Preparation of Papers for Middleware for Internet of Things (2021)

Vouillon Benjamin and Todesco Gabin

Corresponding author: Vouillon Benjamin (e-mail: benjamin.vouillon@etu.unice.fr)

Todesco Gabin(e-mail: gabin.todesco@etu.unice.fr)

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ABSTRACT

The smart car is first of all a cluster of objects connected to each other, each of these objects controls more or less vital functions ranging from trajectory calculation to management of lighting in the passenger compartment, including opening. access to external smartphones to the internal sound system. More broadly, the intelligent car is a member of a connected city and must guarantee the safety of all users and constantly exchange information within this ecosystem. To do so, the IOT allows all these connections but causes new issues such as cybersecurity, available speeds and consumption. The IoT thus allows the addition of new functions in the passenger compartment (light environment, mobile workspace layout, ...) but also outside (parking management, traffic decongestion, ...).

INDEX TERMS IOT, Smartcar, Cybersecurity, Smartcity

I. INTRODUCTION

The car as an object has revolted society by reducing the distances between individuals, by changing the landscape by its needs such as roads, gas pumps or chargers, ... and now with the advent of smart cars the vehicle is impacted by this society and the cities it has shaped, so that the vehicle finally gains its autonomy. The vehicle needs more sensors, more actuators and more computing power. To allow this interconnection we use an IOT or Internet of Things.

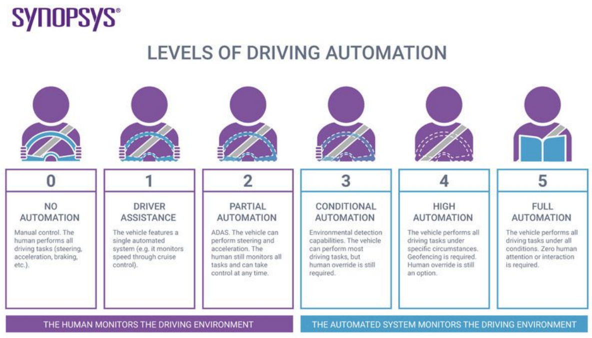
In this paper, therefore, we are going to make a state of the art of connected objects within vehicles, the functionalities they allow, the various networks put in place which allow the intelligence of the car as well as those that the technological means allowing integrate a smart car into a larger ecosystem such as connected cities or simply on the road network.

A. The Smart Car

The smart car is by definition a car capable of making decisions without user action, so an artificial intelligence is implemented that can make decisions about driving. To do this, there are various sensors installed in the car which provide information on driving conditions, the state of the mechanics and the interior are there to allow real-time control of the vehicle. Then the vehicle's AI acts on the various actuators at the level of the steering, of the engine to steer the vehicle. In addition, the intelligent vehicle is also connected and therefore transmits information to other vehicles (called V2V) and information is exchanged online to assess the state of the vehicle, the AI and then allow other functionalities such as GPS, downloading of entertainment content or the management of parking spaces in cities.

B. The Autonomy Level

Improving a car to make it smart and connected to the IoT has one main goal: the vehicle's driving range. To quantify the level of autonomy of a car There are 6 levels of autonomy: level 0, the user must be present at all times when the vehicle is loaned, he is the only master on board, the vehicle can when even have computers that can take control in some cases but do not drive as brake assistance or even the inflation indicator. The IOT does not necessarily have a place in this kind of function. Level 1 called “Driver assistance” means that the vehicle takes control while driving, for example the help function to keep in the lane is part of this level. Here, the calculations can be carried out directly in the vehicle, a communication network between the various devices of the vehicle. Level 2 is the highest reach for general public cars, where in certain simple cases driving can be taken over 100% by the vehicle such as the motorway, for example, the user can take control at any time. on the steering wheel. From level 3 the system can be autonomous at a certain data speed but the user must always be ready to act. Then level 4 allows the user to fall asleep in the vehicle in certain areas regardless of the traffic, if an area or a situation where the vehicle must absolutely leave the hand to the driver but the person does not take control then the vehicle must be able to put users to safety. To do this, the vehicle must be able to communicate its position and have additional information to predict this kind of situation. Finally level 5 is the ultimate where the vehicle is autonomous and no driver is necessary, the vehicle's cockpit changes more steering wheel, more control and the vehicle becomes a living room, a place of work or life where new objects connected thus appear to occupy the time available to the driver again.



The different level of autonomous cars [1]

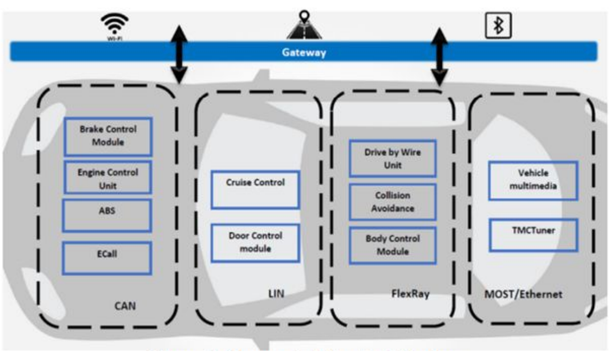
C. Safety vs Security

In order to rich those autonomous levels the smart car and the cluster of connected devices embedded need to be on one hand safety compliant; they need to avoid failure that could harm the passenger. On second hand security complaints; IoT protocols in the car should not be hackable and the software should cause any issue in the integrity of the system.

II. NETWORKING

A. Overview

IoT in smart cars is an embedded system, a multi-layered network composed of multiple subnetworks (CAN, LIN, FlexRay, MOST/Ethernet), each of them have different requirements, use differents protocols, are made of a different amount of Electronic Control Units (ECU), contain different sensors and actuators and represent different critical levels. That's what we call the Internet of Vehicles, but the IoV is also about communication with external networks (basically Internet) via embedded or third-party devices such as smartphones.



[2] Figure 2: Connected Car Architect

The external connections append in a Mobile Ad-hoc Network (MANet) or more precisely a Vehicle Ad-Hoc Network (VANet), a network that does not have a predefined infrastructure. The topology of a VANet is changing as the nodes are moving through space, it is a dynamic network where each node must be regularly updated and may be disconnected at some point. There are three types of external communications:

- **Communication with other vehicles (V2V)** is used to prevent accidents computing nearby cars behaviour, manage traffic
- **Connection with road infrastructure (V2R)** for again ensure security by being notified of danger zones in advance, but also to allow services like parking spot detection
- **Connection with other networks and services and Internet (V2I)** to ensure access to Internet and all the user experience from it through the infotainment system.

B. IoT Communication protocols

The different communication in the IoT system that are smart cars use multiple protocols that each have its specificities making it optimal for specific situations:

- **RFID** : Radio Frequency Identification System is composed of a passive RFID tag and a reader that broadcasts signal and reads the tags responses to identify the instance. The frequency used is between 120kHz and 433MHz [4] depending on Low, High or Ultra High frequency which makes a range of action of 10cm to 200m.
- **ZIGBEE** : Short range radio standard used for low powered devices to send and forward data along a network. The bandswitch goes from 250kb/s at 2.4GHz to 40kb/s at 915MHz [2] and operates in a range of 1 to 75m [4].
- **Bluetooth** : Short range communication standard for portable devices with a bandswitch up to 3Mb/s at a frequency of 2.4GHz [2] and a range up to 100m. It requires high power and can not support more than 8 devices at once.
- **Wi-Fi** : Wireless Fidelity for speed and flexible communication up to 100m with a rate of 11Mb/s or 54Mb/s at respectively 2.4GHz or 5GHz.
- **UWB** : Ultra Wideband for low power communication up to 10m in a VANET. [2] Uses unlicensed frequencies between 31.GHz and 10.6GHz for a rate up to 480Mb/s.
- **Cellular/Mobile network** : including here the GSM, 3g, 4g and soon 5g networks that use frequencies between 3GHz and 30GHz

C. Challenges

Adding more and more sensors and actuators to smart cars and road infrastructures adds costs. Also as every component must communicate with the globality of the system, they would have to be wired each to one another which is a lot of cables, a lot of additional cost and a lot of additional weight. That is without mentioning the complexity of the maintenance operations. The solution to this problem is done by making the internal network a wireless star-topology network, this way only the power supply wires are necessary and the amount of components is less restricted.

However this causes new issues as wireless communication in large numbers can produce interferences, consume a high quantity of bandswitch causing delays in data transfers and cause reliability problems. Moreover a wireless communication is exposing the system to malicious attacks and therefore compromising data security. The low latency and high reliability are required to satisfy the real-time constraints of the system.

III. Are cities ready for Smart Cars?

A.Overview

In order to enrich the level 5 autonomous cars we have to create a wide range of solutions to make smart cars connected to the rest of the Big Data network, plus safety and security complaints. But those things should be done in a bigger ecosystem called Smart Cities, so is the IoV and the smart cities ready for this change ?

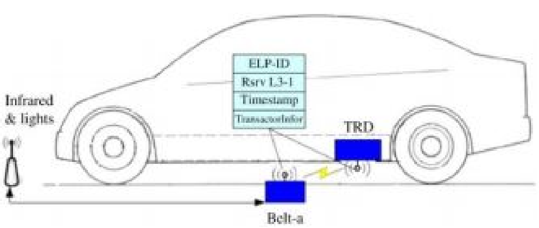
B. A way to connect them all

First of all we need to give access to the internet to all devices, and doing so for moving things like vehicule, actually the most important. A solution to this is by using the current 4G LTE and 3G network available in cities. that good but not enough to solve the problem, cause “experts say an autonomous car can generate 40TB of data for every eight hours of driving” [10]. On a single 4G emitter we have a lot of cars cause it’s a long range Protocol so there will be a lot of network bottlenecks, and you need a Physical Sim card that needs to be changed manually, that's not optimus. Obstacles in a city are everywhere, because buildings are everywhere. That is why a new solution represented by the 5G or WIFI, WiMAX are coming, as a short range alternative MANet protocol with high speed datas communication to the previous approach. For example for the 5G eSIM card can be used and modified by just an update, it’s much easier to use and to manage. The emitters are installed on each road infrastructure like crossroad and signal Lights or street Lamp, and you are garantie to not miss any car.

But for this we need a lot of new infrastructure to deploy these services in the city cause it’s not currently available in the city.

C. Parking

Adding sensor and communication tools to Cities offer new opportunities, one of them is the V2R (Vehicle to Road) and an implementation is the Smart Parking. A smart Parking should tell the car if there is an empty slot, providing the path to this slot and helping the car to enter the slot.



[2] Figure 3: Vacancy of parking slot detection by sensors

The picture above represents an implementation of connected objects used to park a car. First the car asks the parking attendant if it can use the slot. After that the car is guided to the slot. The car uses here infrared devices to stay in the slot and advertise its position and TRD will communicate with Belt-a to validate the car reservation.

Now the car is parked.

IV. Conclusion

We saw that the smart cars raise different challenges for IOT, that is why a specific IoT part is called IOV and is here to focus on the vehicle's constraints in order to get the fully autonomous car. These constraints are like the need of an ad-hoc network protocol to work with mobile devices called MANet with a special flavor VANet (Vehicle Ad-Hoc Network) adapted for the smart car.

The amount of data transfer speed is so huge and the disponibility is so critical for autonomous cars (Safety) that we have to change the cities infrastructure to handle this, like using 5G or WiMax.

One failure in the smart car could be so dangerous (lethal injuries, infrastructure destructions, privacy violations,...) that we made norms to avoid that the smart cars must be safety and security compliant, so the IoV too.

To conclude some technological solutions are currently in deployment, others are currently installed or need to be reprogrammed but every smart car and IoV system should be tested before being deployed.

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Vouillon Benjamin was born in Le Mans in France in 1998. He did his preparatory school from 2017 to 2019 in Polytech'Nice. After that received a Master I degree in computer science at Polytech Tours in the city of Tours in 2020.
During the summer of 2019, he was an Android Developer and had to find a way to Test IoT devices and store those datas in the company infrastructure. The next summer, he was Kotlin research, during this internship in Let's Build he was in charge of finding a way to exchange datas between different apps on the same phone and guarantee a full integrity of the datas.

Gabin A. TODESCO was born in Amiens, France, in 1998. Graduated from the Nice University Institute of Technology in Computer Science. Currently in his last year studying Computer Science Engineering (2020-2021).