Implementation of a Car2Car communication system on different platforms using Wifi Direct as communication protocol

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Shortcuts

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Chapter 1

Introduction

Car2Car (C2C) also known as Vehicle2Vehicle (V2V) Communication is a communication technology that allows vehicles or in the future road signs and other traffic related things to exchange information. The technology was first developed and successfully demonstrated by General Motors in 2005[1]. Since C2C communication is a trendsetting and complex topic you can't find much literature. Only a few internet sources currently offer relevant information. A standard does not exists yet.

The aim of this work is to provide a basic understanding of the principles of C2C communication and to implement three prototypes for Windows Phone and Android based mobile phones and a raspberry pi. Furthermore this paper should demonstrate a cheap way for upgrading an ordinary car with a C2C communication system and illustrate the possibilities which customer products are offered for realizing such a system.

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[1]http://www.worldcarfans.com/10510278356/general-motors-develops-vehicle-to-vehicle-communication

Chapter 2

Car2Car

C2C describes the communication between vehicles and other infrastructure. The goal is to improve the safety on the streets and to inform road user about upcoming problems on the road immediately including different car manufactureres and roadside units. Furthermore the Car 2 Car Communication technology should be a basis for decentralized active safety applications and therefore reduce accidents and their severity. Besides active safety functions, it includes active traffic management applications and helps to improve traffic flow.

2.1 Actors

One Actor of the System is the driver, which receives road information and warning messages or route recommendations.
Another Actor is the road operator, which receives road information from cars or other infrastructure and therefore will improve the control of the traffic in a more efficient way.
The last important actors are hotspot and internet providers, who can install their communication systems for example at gas stations.

2.2 Car 2 Car Communication Safety Scenarios

2.3 Car 2 Car Communication Traffic Efficiency

2.4 Car 2 Car Communication Infotainment and Other Services

Chapter 3

Wifi Direct

This chapter gives a short overview over Wifi Direct. Everything not mentioned or details about Wifi Direct can be found in the article "Wi-Fi CERTIFIED Wi-Fi Direct" from the Wi-Fi Alliance[1].

3.1 Overview

Wi-Fi Direct, or sometimes simply Wi-Fi P2P, is a standard which allows devices to connect directly to each other without requiring a wireless access point. With this technology users can connect to other devices in a way that makes it more simple and convenient for them. Because of the ability to connect directly to other Wi-Fi Direct devices without to access a traditional network , smartphones , printers, PCs and gaming devices can share their services anytime and anywhere. Instead of connecting first to an existing infrastructure network and then connecting to another device, users can so directly connect to the device which offers the services they need. Wi-Fi Direct devices are allowed to create a one-to-one connection, or they could form a group with several devices. Wi-Fi Direct devices support also the possibility to establish a connection with existing legacy Wi-Fi devices. This offers the possibility to create a direct connection with the hundreds of millions legacy Wi-Fi certified devices (802.11 a/g/n). The usage of Wi-Fi Direct brings some benefits for their users, among these:

Mobility and Portability:
>   Wi-Fi Direct devices can connect anytime and everywhere, because a Wi-Fi router or an access point is not required.

Immediate Utility:
>   Once the user buys his first Wi-Fi Direct device, he is immediately able to create a direct connection between devices. Even if it is his first Wi-Fi Direct device at home, he could establish a direct connection with his existing legacy Wi-Fi devices.

Ease of Use:
> The ability of Wi-Fi Direct discovery and the Service discovery allow users to find and identify available devices and services before establishing a connection.

Simple Secure Connection:
> Devices with Wi-Fi direct use Wi-Fi Protected Setup (WPS) which allows to simple create a secure connection. To establish a secure connection the user has to press a button on both devices, or type in a Pin. The procedure depends on the device type

3.2   Technology Basics

Wi-Fi direct devices are capable of establish a peer-to-peer connection. They can form groups in a one-to-one or one-to-many topology. One Wi-Fi direct device is responsible for the group and acts as group owner. For legacy clients the group owner will appear as an Access Point on which they could connect. All Wi-Fi direct devices must be able to be in charge of a group and act as group owner. Furthermore all devices must be able to negotiate which device adopts the group owner role when they forming a new group with other Wi-Fi Direct devices. A group can contain Wi-Fi Direct devices and legacy devices, with the limitation that legacy devices can only act as clients within a group. The picture below shows a typical Wi-Fi Direct P2P group.

Chapter 4

Prototypes

This chapter will describe the implementation of a C2C application on three different devices. These devices are an Android Device, a Windows Phone and a rasberry pi.

4.1   Android

Since Android 4.0, devices with appropriate hardware are allowed to connect directly to each other over WI-FI P2P without an access point between them. Android P2P framework complies with the WI-FI Alliances' WI-FI Direct certification program. With the usage of this API you are able to discover and connect to other devices when they support WI-FI P2P. According to documentations the advantage of WI-FI P2P beside Bluetooth or similar connection types is a fast connection across distances much longer than others. This allows applications a fast exchange of data between multiple users, which could be useful for applications such as multiplayer games, photosharing applications and in general, all applications which are relying on a fast connection between a long distance.

Prototype Implementation

In regard to the Car2Car project an Android application which tests the reliability and the functions of the WI-FI P2P APIs was developed. In light of the idea behind the Car2Car project and the ability of modern Android phones, to track the location of a user, this subchapter will show the results of the simple WI-FI P2P and GPS prototype. The simple prototype should discover available peers, after a successful connection it should send the GPS location of the user to all connected peers. All peers should mark the position of the other devices on the included google maps map with a marker. The picture below shows the design of the prototype application and describes the different sections.

Limitations and Problems

According to the WI-FI P2P documentation the range of the WI-FI P2P signal could be up to 500 meters. For the Android Car2Car prototype the test devices Samsung Galaxy S4 and Samsung Galaxy S2 Plus was used. It was not possible to confirm the range of 500 meters with the two devices. To test the maximal range of the signal, a few tests on a straight level road were carried out. It was determined that the signal at about 100-120 meters is lost. The tests were performed on foot and by car without any major differences. For a successful reconnect the distance between the devices was about 50-70 meters. The pictures below show the performed tests and describe their results.

4.2 Rasberry Pi

4.3 Windows Phone

Microsoft included Wifi Direct in his new Windows Phone 8.1 SDK, but actually there is no good documentation or sample which describes the usage of Wifi Direct in a Windows Phone app.
The other option would be to use there own namespace which connects two phones directly to each other, but this requires Bluetooth and WIFI and the same app on both devices. Since this is not compatible with any other devices than Windows Phones this is not good solution. Furthermore are the devices limited to the Bluetooth range which is in fact not very long.

Chapter 5

Evaluation

Chapter 6

Conclusion and Outlook

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References

[1]   Wi-Fi Alliance. "Wi-Fi CERTIFIED Wi-Fi Direct". In: (2010), p. 14.