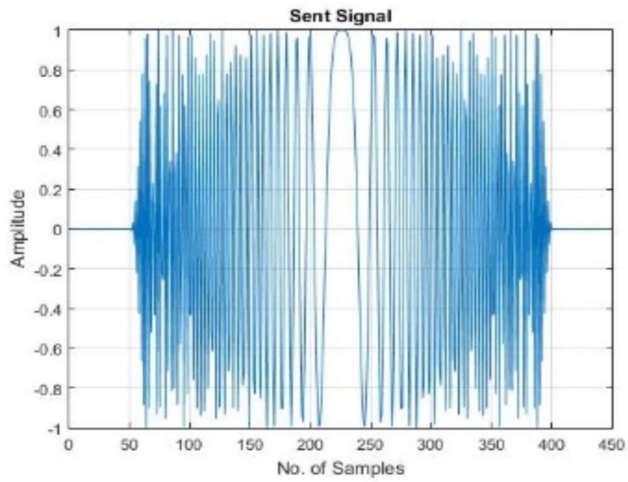

Figure 5: Transmitted P4 Code

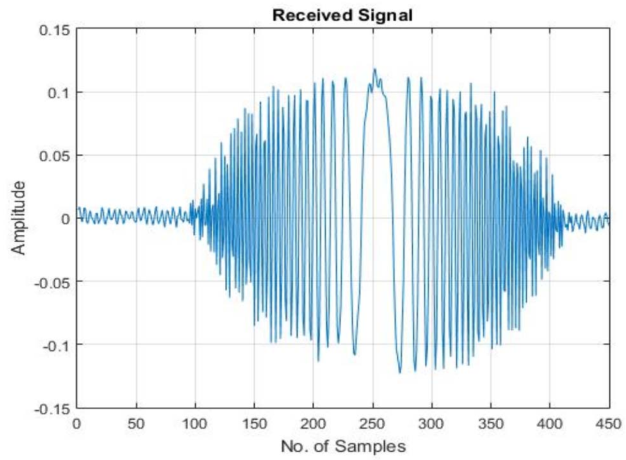

Figure 6: Received P4

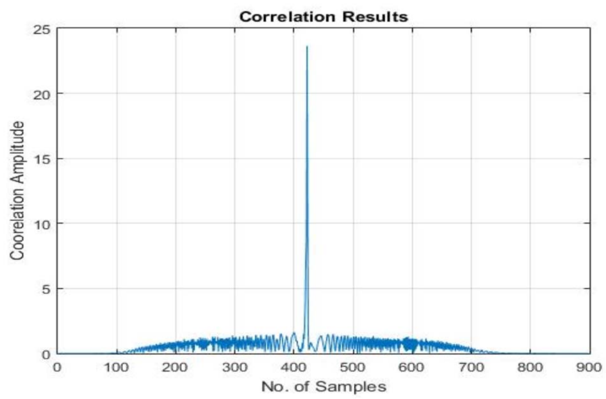

Figure 7: Correlation Output

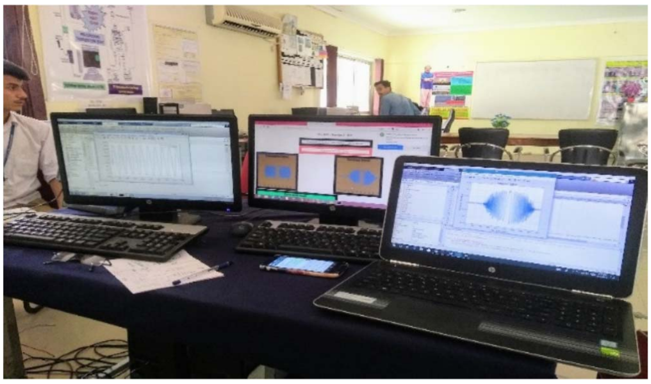

Figure 8: Cloud- Client Communication

Figure. 9 : IoV Service in Run

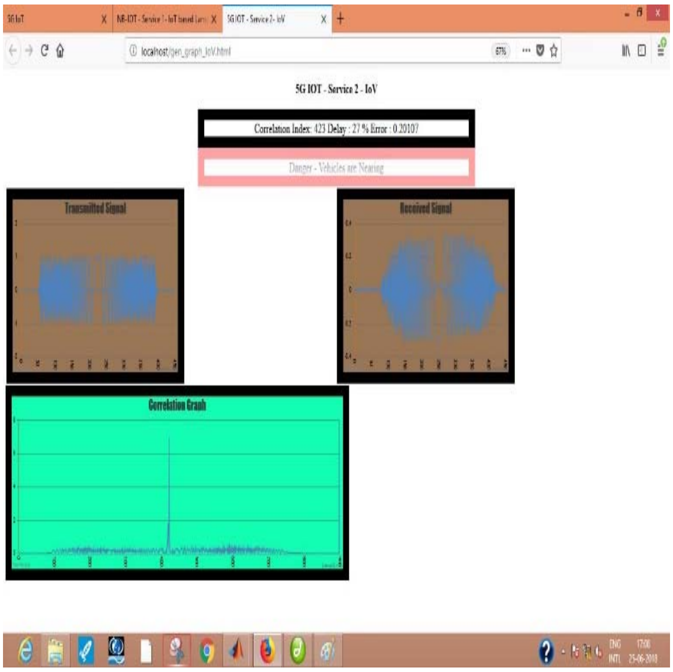

Figure 10: Web Server for IoV Service

Figure 5 shows the transmitted P4 Signal, and Figure 6 is the Received signal along with on-channel delay. Figure 7 is the correlation results between the Transmitted and Received signal which basically used for finding the distance between the vehicles. Figure 8 shows the Server-Client setup that was used for control activity of IoV experiment. Figure 9 is two toy car used to emulate the real road condition. In these two cars two horn antennas are placed used for Transmission and Reception of P4 code. Both the cars are moveable, by changing the position of any one we can vary the distance in between which is mainly detected using correlation method and converted to real distance. Finally, the service was hosted on a web server shown in figure 10, which is mainly calculating the threshold and generation a sound alert along with a RED blinking alert comment "DENGER-VEHICLE ARE NEARBY" in the web page, if the TX and RX are very nearby. Authors are able to detect nearby vehicle with more than 95 percent probability of detection rate and that is communicated to sever within almost no time which helping to take decision very fast and generating the alert signal well ahead.

4. Conclusion

This paper came up with a method to obtain Vehicle to Vehicle communication system to minimize Traffic Accidents and presented the subsequent results. The research is intended to develop an Internet of Vehicles service on an experimental basis that can further be improved towards deploying Ultra Reliable and Low Latency Communication feature of forth coming 5G New Radio (NR) Communication Networks.

5. Acknowledgements

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