PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
KASDI MERBAH UNIVERSITY - OUARGLA
FACULTY OF NEW INFORMATION TECHNOLOGIES AND COMMUNICATION
DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATIONS

**End of studies dissertation**
**With a view to obtaining the Professional Master's Diploma**

**Domain:** Science and Technology
**Sector:** Electronics
**Specialty:**Electronics embedded system

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# THEME

# IoT-Driven Solution for Enhancing Automotive Security, Maintenance &Services

**In front of the jury composed of:**

| | | |
|---|---|---|
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**Academic year:2023/2024**

# Thanks

First, we praise ALLAH and thank Him for His grace and blessings that He has bestowed upon us the ability to reach this station, which is the level of a second year master’s degree, and to submit this work.

The production of this thesis has been made possible by the help of many people we would like to express our gratitude.

Thank you to our professor, Mohammed Said ACHBI, for his valuable guidance, the inspiration he provided us, and the motivation he provided us with.

We also thank the parents for their support and encouragement.

We extend our sincere thanks to the members of the jury for agreeing to chair our work committee, and for agreeing to judge this humble work, and we thank all the professors for the support and guidance they provided during our study period and the preparation of the graduation project.

This journey has been an inspiring challenge, and without your support, we would not have been able to achieve it.

# Dedications

To the best of fathers

To our dearest mom

May they find in me the source of their pride to whom I owe

All to My Friends

To all those dear to me

ABSTRACT:

The late 20th century witnessed significant advancements in electronics, catalyzing profound changes across various facets of human life, notably through the Internet of Things (IoT) technology. IoT has revolutionized daily routines by enabling automated systems to surpass manual counterparts, integrating seamlessly into contemporary lifestyles. This paper explores a remote vehicle control system utilizing IoT principles, designed to enhance vehicle safety, maintenance, and user convenience. The system leverages a control panel and GSM SIM card for remote access, facilitating real-time monitoring and control via internet-enabled devices worldwide. Key functionalities include engine overheating detection using a Temperature/Humidity sensor, theft prevention via a SW-420 vibration sensor and JCC-3FF circuit breaker, and surveillance capabilities with an ESPCAM32 camera. These features are integrated into a scalable and cost-effective framework, accessible through the MyCar mobile application, showcasing the practical applications of IoT in automotive technology.

**Keywords**:
Internet of Things (IoT), Internet of Vehicle (IoV), Remote Vehicle Control System, MyCar app.

**ملخص:**

**في نهاية القرن العشرين، شهدت التقنيات الإلكترونية تطورات كبيرة، مما أدى إلى تغييرات عميقة عبر مختلف جوانب حياة الإنسان، بشكل ملحوظ من خلال تقنية الإنترنت من الأشياء .(IoT) ثورةIoTفي الروتين اليومي من خلال تمكين الأنظمة التلقائية من تفوق النظم اليدوية، ودمجها بسلاسة في أساليب الحياة المعاصرة. يستكشف هذا البحث نظام تحكم بالمركبات عن بعد باستخدام مبادئIoT، مصمم لتعزيز سلامة المركبات وصيانتها وراحة المستخدم. يستفيد النظام من لوحة تحكم وبطاقة SIM GSMللوصول عن بعد، مما يسهل مراقبة والتحكم في الوقت الحقيقي عبر أجهزة متصلة بالإنترنت في جميع أنحاء العالم. تشمل الوظائف الرئيسية اكتشاف تسخين المحرك باستخدام مستشعر الحرارة / الرطوبة، والوقاية من السرقة من خلال مستشعر الاهتزاز SW-420 ومفتاح الدائرةJCC-3FF ، وإمكانيات المراقبة باستخدام كاميرا .ESPCAM32 تم دمج هذه الميزات في إطار قابل للتوسع وفعال من حيث التكلفة، يمكن الوصول إليه من خلال تطبيقMyCarالمحمول، مما يبرز التطبيقات العملية لـIoTفي تقنيات السيارات.**

**الكلمات المفتاحية:**
**إنترنت الأشياء(IoT)، إنترنت المركبات(IoV)، نظام تحكم بالمركبات عن بعد، تطبيق MyCar.**

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# GeneralIntroduction

The project we are working on involves the security, maintenance, services, and automation of vehicles. In the security domain, we work with sensors (DHT11,SW-420, JCC-3FF) and surveillance using the ESP-CAM32 camera with the Arduino Mega2560 board and a mobile application called MyCar, which needs to be installed. Communication between the devices and the application is done using the SIM900A module.

We start by identifying the goals of this project, the deliverables, and the necessary hardware and software components. Documentation is crucial to get a clear view of the project, using the experiences of others to improve our approach, combining research and new insights. We conducted extensive research on software such as Arduino IDE as a programming tool, and Figma as a graphical interface for designing the application's user interface, which is easy to use. Additionally, tools like Bootstrap and Angular are essential for creating applications like this project's application. These documentations were very helpful and took a long time to understand along with many other aspects.

The thesis addresses the topic of vehicle automation and security, with the aim of monitoring, logging, and controlling sensors and vehicles, as well as facilitating communication between vehicle owners or drivers in innovative and distinctive ways. The primary focus is to ensure the safety and security of vehicles. The same can be achieved when the user is in the vehicle. Thanks to the system, they can make arrangements from home or anywhere else, saving effort and cost while ensuring the security of their vehicle remotely. Using this set of sensors and electronic devices, we can solve some existing issues related to vehicle security, maintenance, and services.

The project is divided into three chapters. The first chapter focuses on enhancing vehicle security, maintenance, and services through IoT technology ,discusses current problems, and states the goal of this study, explaining how these technologies integrate to provide a final product that makes our properties and lives more secure. The second chapter defines the Internet of Things (IoT) and the Internet of Vehicles (IoV). The third chapter details the practical application, discussing programmable devices, specifically the Arduino Mega 2560 board, which is a key component of this project, along with other utilized devices. This part was challenging as we needed to source the sensors that were not available in the region. After acquiring all the necessary materials, we began experimenting with these sensors for a while to get familiar with them. For software, we conducted extensive research, went through documentation, to handle these programs effectively. In the end, it was a very good experience in launching a project about IoT in the field of vehicle automation.

Among the main goals of the project is to reduce theft incidents and improve emergency response by providing an integrated security system that includes sensors and cameras that monitor all movements around the vehicle and immediately alert users when any unusual activity occurs. Additionally, the project aims to facilitate maintenance operations by continuously monitoring the vehicle's condition and sending alerts when maintenance is needed or any potential issue arises, helping to avoid major and costly breakdowns.

The project also seeks to enhance the user experience by offering innovative services such as the ability to remotely start and stop the engine, allowing users to control their vehicles easily and conveniently. Furthermore, the application provides the capability for direct communication between car owners in emergencies, wrong parking situations, or when immediate assistance is needed.

In terms of infrastructure, the project involves developing a robust and secure database to store data related to vehicles and users, as well as developing APIs (Application Programming Interfaces) that allow the system to integrate with other platforms and services, paving the way for system expansion and the addition of new features in the future.

Moreover, the project focuses on the educational and research aspects, documenting all development stages and using these documents as references for future research and the development of new technologies in the field of vehicle automation and security.

Overall, the project aims to create a safe and reliable environment for vehicles, providing innovative services that facilitate users' lives and enhance their daily experience, reflecting the positive impact of Internet of Things and Internet of Vehicles technologies on our lives.

# CHAPTER 1

# Vehicle Security, Maintenance and Services

# I. Vehicle Security, Maintenance and Services

## I.1. Introduction

In our modern world, vehicles are not merely modes of transportation; they are extensions of our lives, carrying us safely from one destination to another while also reflecting our style and personality. However, with this convenience comes responsibility. Ensuring the security and maintenance of our vehicles is paramount for our safety.

In this chapter, we underscore the critical importance of security, maintenance and services in modern vehicles. As technology evolves, vehicles become more interconnected and susceptible to security breaches, emphasizing the necessity for robust protective measures.

This chapter also presents a study on vehicle monitoring systems. It begins by defining the problem statement. The objectives of the study are then stated, followed by a discussion of the scope and limitations, acknowledging the boundaries within which the research will operate. Additionally, the chapter addresses the limitations or delimitations that may affect the research process and results. Finally, a summary of existing work on vehicle monitoring systems is provided, laying the foundation for the current investigation.

## I.2. Significance of security, maintenance and services in modern vehicles

Thanks to advanced technology, that improves performance, comfort and even safety, modern cars are a miracle of engineering. However, this complexity creates additional difficulties. More than ever, security and maintenance have become essential to ensure that these vehicles operate according to design and protect both passengers and vehicles.

On the one hand, periodic maintenance is crucial for modern vehicles to ensure that they continue to operate efficiently and safely in this era of rapid technological innovation, where periodic maintenance prevents unforeseen disruptions that can cause accidents by identifying and repairing any problems in important parts, including suspension and brake systems, battery control and wheels.

Modern vehicles also have advanced safety features that contribute to safer driving, but maintaining such advantages on a regular basis is also required to maintain their proper functioning. For example, if the brakes are not regularly maintained and are in poor condition, the ABS systems may not function as intended.

On the other hand, keeping the car safe is not just a duty, it is an investment in the safety of the driver and passengers, and we attach importance to car safety in protecting people's lives, maintaining the confidence and experience of the driver while driving, avoiding extra costs, maintaining the market value of the car and others.

## Technological Advancements in vehicle Management

Technological advancements in vehicle management, specifically in security and maintenance services, have led to significant improvements in tracking, securing, and maintaining vehicles. With GPS tracking, real-time monitoring enhances security and enables efficient fleet management.

Advanced sensors and diagnostic tools predict maintenance needs, ensuring vehicles stay in optimal condition. These advancements enhance security, simplify maintenance, and ultimately improve vehicle reliability while reducing downtime.

In the following section, we will provide specific examples of technological advancements in vehicle management for security and maintenance services:

1) **RemoteMonitoring**: Advanced systems now allow for real-time tracking of vehicle status, including location, fuel levels, and engine health, reducing the risk of theft and aiding in timely maintenance.

2) **Predictive Maintenance**: Vehicle management systems can now predict when maintenance is needed based on data collected from sensors and diagnostic tools. Predictive maintenance helps prevent breakdowns and extends the lifespan of vehicles by addressing issues before they become critical.

3) **Autonomous Driving**: While fully autonomous vehicles are still in development, many vehicles today feature advanced driver assistance systems (ADAS) that automate certain driving tasks, such as lane-keeping assistance, adaptive cruise control, and automatic parking. These technologies improve safety and convenience for drivers.

4) **Electric and Hybrid Vehicles**: The shift towards electrification is transforming vehicle management by reducing reliance on fossil fuels and lowering emissions. Advanced battery management systems optimize energy usage and prolong battery life, while charging infrastructure continues to expand to support the growing fleet of electric vehicles.

- **NavigationandTrafficUpdates**: Real-time traffic updates and GPS navigation help drivers avoid congested routes.
- **MaintenanceAlerts**: Automated alerts for maintenance schedules and diagnostics help prevent breakdowns.
- **E-CommerceIntegration**: Services for buying and selling vehicles and ordering parts online enhance convenience.
- **EmergencyAssistance**: Features such as SOS alerts and roadside assistance improve safety during emergencies.

The effective management and monitoring of cars are critical to addressing the challenges posed by increasing vehicle numbers, environmental impacts, security concerns, and maintenance needs. Leveraging technological advancements can significantly improve the driving experience, reduce congestion, and enhance the overall efficiency of urban transportation systems.

## I.3. Problem statement

In today's era, society faces numerous challenges in terms of managing and monitoring cars effectively and efficiently. The increasing number of cars on the roads and in cities leads to increased traffic congestion and complications in finding parking.

Among the main challenges that society faces is the difficulty of determining a place to park cars in public or private places, especially in crowded areas. This leads to the consumption of a large amount of time to search for parking spaces, and thus negatively affects traffic and increases congestion and emissions problems. Because of the lack of time, people are obliged to by leaving his car in a place where he blocks another car and does not allow it to pass.

Managing vehicle services involves several challenges, especially as vehicles become more technologically advanced and diverse. Here are some common challenges faced in providing vehicle services:

1) **Maintenance Challenges:**

- **RegularMaintenance Needs**: Vehicles require consistent maintenance to ensure they remain safe and functional, including oil changes, tire checks, and brake inspections.
- **CostandTime**: Maintenance can be costly and time-consuming, often leading to neglect, which increases the risk of breakdowns and accidents.

2) **Security Concerns:**

- **Theft and Vandalism**: Cars left unattended for extended periods are at a higher risk of theft and vandalism, causing financial loss and inconvenience for owners.
- **UnattendedVehicles**: Lack of monitoring can lead to issues such as unauthorized access or damage to parked vehicles.

3) **Traffic Congestion and Parking Issues:**

- **Increasing NumberofCars**: Rapid urbanization and population growth have led to a surge in the number of cars on the roads, resulting in severe traffic congestion.
- **ShortageParkingSpace**: Finding parking in crowded urban areas is challenging, leading to significant time spent searching for available spots.
- **IllegalParking**: Due to the scarcity of parking spaces, drivers often resort to illegal parking, which blocks other vehicles and exacerbates traffic issues.

4) **Services challenges:**

- **CustomerExpectations**: Meeting and exceeding customer expectations for quality, timeliness, and value is paramount. This includes providing excellent customer service, timely repairs, and transparent communication throughout the service process.
- **TechnicalComplexity**: Modern vehicles have intricate systems needing specialized diagnostics and repair expertise. Staying updated on technology is vital but challenging, given the shortage of skilled automotive technicians. Recruiting and retaining talent is crucial for delivering top-tier service.
- **DiagnosticChallenges**: Diagnosing and troubleshooting vehicle problems accurately can be challenging, especially with intermittent or complex issues. Investing in advanced diagnostic equipment and providing ongoing training for technicians is essential for improving diagnostic accuracy.

Through our vision of the development of technology, cars have become able to provide a variety of services connected to the Internet that facilitate their daily lives for drivers and vehicle owners and improve their experience while driving. These services and advantages vary to basic services such as remote monitoring of vehicles and repair. Also, advanced services are considered such as buying and selling and requesting help.

## I.4. Objectives of the study

The main goal of this dilemma is to reduce the problem of car confinement, reduce the time of the arrival of the annoying car owner, reduce tension, and prevent problems that may occur in the event of confinement, in addition to several goals, including:

- Developing new innovative technologies that keep pace with our generation and advanced technology, such as developing the license plate scanning technology and linking it to an application that allows communication between car owners.
- Monitoring the car remotely through visual vision using a camera located at the level of the car.
- Providing advanced services through the application to help and guide people.
- Providing regular maintenance for vehicles to reduce risks to cars.

## I.5. Scope and limitation

**Scope:**

**1. Create and assemble a gadget:**

- Utilize either a Raspberry Pi board or Arduino board.
- Incorporate various instruments such as a camera, vibration, and temperature sensors.

**2. Integrate battery voltage sensors:**

- Implement sensors to monitor the battery's status continuously.

**3. Design a remote control interface:**

- Develop a user-friendly interface for managing vehicle functionalities like door locking and unlocking remotely.

**4. Add GPS feature:**

- Incorporate GPS technology to track the car’s location and monitor its movements in real-time.

**5. Incorporate a camera:**

- Install a camera for real-time monitoring of the vehicle and its surroundings.

**6. Create a mobile application:**

- Develop a mobile app allowing users to communicate with car drivers.
- Enable features for facilitating car sales and purchases.

- Implement monitoring and security features to safeguard vehicles.

**7. Process multiple pieces of information:**

- Handle data from different sensors and communication channels simultaneously.

**8. Implement algorithms:**

- Develop algorithms to integrate data and make decisions regarding multiple streams of information.

**9. Ensure robust communication protocols:**

- Establish reliable communication protocols between device components and the mobile application to exchange data seamlessly.

**10. Develop fault-tolerant mechanisms:**

- Create mechanisms to effectively handle data inconsistencies or communication failures.

**11. Integrate security measures:**

- Implement security measures to protect sensitive information during transmission and processing.

**Limitations:**

1. **Time and Resources:** It's crucial to accurately assess the time and resources required for the project to ensure timely delivery and effective resource allocation.
2. **CostofComponentsandTechnology**:

Cost considerations are important, and it's wise to explore cost-effective solutions without compromising on quality and functionality.

3. **Difficulty in Meeting All Required Features:** Prioritizing features and breaking down the project into manageable tasks can help in addressing this challenge. Agile methodologies like Scrum can be beneficial.
4. **Compatibility and Integration:** Thorough testing and prototyping can help in verifying compatibility and ensuring seamless integration between components and technologies.
5. **Confidentiality and Security:** Implementing robust security measures, such as encryption and access controls, is essential to safeguard personal and sensitive data.**Managing Multiple Data Streams**: Utilizing efficient data processing techniques and optimizing algorithms can help manage multiple data streams within the device's computing capabilities.
6. **Designing Effective Algorithms for Data Fusion and Decision Making:** Researching best practices, leveraging machine learning algorithms, and conducting thorough testing can aid in designing effective algorithms for data fusion and decision making.

## I.6. Constraints or limitations that may impact the research

We faced challenges in obtaining the appropriate technology, financial and human resources to implement the practical part of the research, so we decided to search for the most efficient technical solutions available at a reasonable cost. Be careful about personal and sensitive data collected from cars and monitored. Because we found that there is local and international legislation that regulates the use and storage of this data, therefore it must be taken into account and worked in accordance with it.

Technical compatibility and local laws it is necessary to ensure that the devices and technologies used are compatible with local laws and legislation related to vehicle safety and wireless communications. We needed to obtain special approvals and licenses before carrying out some practical aspects of the research.These are some of the obstacles that we encountered during the implementation of the research, which must be taken into consideration.

## I.7. Vehicle challenges

### I.7.1. Vehicle Security challenges

Today's automotive industry faces increasing challenges in the areas of safety and maintenance, as a result of rapid technological developments and the complexities of modern vehicles.

We will address the challenges related to car protection:

- Cars are more vulnerable to cyber threats as a result of cars being connected to the Internet, and this includes hacking the car's electronic system to control it remotely.
- Theft of personal data and hacking of security systems.
- Theft of cars or personal property inside them.
- Late detection of sabotage, theft and damage attempts.
- Weak encryption techniques protect personal data and vehicle data.
- Not updating the device firmware regularly.

### I.7.2. Vehicle Maintenance challenges

Preventive and predictive maintenance, which identifies potential car problems before they occur, represents a major challenge, especially with the increasing complexity of design and technology used in cars. Among these difficulties and challenges we mention the following:

- It has become difficult for users to perform simple maintenance themselves. This requires relying on specialized service centers, which may lead to higher maintenance costs and delay necessary repairs.
- Failure to monitor engine temperature and thus failure to take preventive measures and early measures.

### I.7.3. Vehicle Services challenges

Providing reliable and easy-to-use services is the key to the project's success. These services must be able to effectively meet the needs of users. Among the problems and challenges in this aspect are:

- The application should be provided with a user-friendly and intuitive interface, so that users can interact with all the features without complications. Focus on designing an effective and attractive user experience, as there are some applications that have a difficult and complex user interface.

- Failure to provide quick and effective technical support to users in the event of problems or inquiries.
- Failure to achieve seamless integration between services.
- Some features may require a permanent Internet connection, which is a challenge in areas with poor coverage and high data costs.

## I.8. Conclusion

In conclusion, the chapter titled "Vehicle Security, Maintenance, and Services" highlights the rapidly evolving landscape of automotive care and safety. This chapter emphasizes the critical importance of robust security measures, encompassing both traditional locks and advanced digital safeguards against theft and cyber threats. This shift reflects the increasing challenges faced by the automotive industry in the digital age, where adopting modern technologies has become essential to ensure the safety of vehicles and their owners.

Regarding maintenance, practices have transitioned towards predictive techniques that contribute to extending vehicle longevity and enhancing performance while reducing the costs associated with traditional maintenance. This shift underscores the trend towards utilizing data and analytics to anticipate issues before they occur, ensuring minimal downtime and providing a better user experience.

Automotive services have also seen significant expansion, with a growing range of specialized repair options and innovative service models that prioritize customer needs. This customer-centric approach reflects a deep understanding of evolving consumer expectations and their desire for more personalized and efficient services.

Overall, this chapter illustrates the comprehensive transformation in how vehicle security, maintenance, and services are handled, pointing towards a future characterized by greater security, efficiency, and a focus on customer experience. These developments are not merely technical enhancements but fundamental changes that are reshaping the relationship between humans and vehicles in the modern era.

# CHAPTER 2

# An overview of
# Internet of Things (IoT)
# and
# Internet of Vehicle (IoV)

# II. Overview of IoT and IoV

## II.1. Introduction

In recent years, the integration of Internet of Things (IoT) technology in various sectors has revolutionized how we interact with and perceive the world around us. By connecting the digital and physical worlds through interconnected devices, IoT enables real-time monitoring, communication, and data exchange, leading to smarter decision-making and more efficient processes. This technology spans across numerous applications, from household items and industrial machinery to smart city infrastructure and transportation systems.

One of the most transformative applications of IoT is in the automotive industry. The Internet of Vehicles (IoV) leverages IoT to enhance vehicle security, maintenance, and services, thereby revolutionizing Intelligent Transportation Systems (ITS). Despite these advancements, the implementation of IoT and IoV technologies presents several challenges. As vehicles become increasingly connected and reliant on technology, they are exposed to a myriad of security threats, user privacy concerns, and issues related to standardized protocols. Inadequate service and lack of early maintenance can also lead to significant problems.

This chapter explores the definition, history, and key components of IoT, along with examples of its diverse applications. Following this, we delve into the Internet of Vehicles (IoV), examining its concept, history, principles, and the associated challenges. By addressing these issues, we aim to highlight the potential solutions offered by IoT technology, marking a new era of smart mobility and intelligent systems that offer unparalleled convenience, safety, and connectivity.

## II.2. Definition of IoT

The Internet of Things (IoT) is described as "a global infrastructure for the information society, which provides advanced services by interconnecting objects (physical and virtual) through existing or evolving interoperable information and communication technologies" by the International Telecommunication Union (ITU) [3].

The emergence of ubiquitous computing can be attributed to a new paradigm known as the Internet of Things. By connecting to the Internet, it enables a large number of IoTstakeholders to exchange discovered data, react to events, and interact with the environment. IoT applications are made possible by this interaction amongst heterogeneous devices. Given the enormous amount of things that are linked to the Internet and the vast array of applications that the Internet of Things (IoT) offers, it is essential to have an architecture that permits [11].

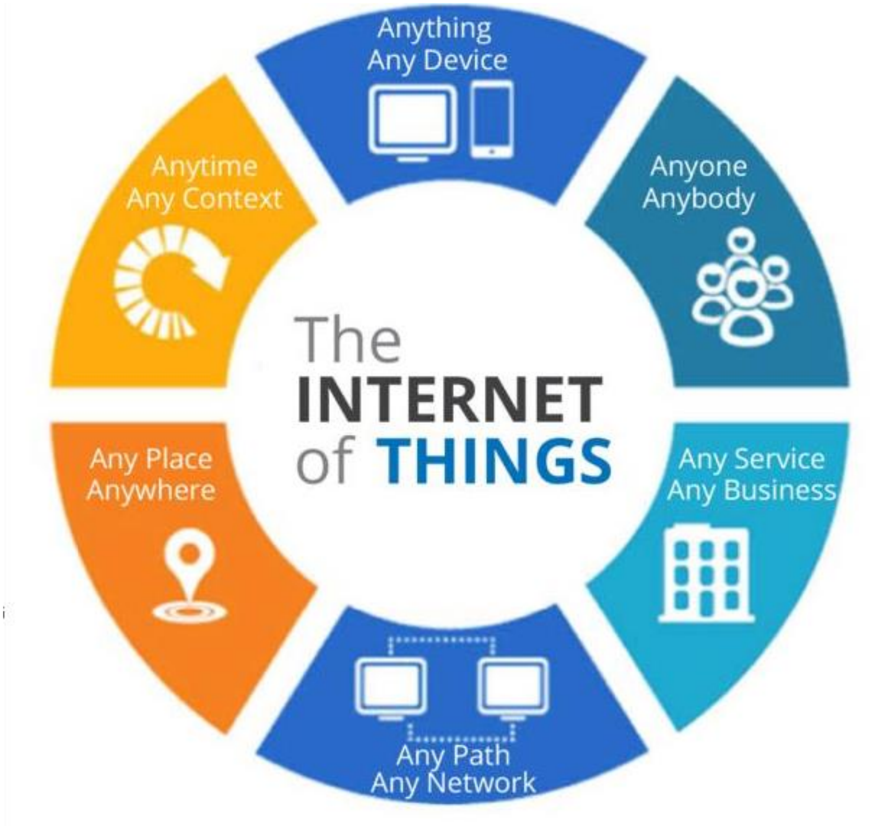


Figure II.1 : Internet of Things.

### II.2.1. Evolution of IoT Technology

The idea for the Internet of Things was first proposed almost two decades ago, although the underlying technologies had been in development for many years. Let's take a look at the development of the Internet of Things and its technologies in chronological order:

1. **Early Conceptualization:**The Internet, which was the primary technology behind the Research Project Agency Network in 1964, was primarily used by academia to carry out research, develop new networking techniques, and connect computers to numerous computer centers run by the US Department of Defense as well as by the public and private sectors [4]. The idea of connecting devices to the internet dates back to the late 20th century, but it wasn't until the early 2000s that the term "Internet of Things" was coined. The concept involved connecting everyday objects to the internet to enable communication and data exchange.

2. **RFID and Sensor Networks:**RFID (Radio FréquenceIDentification), another essential technology for the Internet of Things, was first introduced in 1973. Even though the technology dates back to World War II and saw significant developments in the 1950s and 1960s, Mario W. Cardullo was the first American to receive a patent for an RFID balise with rewriteable memory in 1973. However, Californian entrepreneur Charles Walton also received a patent for a passive transponder -which would allow for remote door opening- that same year [5].
3. **Expansion of Connectivity (Mid-2000s):** With advancements in wireless technologies such as Wi-Fi, Bluetooth, and cellular networks, connectivity became more widespread and accessible. This enabled a broader range of devices to be connected to the internet, from Smartphone and wearables to home appliances and industrial machinery.
4. **Cloud Computing and Big Data (Late 2000s):** The rise of cloud computing platforms provided scalable storage and processing capabilities for the vast amounts of data generated by IoT devices. Big data analytics tools emerged to extract valuable insights from this data, driving innovations in areas like predictive maintenance, personalized healthcare, and smart cities.
5. **Standardization Efforts (2010s):** Various organizations worked on standardizing IoT protocols and architectures to ensure interoperability and security across different devices and platforms.
6. **Edge Computing and Fog Computing (2010s):** As IoT deployments grew larger and more complex, there was a need to process data closer to the source to reduce latency and bandwidth usage. Edge computing and fog computing architectures emerged to distribute computing resources closer to IoT devices, enabling real-time analytics and decision-making at the network edge.
7. **AI and Machine Learning Integration (2010s-Present):** The integration of artificial intelligence (AI) and machine learning (ML) algorithms with IoT systems has enabled more intelligent and autonomous decision-making. IoT devices can now analyze data in real-time, detect patterns, and adapt their behavior accordingly, leading to advancements in areas like autonomous vehicles, smart homes, and agriculture.
8. **BlockchainforIoT Security (2010s-Present):**Blockchain technology has been explored as a means to enhance security and privacy in IoT deployments. By providing a decentralized and tamper-resistant ledger, blockchain can help secure transactions, verify device identities, and ensure the integrity of data exchanged between IoT devices.

9. **5G Connectivity (Present-Future):**The deployment of 5G networks aims to transform IoT with faster speeds, reduced latency, and increased capacity. This advancement will support demanding applications like augmented reality, autonomous vehicles, and remote surgery, which rely on high-bandwidth, low-latency connectivity.
10. **Continued Expansion and Diversification (Future):** Looking ahead, IoT technology is expected to continue expanding into new industries and domains, including healthcare, agriculture, energy, and environmental monitoring. Advances in hardware miniaturization, energy efficiency, and sensor technology will drive further innovation, making IoT ubiquitous in our daily.

### II.2.2. IOT components

Whenwe talk about the "components" of IoT, we're referring to the hardware and software that make up an IoT device or system. The hardware component refers to the physical devices that are connected to the internet. These can be anything from sensors and cameras to cars and industrial machines. The software component, on the other hand, is the set of programs and algorithms that run on these devices and enable them to collect and analyze data, make decisions, and carry out actions. It is said that there are typically 4 main components of IOT: sensors and actuators, connectivity, data processing, and user interface [10].

- ✓ **Sensors and actuators:**

These devices collect data from the environment and carry out actions based on that data. They are sometimes referred to as "things" in IOT.Sensors are used to collect data, such as temperature, light, sound, or pressure. Actuators, on the other hand, are used to carry out an action based on the data that has been collected, such as turning on a light or opening a door.

- ✓ **Interaction:**

For the purpose of processing and analysis, the data must find a means to get to the cloud or another data storage place after it has been gathered. Herein lies the role of connectedness. The term "connectivity" refers to the range of technologies, including Wi-Fi, Bluetooth, cellular, and satellite, that are used to link devices to the internet. One of these methods is then used to transmit the data collected by the sensors via the internet.

- ✓ **Data processing:**

Data must be processed and examined through data processing in order for it to be valuable. The software and techniques used to interpret the gathered data are referred to as data processing. This might involve everything from basic data gathering to sophisticated machine learning, as was previously indicated.

- ✓ **User interface:**

Not to be overlooked is the user interface. Human interaction with IOT systems and devices is made possible by the user interface. This completes the data processing pipeline and gives us the ability to inspect the collected data or operate the devices. After all, the information gathered must be useful to us in some way, whether it is by informing us or by assisting in decision-making.

### II.2.3. Examples of Internet of Things applications

There are many examples of how the Internet of Things can be applied across various sectors to improve efficiency, enhance convenience, and enable innovative services and solutions. The capability to network embedded devices despite constraints in CPU, memory, and power resources has led to the widespread adoption of IoT across various domains.

These systems are adept at collecting information efficiently. The applications of IoT span across technology, business, and personal spheres, showcasing its versatility and limitless potential.

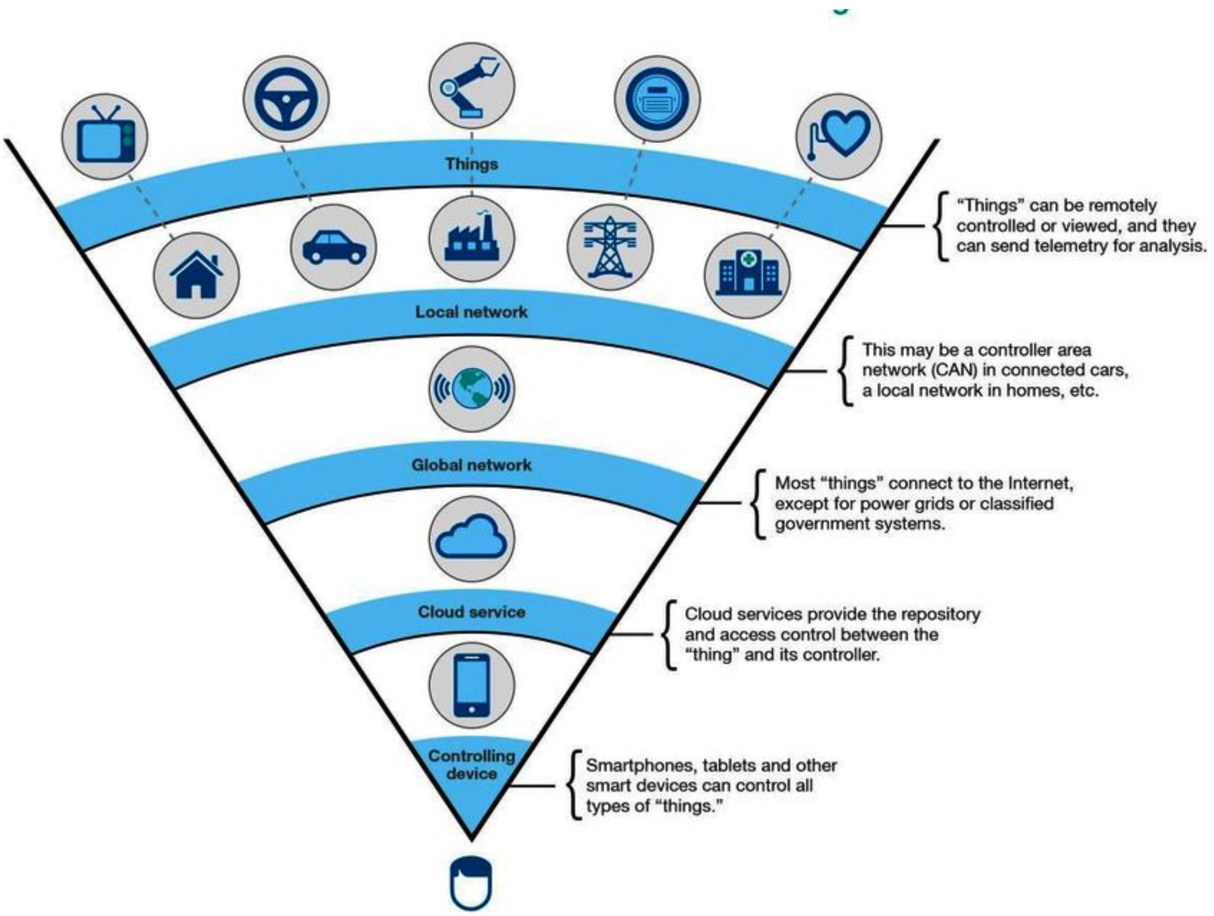


Figure II.2 :Internet-of-Things Model by IBM (IBM X-FORCE, 2016).

**a) Smart Home (Home Automation)**

Smart home technology offers users greater freedom and enhances their quality of life. Household devices connected to the internet can be monitored and controlled from anywhere, whether it's within the confines of one's home or from any part of the world.A comprehensive home automation system manages various aspects such as lighting, climate control, entertainment systems, and household appliances. Additionally, it encompasses home security features like access control and alarm systems. By integrating with the internet, these home devices become integral components of the Internet of Things (IoT).

**b) Industrial Automation**

Smart home technology integrates various household devices, offering users enhanced control and convenience. This interconnected system allows individuals to monitor and manage devices remotely, ensuring seamless control over lighting, climate, entertainment, and appliances. Advanced automation oversees tasks efficiently, while integrated security features like access control and alarms enhance home safety. By connecting to the internet, these smart devices become part of the IoT, ushering in a new era of interconnected living and improving everyday experiences.

**c) Security System**

Home and shop security systems, leveraging the Internet of Things (IoT), are now seamlessly interconnected with online networks. This connectivity not only allows for instant alerts in case of security breaches but also enables owners to remotely monitor their properties in real-time using Smartphone or other devices. Through IoT, these systems can analyze patterns and detect anomalies, providing predictive insights to prevent potential threats. Moreover, data collected from these devices can be utilized for continuous improvement, enhancing the overall effectiveness of security measures. In essence, IoT revolutionizes security, offering a dynamic, proactive approach to safeguarding homes and businesses.

**d) Agricultural Automation**

Agricultural fields are undergoing a transformative shift with the integration of IoT technologies. Sensors for soil moisture, humidity, and temperature are just the beginning; IoT enables a sophisticated network where water pumps and other equipment can be seamlessly connected to the internet. This integration facilitates real-time data collection and analysis, empowering farmers to make informed decisions remotely. Through IoT, farmers can optimize resource usage, enhance crop yields, and mitigate risks more effectively, ushering in a new era of precision agriculture that promises sustainability and efficiency in food production.

### II.2.4. Benefits and Risks of IoT

Similar to any emerging technology, the Internet of Things (IoT) offers significant advantages alongside potential drawbacks.

**- Benefits:**

1. **Enhanced Efficiency:**IoT facilitates automation and remote monitoring, optimizing processes and resource utilization.
2. **Improved Decision Making:** Real-time data collection and analysis empower informed decision-making, leading to better outcomes in various domains such as healthcare, agriculture, and manufacturing.
3. **EnhancedConvenience**: Connected devices enable seamless communication and control, enhancing convenience for users in their daily lives.
4. **InnovationandEconomicGrowth**: IoT fosters innovation, creating new business opportunities and driving economic growth through the development of smart cities, industries, and infrastructure.

**- Risks:**

1. **PrivacyandSecurityConcerns**: The vast amount of data collected by IoT devices raises concerns regarding privacy breaches and cybersecurity threats, potentially exposing sensitive information to unauthorized access.
2. **InteroperabilityIssues**: Compatibility issues between different IoT devices and platforms can hinder seamless integration and data exchange, limiting the overall effectiveness of IoT solutions.
3. **Reliability and Stability**: Dependency on interconnected devices raises concerns about system reliability and stability, as malfunctions or disruptions in one component can cascade across the entire network.
4. **EthicalandSocialImplications**: IoT raises ethical dilemmas related to data ownership, consent, and the potential exacerbation of existing social inequalities, necessitating careful consideration and regulation to mitigate negative consequences.

## II.3. Internet of Vehicle

The Internet of Vehicles (IoV) concept is fundamentally about connecting vehicles to each other and to the wider infrastructure, just like the Internet of Things but designed specifically for the automotive world. With IoV technology, cars become part of a larger network, communicating with each other, in a good and innovative way.

### II.3.1. Definition of IoV

Internet of vehicles (IoV) is a network of vehicles equipped with sensors, software, and the technologies that mediate between these with the aim of connecting & exchanging data over the Internet according to agreed standards [15, 16].

IoV evolved from Vehicular Ad Hoc Networks ("VANET", a category of mobile ad hoc network used for communication between vehicles and roadside systems) [17], and is expected to ultimately evolve into an "Internet of autonomous vehicles"[18]. It is expected that IoV will be one of the enablers for an autonomous, connected, electric, and shared (ACES) Future Mobility[19].

### II.3.2. Histories of IoV

Theinception of IoV dates back to the early 2000s, when scientists and engineers started to imagine the possible advantages of linking automobiles to the internet in order to enhance convenience, effectiveness, and safety.

- **Initial Conceptualization in the 2000s:** The emergence of modern automotive technologies and the growing accessibility of internet connectivity led to the idea of IOV. In order to improve entertainment systems, vehicle-to-vehicle communication, traffic management, and other areas of transportation, researchers and industry specialists started looking into ways to use internet connectivity.
- **Development of linked car Technologies (2010s):**During the 2010s, significant advancements in linked car technologies contributed to the realization of the Internet of Vehicles (IOV). Internet connectivity enabled features such as over-the-air software updates, remote diagnostics, and real-time navigation. Additionally, organizations like the IEEE and the Car Connectivity Consortium played a crucial role in standardizing communication protocols and interfaces for IOV systems.
- **Present-day IOV Integration with Smart Transportation Systems:** In many urban locations, IOV has become a crucial part of smart transportation networks in recent years. Governments and municipalities are making more investments in infrastructure and implementing IOV solutions in an effort to enhance traffic flow, lower accident rates, and lessen their negative effects on the environment. Furthermore, more complex uses of IOV, such autonomous driving and predictive maintenance are made possible by developments in artificial intelligence and machine learning [14].

### II.3.3. Types of communication models in IOV

- The core principle of the Internet of Vehicles (IoV) is to establish seamless connectivity between vehicles, infrastructure, and other devices, enabling real-time communication, data sharing, and coordination with the surrounding environment. IoV primarily encompasses five types of vehicular communications.
- **Vehicle-to-Vehicle (V2V):**This type of communication enables direct exchange of data between vehicles in close proximity to each other.
  - **Vehicle-to-Roadside Unit(V2R):**V2R communication facilitates real-time data exchange between vehicles and roadside infrastructure, providing updated road conditions and traffic signals to enhance safety and transportation efficiency.
  - **Vehicle-to-Infrastructure of cellular networks(V2I):** The exchange of data between vehicles and cellular network infrastructure. In V2I communication, vehicles utilize cellular networks, such as 4G LTE or 5G networks, to connect with roadside infrastructure elements and other network resources.
  - **Vehicle-to-Personal devices (V2P):**This type of communication involves the **exchange** of data between vehicles and pedestrians or other vulnerable road users, such as cyclists. V2P communication enables vehicles to detect the presence of pedestrians or cyclists in their vicinity and to communicate with them to enhance safety on the road.
  - **Vehicle-to-Sensors(V2S):**The exchange of data between vehicles and various sensors deployed within the transportation infrastructure or onboard the vehicle itself. These sensors can include cameras, radar, ultrasonic sensors, and other types of sensors used for environmental perception and situational awareness [12].

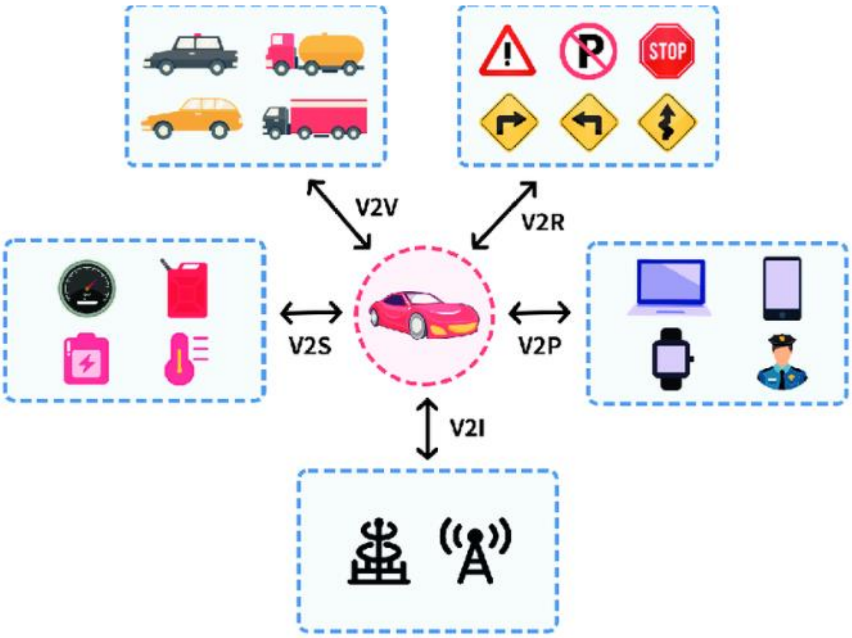


Figure II.3 :The five types of communication models in IOV.

## II.4. Synergy between IoT and IoV

The convergence of IoT and IoV creates a powerful ecosystem that enhances the capabilities of both technologies. IoT provides the foundational infrastructure for data collection and connectivity, while IoV leverages this infrastructure to improve transportation systems. Key areas of synergy include:

1. **Data Collection and Analysis:**
   - **IoT Sensors in Vehicles:**IoT sensors embedded in vehicles collect vast amounts of data, including speed, location, fuel consumption, and engine performance. This data can be analyzed to improve vehicle efficiency, predict maintenance needs, and enhance overall driving experience.
   - **Environmental Monitoring:** Vehicles equipped with IoT sensors can monitor environmental conditions such as air quality and weather, providing valuable data for urban planning and environmental protection.
2. **Real-Time Communication:**
   - **Vehicle-to-Everything (V2X) Communication:**IoV enables vehicles to communicate with each other (V2V), infrastructure (V2I), and other devices (V2D). This real-time communication enhances road safety by providing timely information about traffic conditions, accidents, and roadwork's.
   - **Connected Infrastructure:**IoT-enabled infrastructure, such as smart traffic lights and connected road signs, can communicate with vehicles to optimize traffic flow and reduce congestion.
3. **Enhanced Transportation Systems:**
   - **Autonomous Vehicles:** The synergy between IoT and IoV is critical for the development and deployment of autonomous vehicles. IoT provides the necessary data and connectivity, while IoV ensures seamless communication between autonomous vehicles and their environment.
   - **Fleet Management:**IoT and IoV enable fleet managers to monitor and manage vehicles in real-time, optimizing routes, reducing fuel consumption, and improving service delivery.
4. **Smart Cities:**
   - **Integrated Urban Mobility:** The integration of IoT and IoV is essential for the development of smart cities. It facilitates integrated urban mobility solutions, such as intelligent public transportation systems, shared mobility services, and dynamic traffic management.

- **Emergency Response:**IoT and IoV enhance emergency response by providing real-time data on traffic conditions, vehicle locations, and road incidents, enabling faster and more efficient deployment of emergency services.

## II.5. Conclusion

In conclusion, the Internet of Things (IoT) and the Internet of Vehicles (IoV) represent a revolutionary way of living, working, and traveling. By integrating these technologies, we can create smarter, more efficient systems that enhance our daily lives and address critical challenges in transportation, urban development, and beyond.

Looking ahead, effectively addressing the challenges and leveraging the potential of IoT and IoV will be essential in shaping a connected and intelligent future. These technologies are not just means of improvement but catalysts for innovation, enhancing human interaction with urban environments and transportation systems. Developing digital infrastructure, enhancing security, and promoting sustainability will bolster the global economy and create sustainable, safe environments for everyone.

Thus, IoT and IoV emerge as cornerstones for comprehensive progress towards an advanced future that integrates intelligence and advanced communications, contributing to realizing a vision of sustainable and integrated urban life.

# CHAPTER 3

# Enhancing Vehicle Security, Maintenance, and Services through IoT Solutions

# III. Enhancing Vehicle Security, Maintenance, and Services through IoT Solutions

## III.1. Introduction

In the era of modern technology, the Internet of Things (IoT) has become a fundamental element in enhancing our daily lives by enabling devices to communicate and interact more effectively. This project addresses how IoT technology can be leveraged to improve vehicle security, maintenance, and provide exceptional services to vehicle owners.

This practical and final chapter aims to demonstrate how the proposed system can be implemented in reality, covering all stages from setting up the hardware and software components to testing the system and evaluating its performance. A detailed overview of the tools used, the design and development process, as well as the challenges encountered and the solutions adopted to overcome them, will be presented.

Through this chapter, we will illustrate how a remote vehicle control system can contribute to enhancing vehicle security, reducing costs, and providing a comfortable experience for users. The study will include a practical demonstration of how sensors, cameras, and software applications integrate to create an efficient and scalable system, thereby improving the efficiency and security of vehicles in our daily lives.

## III.2. General definition of the topic

A system of solutions based on the Internet of Things to enhance the security, maintenance, and services of cars within the framework of establishing an emerging institution is seen as a program that helps in remote control and monitoring of cars and benefiting from their services, in addition to benefiting from the Internet of Things in communication between vehicle owners through a mobile phone application. Engine maintenance and advance alert, in addition to many services.

The system for enhancing car security, maintenance and services is a useful tool for everyone who owns a vehicle and thinks about its safety, and for owners of car sales agencies and car maintenance shops. This project targets this group, which is present in large numbers.

# III.3. IOV based solutions

As IoT technology advances, new solutions have been developed to increase the safety and maintenance of vehicles. These solutions rely on the use of some devices, such as sensors, surveillance cameras, and audio alarms, to provide accurate monitoring of the vehicle's condition and predict potential malfunctions. The following are the solutions reached in our project:

## III.3.1. IOV-Based security solution

### III.3.1.1. App. Security:

- Robust encryption techniques safeguard your personal and vehicle data.
- Regular app updates address any potential security vulnerabilities.
- Your data is stored on secure, highly protected servers.

### III.3.1.2. Hardware Security:

- High-quality electronic components from reputable companies are employed.
- Device firmware is regularly updated to address any security vulnerabilities.

### III.3.1.3. Security Features:

1) **Anti-theft Alarm System:**

- The device incorporates a vibration sensor to detect theft or vandalism attempts.
- Upon detecting a theft attempt, an alert is sent to your Smartphone and the alarm siren is activated.
- The battery and the fuel pump can also be cut off to prevent the thief from starting thevehicle.

2) **Surveillance Camera:**

- Remotely view your car's surroundings using the surveillance camera.

3) **Engine Temperature Monitoring:**

- Monitor engine temperature remotely using the app.
- If the engine temperature rises abnormally, an alert is sent to your Smartphone.

4) **Privacy Policy:**

- We are committed to protecting your privacy and only use your data for the purposes specified in our privacy policy.
- We will not share your data with any third party without your explicit consent.

### III.3.2. IOV-Basedmaintenance solution

- Use a temperature and humidity sensor to monitor the engine temperature and the data is sent periodically to the mobile application, allowing vehicle owners to constantly monitor the condition of their vehicles and take preventive measures and early measures in the event of any problems.
- Use a display screen and use the project’s application to alert vehicle owners when the temperature increases so that they can take the necessary precautions and measures before it is too late and before exposure to risks.

### III.3.3. IOV-Based services solution

#### III.3.3.1. Services performed in the application:

- Lock and unlock vehicle doors remotely using the application.
- Turning the vehicle's engine on and off remotely
- Monitor key vehicle metrics, such as fuel level, tire pressure, and battery health.
- Browse and buy used or new cars easily through our integrated marketplace.
- Sell your car safely and efficiently.
- Control your car's climate control system remotely.
- Roadside assistance 24 hours a day in case of breakdowns, accidents or other emergencies.
- Receive timely reminders for essential vehicle maintenance tasks, such as temperature monitoring

#### III.3.3.2. Services in progress and development:

- Receive timely reminders for essential vehicle maintenance tasks, such as oil changes, tire rotations, and filter replacements.
- Schedule maintenance appointments directly through the app with our network of trusted service providers.
- Access real-time diagnostic reports about your vehicle's health, identifying potential problems early.
- Easily locate and reserve parking locations in advance, especially in busy areas.
- Schedule car wash and cleaning services at your convenience, directly from the app.
- Choose from a variety of service packages to suit your needs and budget.
- View your vehicle's condition and driving patterns to enhance your overall safety.

### III.3.4. Explain some parts of the system

In this presentation, we will explain each part of the project and the results we reached:

#### III.3.4.1. Part of the components used

**1) Raspberry Pi 4**

The Raspberry Pi 4 is a smaller version of a modern-day computer capable of performing task effectively. The module utilizes various kinds of the processor; therefore, it can only install opensource operating systems and apps on it. Pi also enables the user to browse the internet, send emails, write documents using a word processor, and much more. Raspberry Pi supports various programming languages such as Python, C, C++, BASIC, Perl and Ruby [29].

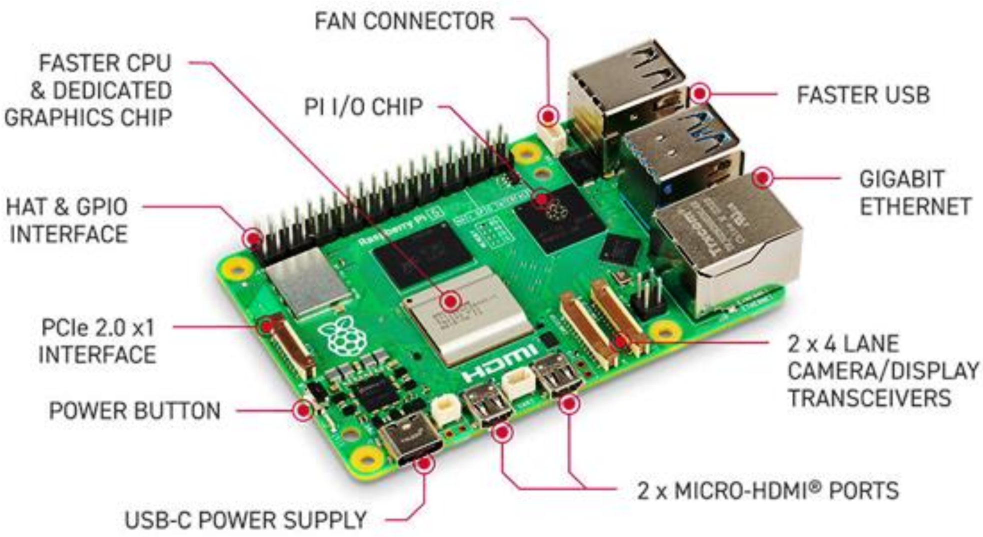


Figure III.1:Raspberry Pi 4.

TableIII.1: Raspberry Pi Key Properties.

| | |
|---|---|
| Processor | Broadcom BCM2711, Quad-core Cortex-A72 (ARMv8) 64-bit SoC @ 1.5GHz. |
| Memory | Options for 2GB, 4GB, or 8GB LPDDR4-3200 SDRAM. |
| Storage | MicroSD card slot for operating system and data storage. |
| Connectivity | ▪ 2 × USB 3.0 ports<br>▪ 2 × USB 2.0 ports<br>▪ 2 × micro HDMI ports supporting up to 4K resolution<br>▪ Gigabit Ethernet<br>▪ 2.4 GHz and 5 GHz IEEE 802.11b/g/n/ac wireless LAN<br>▪ Bluetooth 5.0, BLE |
| GPIO | 40-pin GPIO header for connecting peripherals and expansion. |
| Power | 5V/3A DC via USB-C connector. |
| Operating System | Supports various Linux distributions (Raspberry Pi OS, Ubuntu, etc.) and can run Windows 10 IoT Core. |

**Applications:**

- Educational projects (teaching programming and electronics).
- Home automation.
- IoT (Internet of Things) applications.
- Robotics.
- Server applications.

**2) ArduinoMega:**

The Arduino Mega is a powerful microcontroller board based on the ATmega2560 microcontroller. It is widely used for more complex projects that require a larger number of input/output pins, more memory, and higher processing power compared to other Arduino boards like the Arduino Uno. It is designed to make it easier to use electronics specifically, Atmel AVR-type microcontroller processors in a variety of applications, Arduino is an open-source single-board microcontroller that was created from the Wiring Platform IC [2].

The microcontroller is an integrated circuit, or chip, that a computer can program. A microcontroller's program is embedded in order for the electronic circuit able to comprehend the information, process it, and generate the intended result. As a result, the microcontroller functions as the brain that manages the insertion and removal of electronic circuits. Compose. For a manuscript, the minimal need for this template is to adhere to this advice.

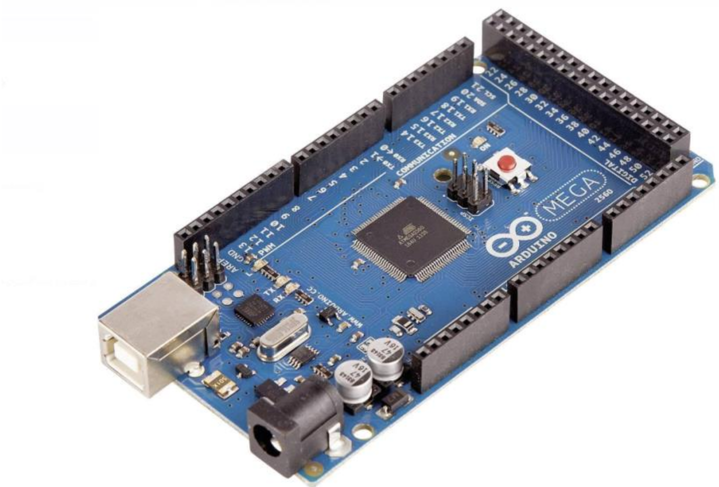

Figure III.2 :Arduino mega 2560.

The board has multiple I/O pins, including 4 UART (hardware serial ports) ports, 16 analog input pins, and a total of 54 digital I/O pins, 15 of which are PWM pins. A 16 MHz oscillator, USB, DC power connection, ICSP header, and reset button are all features of the Mega port Arduino 2560. This board has everything microcontroller needs [21].

Table III.2: ArduinoMega 2560 Specifications.

| **Microcontroller** | **ATMega2560** |
|---|---|
| Operating Voltage | 5 V |
| Input Voltage (recommended) | 7-12 V |
| Input Voltage (limit) | 6-20 V |
| Pins 1/0 Digital | 54 (of which 14 provide PWM outputs) |
| Analog Input Pins | 16 |
| DC Current Per 1/0 Pin | 40 mA |
| DC Current For Pin 3.3 V | 50 mA |
| Flash Memory | 256 kb of which 8 kb is used by the bootloader |
| SRAM | 8 kb |
| EEPROM | 4 kb |
| Speed Clock | 16 MHz |

**3) SW-420 Vibration Sensor :**

The SW-420 vibration sensor is designed to detect vibrations and trigger actions based on those vibrations. It consists of a spring-mounted mass that moves in response to vibrations, causing the contacts to open or close, thus generating a signal.

Figure III.3 : Vibration sensor.

- **Working Principle:**

The sensor works on the principle of an SW (spring washer) touching a metal conductor in the absence of vibration. When vibration occurs, the mass moves, breaking the connection and altering the output signal.

- **ThresholdAdjustability**:

Some models may feature a potentiometer to adjust sensitivity, allowing customization based on application requirements.

- **ResponseTime**:
  Rapid response to vibrations, making it suitable for real-time applications.

Table III.3: SW-420 Vibration Sensor Specifications.

| | |
|---|---|
| Operating Voltage | Typically operates at 3.3V or 5V. |
| Output Signal | Digital output signal (HIGH or LOW) depending on vibration intensity. |
| Sensitivity | Can detect slight vibrations to more intense shaking. |
| Interface | Typically has three pins: VCC (power supply), GND (ground), and OUT (output signal). |
| Dimensions | Small form factor, typically around [insert dimensions here]. |

**Typical Applications:**

- Vibration Detection: Used in alarm systems, thief alarms, earthquake detection, etc.
- Impact Sensing: Can be utilized in devices to detect impacts or collisions.
- Condition Monitoring: Employed in industrial machinery to monitor vibrations for maintenance purposes.

**Limitations:**

- False Positives: May trigger false positives due to sensitivity to external vibrations.
- Single Axis Detection: Typically detects vibrations in a single axis.
- Limited Range: Effective detection range may vary based on environmental factors and mounting orientation.

**Tips for Usage:**

- Mounting: Securely mount the sensor to minimize false triggers.
- Calibration: Adjust sensitivity based on the desired application and environmental conditions.
- Signal Processing: Implement filtering or debouncing techniques in software to handle noisy signals.

**4) Sensor DHT11:**

The DHT11 is a basic digital temperature and humidity sensor. It uses a capacitive humidity sensing element and a thermistor for temperature measurement.

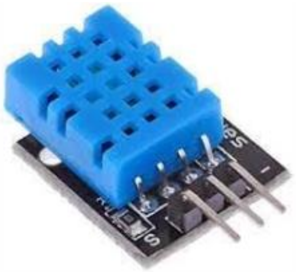

Figure III.4 :Temperature sensor.

Table III.4: DHT11 Key Properties.

| | |
|---|---|
| Measured Parameters | Temperature and Humidity |
| Output | Digital (Single-bus serial data) |
| Operating Voltage | 3.3V - 5.5V |
| Operating Humidity | 20% - 80% RH (non-condensing) |
| Operating Temperature | -40°C to +50°C |
| Temperature | 0°C to 50°C (Accuracy: ±2°C) |
| Humidity | 20% - 80% RH (Accuracy: ±5% RH) |
| Data Update | Approximately 1Hz (reads data once per second) |
| Dimensions | 3.5 cm x 1.5 cm x 2.5 cm |

**Applications:**

- Weather monitoring stations.
- Home automation systems.
- Thermometers and hygrometers.
- Indoor air quality monitoring.
- Environmental monitoring systems.

**Limitations:**

- Accuracy is moderate compared to higher-end sensors.
- Limited operating temperature and humidity range.
- Not suitable for outdoor applications without proper enclosure.

**Additional Considerations:**

- Requires an external pull-up resistor for the data line.
- Data protocol is single-bus and requires timing for reading data.
- Several libraries are available for microcontrollers to simplify communication with the DHT11 sensor [28].

**5) Relay JCC-3FF (SPDT):**

A JCC-3FF relay is a type of electromagnetic relay commonly used in various electrical applications.


Figure III.5: Relay JCC-3FF.

TableIII.5: Relay JCC-3FF Key Properties.

| | |
|---|---|
| Type | Single Pole, Double Throw (SPDT). |
| Source | Information compiled from various sources due to the difficulty of finding a specific datasheet for the JCC-3FF relay. |
| Coil Voltage | Specifies the voltage required to energize the relay coil (e.g.,5V,12V, 24V). |
| ContactRating | Specifies the maximum voltage and current the relay contacts can handle (e.g., 10A at 250VAC, 10A at 30VDC). |
| Pin Configuration | Coil Pins (2 pins): For connecting the power supply to energize the coil. |
| | Common (COM),Normally Open (NO), Normally Closed (NC): |
| Operating | Generally between -40°C to +85°C |

| | |
|---|---|
| Temperature | |

**Applications:**

SPDT relays like the JQC-3FF are used in:

- Automotive: Used for switching lights, motors, and other circuits.
- Industrial Control Systems: Controls machinery and processes.
- Consumer Electronics: Used in appliances, HVAC systems, etc.
- Telecommunications: Used in network equipment for routing signals.
- Home Automation: Switching devices in smart home systems.

**6) Esp32-Cam:**

This module is a Wi-Fi module that is equipped with a camera. From this module it can be used for various purposes, for example for CCTV, taking pictures and so on. Another feature is that it can detect faces and face recognition.

The ESP32 cam has a very competitive small size camera module that can operate independently with a minimum system. ESP32 cam can be used widely in various IoT applications. It is suitable for smart home devices, industrial wireless control, wireless monitoring, QR wireless identification, wireless positioning system signals and other IoT applications. Several studies [23], [24] have used ESP32 cam as an ideal solution for IoT applications.


Figure III.6:Esp32-Cam.

**7) GSM SIM 900A:**

The SIM900A is a GSM module commonly used for wireless communication in embedded systems and IoT (Internet of Things) applications. GSM SIM900A supports GSM network, allowing devices to communicate wirelessly over mobile networks.


Figure III.7:GSM SIM 900A.

TableIII.6: SIM 900A Key Properties.

| | |
|---|---|
| Network | GSM/GPRS/EDGE |
| Bands | GSM 900/1800 MHz |
| Data rates: | GPRS: up to 40 kbps, EDGE: up to 236 kbps |
| Messaging | SMS, MMS, USSD |
| Interface | UART |
| Power supply | 3.3V |
| Operating temperature | -20°C to +70°C |
| Dimensions | 27.0 mm x 25.0 mm x 3.3 mm |

**Applications:**

- Remote Monitoring and Control Systems: Enables remote data monitoring and device control.
- IoT (Internet of Things): Provides connectivity for IoT devices in remote areas.
- Vehicle Tracking Systems: Facilitates real-time tracking of vehicles for fleet management.
- Home Automation: Integrates into systems for remote control of appliances and security.
- Security Systems: Sends alerts and notifications via SMS or GPRS.
- Smart Metering: Monitors and manages utility consumption remotely.
- Industrial Automation: Enables remote monitoring and control of machinery.
- Environmental Monitoring: Transmits environmental data for monitoring purposes [25].

### 8) Camera Logitech BRIO 4K

The Logitech BRIO 4K is a popular webcam known for its high-resolution video capabilities and advanced features.It is popular among professionals and content creators who require high-definition video quality for video conferencing, streaming, content creation, and more. Its combination of 4K resolution, autofocus, and advanced features makes it a versatile and powerful webcam choice.


Figure III.8:Webcam Logitech brio 4k.

**9) Application Mobile:**

A mobile application, often referred to as a mobile app, is a software application designed to run on mobile devices such as Smartphones and Tablets. These apps are developed specifically to provide users with various functionalities, services, or entertainment options tailored to the mobile platform. They can be downloaded and installed from app stores like the Apple App Store or Google Play Store and can serve a wide range of purposes, from productivity tools and social networking to gaming and multimedia consumption.

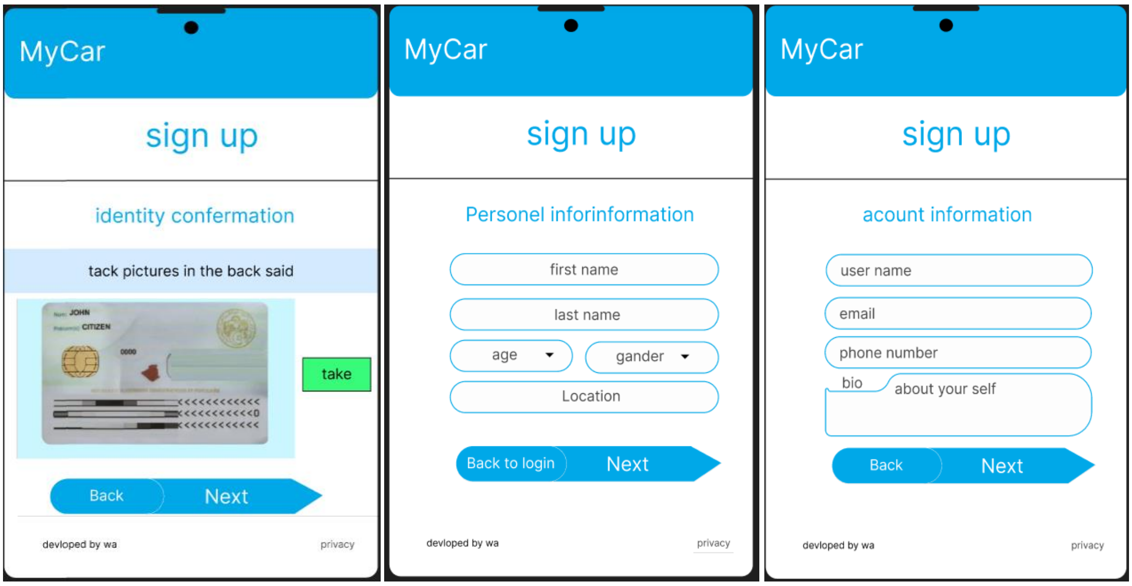


Figure III.9:Application Mobile.

### III.3.4.2. An explanation of each part and how it fits into the system

a) The Arduino Mega 2560 serves as the hub for data collection from sensors and the transmission of orders to other devices.

b) The Raspberry Pi 4 acts as the central processing unit, handling data analysis, decision-making algorithms, and interfacing with external systems."

c) The ESP-CAM32 camera records videos and images that may be viewed remotely. It also offers visual monitoring.

d) The SIM900A Module facilitates GSM-based remote communication, enabling the system to transmit and receive commands through a mobile app.

e) SW-420 Sensor: If it senses vibrations that could be signs of theft or tampering, it will sound an alarm or send out a notification.

f) JCC-3FF Sensor: Prevents theft and accidents by automatically shutting off the fuel pump and monitoring current levels.

g) DHT11 Sensor: Provides vital information to prevent engine overheating and guarantee ideal operating conditions by monitoring temperature and humidity levels.

### III.3.4.3 UsedPrograms:

**a. Figma*:***

Figma is a web-based collaborative interface design tool. It's known for its versatility in enabling teams to create, prototype, and collaborate on digital designs in real-time. Figma allows multiple users to work on the same project simultaneously, making it popular among designers and teams who need to collaborate remotely or across different locations. It supports features like vector graphics editing, prototyping, and developer handoff, making it a comprehensive tool for design workflows.

Figma offers a smooth experience for users to access their projects from any location, whether they are using desktop programs or web browsers. Its collaborative capabilities facilitate effective teamwork and faster processes by allowing numerous users to work together on the same project.

Figure III.10:Figma logo.

We summarize some additional key features and aspects of Figma:

1. Web-Based Tool: Accessible via web browser across different operating systems.
2. Real-Time Collaboration: Multiple users can work simultaneously on the same design file.
3. Vector Editing: Supports scalable and high-quality graphics suitable for various screen sizes.
4. Prototyping: Create interactive prototypes to visualize user interactions.
5. Design Systems: Create and manage reusable components and styles for consistency.
6. Plugins and Integrations: Extend functionality with a variety of plugins and integrate with other tools.

These points encapsulate why Figma is widely favored among designers and teams for its collaborative, versatile, and efficient design capabilities.

#### b. Bootstrap:

Bootstrap is a framework used for creating responsive and mobile-first websites and web applications. It provides pre-styled components, a responsive grid system, customization options, extensive documentation, and strong community support, making it popular for rapid web development.

Figure III.11: Bootstrap logo.

#### c. Angular:

A platform used to develop the dynamic web application and ensure smooth interaction between the app and the backend.

Figure III.12: Angular logo.

**d. Arduino IDE:**

An application called Arduino IDE (Integrated Development Environment) is used to program Arduino boards. It gives code writers, compilers, and Arduino board up-loaders an easy-to-use interface. The Arduino programming environment's guiding principles are followed by the C++ code that makes up the Arduino IDE.

The Arduino Development Environment (IDE) comes with a code editor that highlights syntax, a serial monitor for communicating with Arduino boards and debugging, and a library manager for adding and organizing external libraries with ease. It may be expanded with other libraries and tools, and it supports a wide range of Arduino boards.

The Arduino IDE software is available under the GNU General Public License (GPL), which makes it open-source. It may be installed on Windows, macOS, and Linux operating systems and is freely accessible for download.

Figure III.13:Arduino logo.

## III.3.5. System Design

### III.3.5.1. System diagrams

1) **Electrical Schematics**: Detailed diagrams showing how each component is connected to the Arduino Mega 2560.

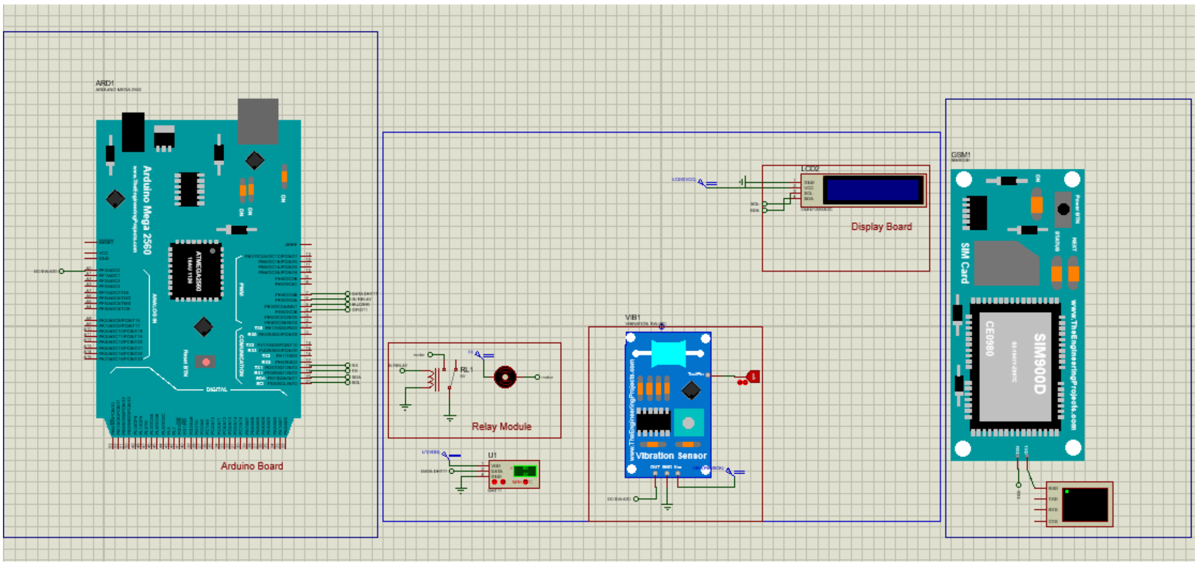


Figure III.14: Electrical Schematics using Proteus.

2) **Flowcharts and Graphical Representations**: Illustrations depicting the data flow and interaction between the components and the mobile application.

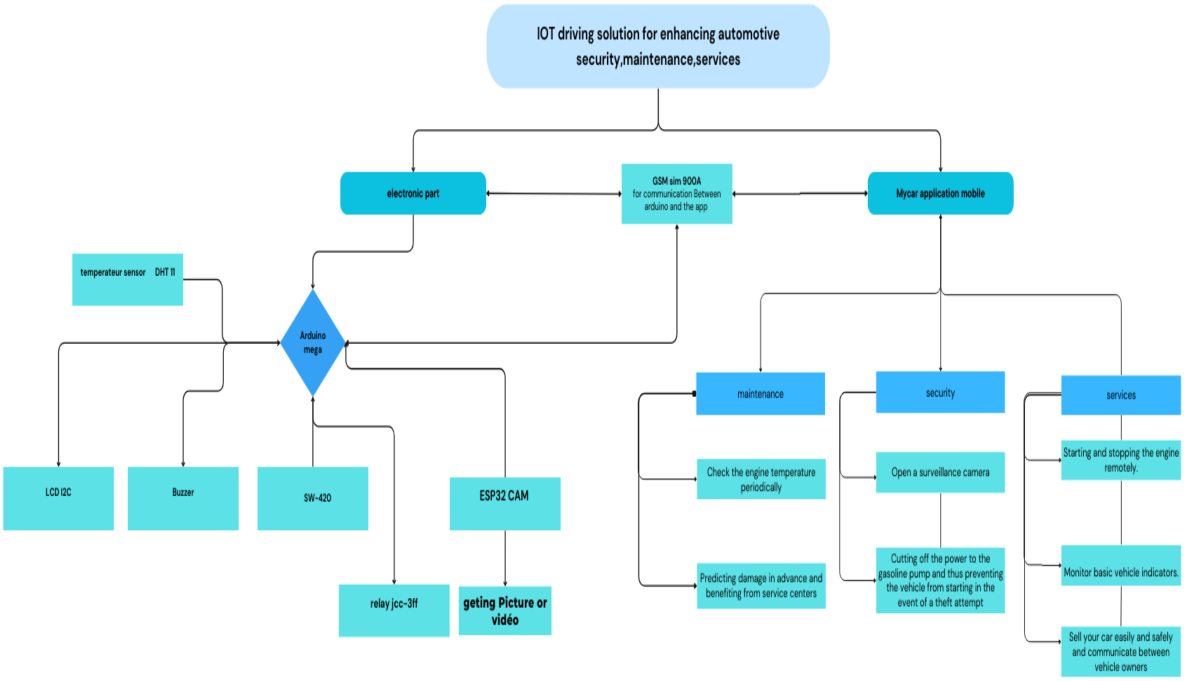


Figure III.15: Graphical Representations using Canva.

3) **User Interface Design Using Figma:** Design the layout of the MyCar application, including screens for monitoring vehicle status, receiving alerts, and controlling various functions remotely.

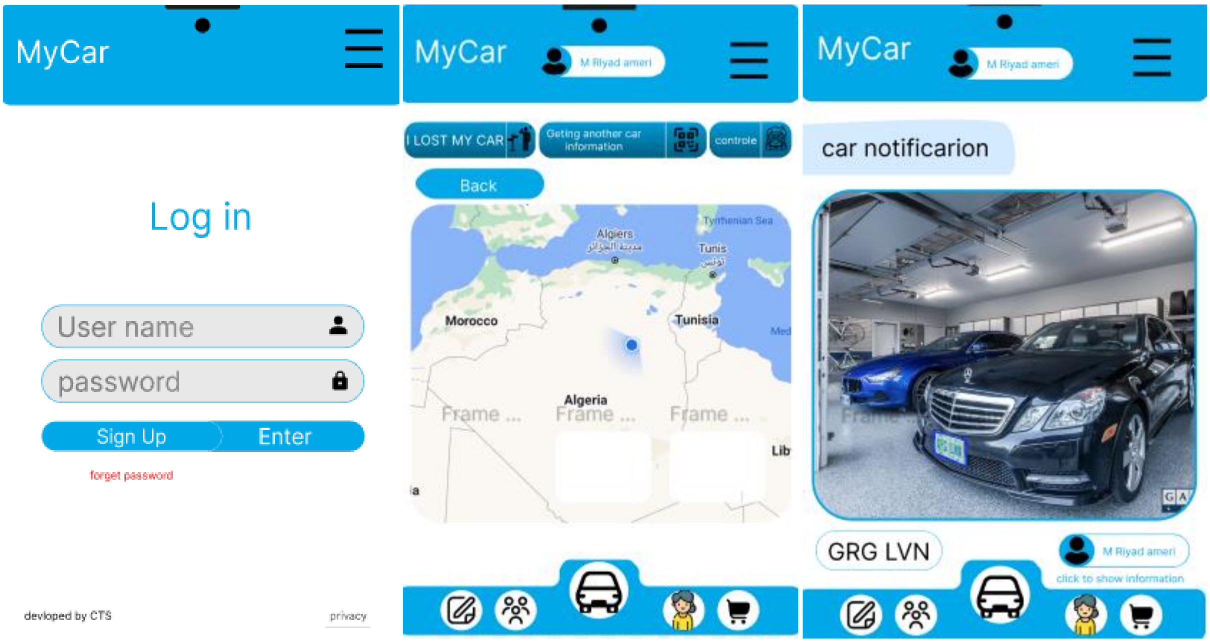


Figure III.16: User Interface design Using Figma.

### III.3.5.2. System Development

1) **Programming the Arduino Mega 2560:**

Programming the Arduino Mega 2560 involves writing code to interact with various sensors and devices, process data, and communicate with the mobile application. we will show you the steps we took to program the Arduinomega2560:

1. Download and install Arduino IDE from the official website.
2. Install necessary libraries for the components like Softwareserial,DHT,Wire,esp32 Camera,sim900,LiquidCrystal_I2C
3. Connecting the components :
   - Connect the camera to the Arduino Mega 2560 using appropriate GPIO pins.
   - Connect the GSM module to the Arduino Mega 2560 using serial communication pins (TX, RX).
   - Connect the vibration sensor to an analog input pin.
   - Connect the relay to a digital input pin.
   - Connect the dht11sensor to a digital input pin.
   - Connect the display to the I2C pins (SDA, SCL).
   - Connect the buzzer to a digital output pin.

4. Writing and testing the code.

**2) Connect GSM to Arduino Mega 2560:**

We connect the Arduino pins with GSM like this:

TXD (SIM900A) to RX (Arduino Mega 2560, pin 18)

RXD (SIM900A) to TX (Arduino Mega 2560, pin 19)

GND (SIM900A) to GND (Arduino Mega 2560)

VCC (SIM900A) to 5V (Arduino Mega 2560)

Initial Setup and Testing

Insert SIM Card:

Insert an active SIM card into the SIM card slot on the SIM900A module.

Check Network Connection:Power on the SIM900A module. We see the status LED blinking. A fast blink (every second) indicates that the module is not connected to the network. A slow blink (every 3 seconds) indicates that the module is connected to the network.

Test Communication:We open the Arduino IDE and try an example code for the Arduino Mega 2560 to communicate with the SIM900A module.

**3) Developing MyCar Application:**

- **Angular**

- To start a project, install the Angular CLI and type ngnew project-name.
- Use ng generate component component-name to create components.
- Create TypeScript application logic.
- Use app-routing.module.ts to create routes and set up routing.
- Use ng generate service service-name to create services to manage data.
- Add services to individual parts.

- **The Bootstrap**

- Use npm to install bootstrap to get started.
- Add the JS and CSS files to the angular.json file.
- Use HTML templates that incorporate Bootstrap components.
- Use CSS classes to apply styles.
- To create responsive interfaces, use the grid system provided by Bootstrap.
- Testing: Run tests on various devices and browsers for the application.
- Build: Use ng build --prod to create the application for production use.
- Installation: Install the application on a web server.

- You may construct cutting-edge mobile applications with a visually appealing and responsive user interface by utilizing Angular and Bootstrap.

#### III.3.5.3. Integration Tests and functionality

The goal of this testing protocol is to verify the correct integration and functionality of various sensors, a camera module, and a communication module connected to an Arduino Mega 2560.

- **Sensor Integration Testing (Sensors Used: SW-420, JCC-3FF, DHT11,…):**

1. Connect each sensor (SW-420, JCC-3FF, DHT11,…) to the Arduino Mega 2560 according to their respective pin configurations.
2. Upload the appropriate Arduino sketch to read sensor data.
3. Manually activate each sensor to ensure it outputs the correct readings.
4. Monitor the output on the Arduino IDE Serial Monitor.
5. Measure and record the response time for each sensor.

- **Camera Integration Testing (Camera Used: ESP32-CAM):**

1. Connect the ESP32-CAM module to the Arduino Mega 2560.
2. Load the ESP32 Camera Web Server sketch to the ESP32-CAM.
3. Access the camera feed via a web browser by entering the IP address of the ESP32-CAM.
4. Test remote photo and video capture functionalities.

- **Communication Module Integration Testing (Module Used: SIM900A (GSM/GPRS)):**

1. Interface the SIM900A module with the Arduino Mega 2560.
2. Insert a SIM card into the SIM900A module.
3. Verify network connectivity by sending AT commands through the Arduino to SIM900A.
4. Test data packet sending and receiving functionalities using the MyCar Application.
5. Check for adequate signal strength from various locations to ensure reliable connections.

- **System Testing:**

System testing involves verifying the complete functionality of the entire integrated system.

- **Connection Verification:**

1. Ensure all sensors (SW-420, JCC-3FF, DHT11), the ESP32-CAM, and the SIM900A module are correctly connected to the Arduino Mega 2560.
2. Verify that the uploaded code runs without errors and all sensors are initialized properly.

- **User Interface and Data Monitoring (Tools Used: Bootstrap, Angular):**

1. Develop a user interface for status monitoring using Bootstrap and Angular.
2. Ensure the application correctly displays real-time data from the sensors.
3. Test the alert system by triggering each sensor and confirming immediate alerts are received.

4. Verify remote control functionalities such as Start/Stop engine actions through the user interface.

### III.3.5.4. Examples of tests performed

In this section, examples of the tests performed to ensure that the system functions correctly and achieves the desired objectives are presented. These tests include verifying the system's functionalities. The following images illustrate some of the tests conducted:

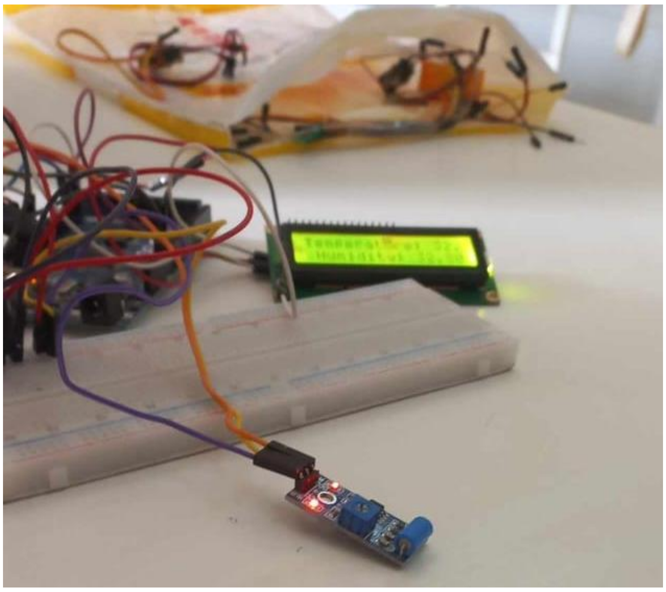

Figure III.17:Testing vibration sensor and the LCD.

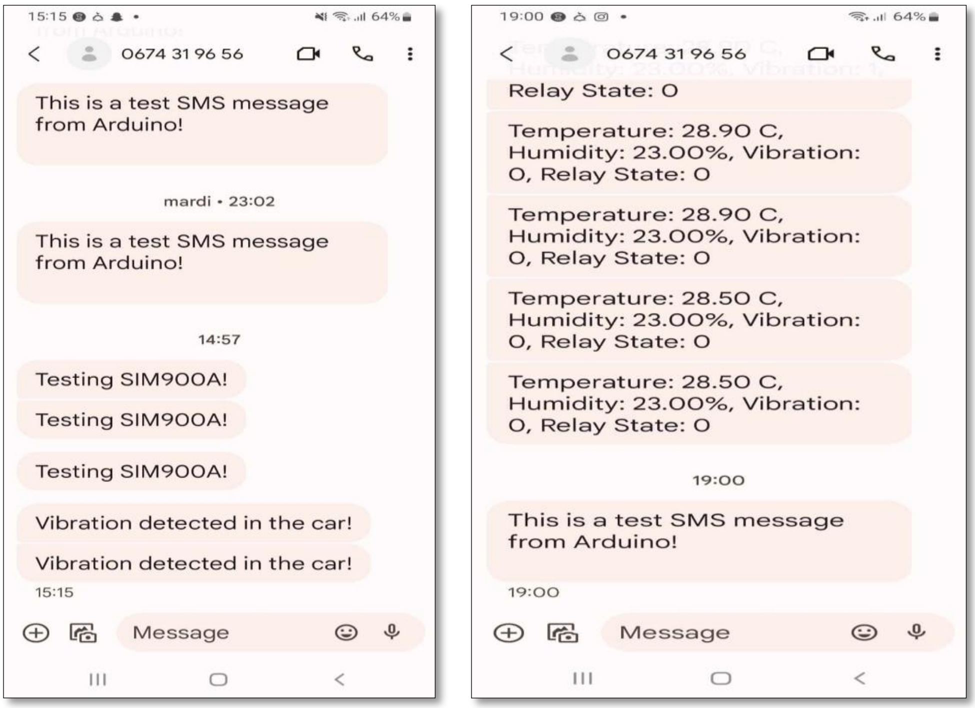


Figure III.18:Test SIM900A and vehicle sensors detection SMS.

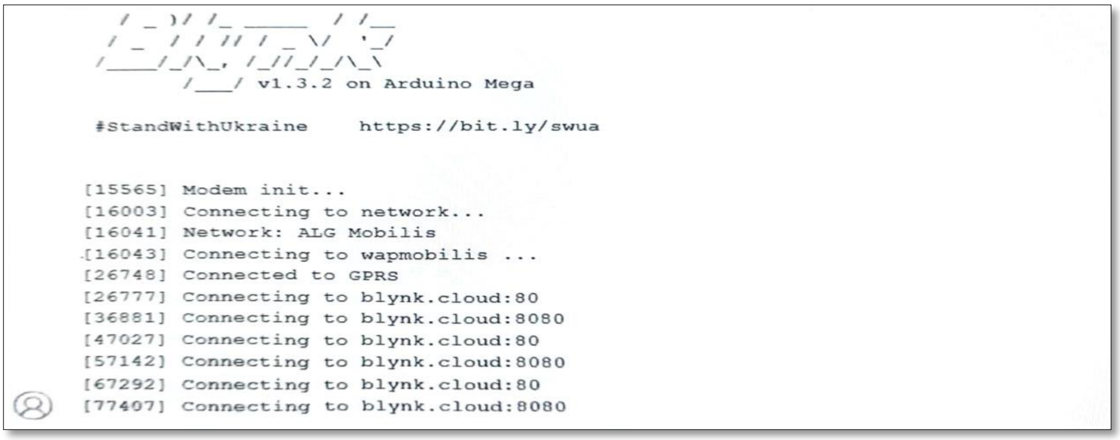


Figure III.19: Connect the BLYNK with Arduino by GSM.

#### III.3.5.5. Document the results obtained

- **Temperature Monitoring Test**: The engine temperature was successfully monitored, and alerts were sent when the temperature rose, demonstrating the system's effectiveness in early detection.
- **Vibration Detection Test**: The sensor detected significant vibrations and sent alerts to the application and phone, confirming the sensor's sensitivity.
- **Integration Test**: All system components worked together seamlessly without conflict.
- **Stress Test**: The system maintained stable performance under harsh conditions and intensive use.
- **User Acceptance Test**: Users expressed satisfaction with the system's performance and ease of use.
- **Performance Test**: The system exceeded industry standards in accuracy and responsiveness, making it a cost-effective and functional solution.

#### III.3.5.6. Challenges and solutions

**1) Challenges encountered during project implementation**

At the beginning of the project, we wanted to use a Raspberry Pi board and program it with a Logitech camera. We succeeded in this process, but we found a problem with the high price of these elements. We also found it difficult to enter sensors and program them with the camera. Therefore, we used an Arduino board to reduce the cost and programming easily.

After installing the Raspberry Pi board and going through the necessary configuration steps, we come to the programming. We programmed the camera to work to take pictures and videos and save them on a microSD memory card. This process was successful, we present in the following images the code used, and the results obtained:

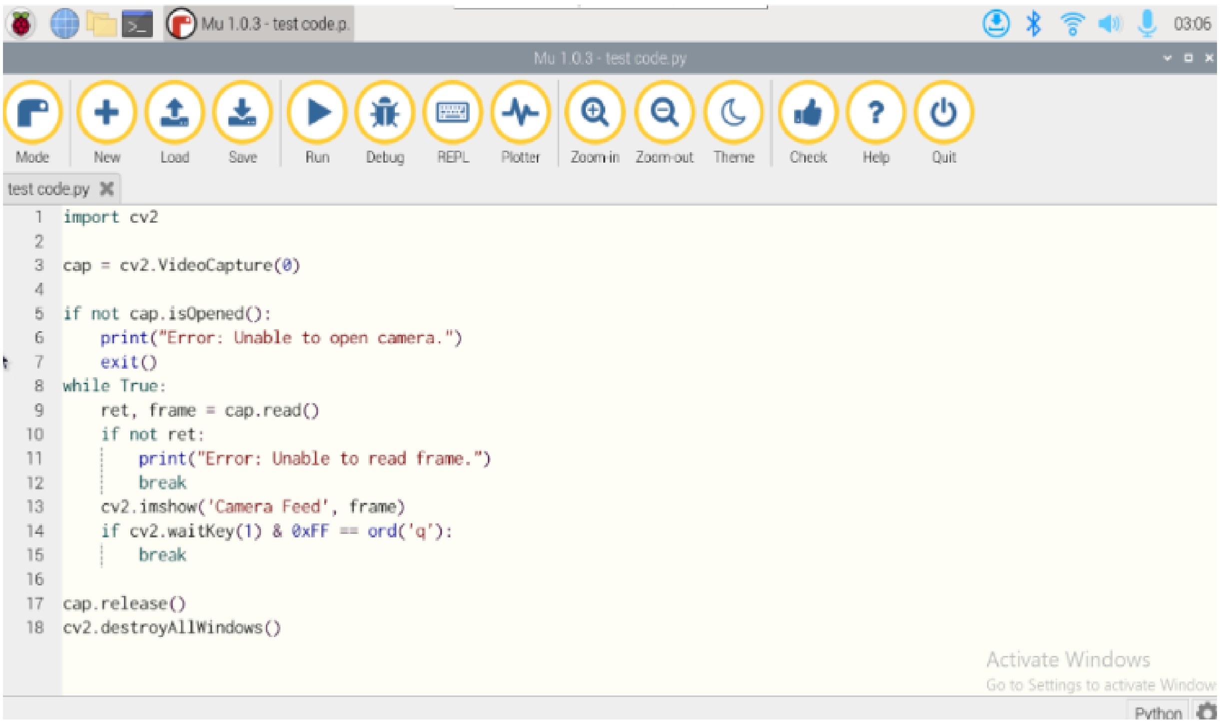


Figure III.20: RaspberryPi code.

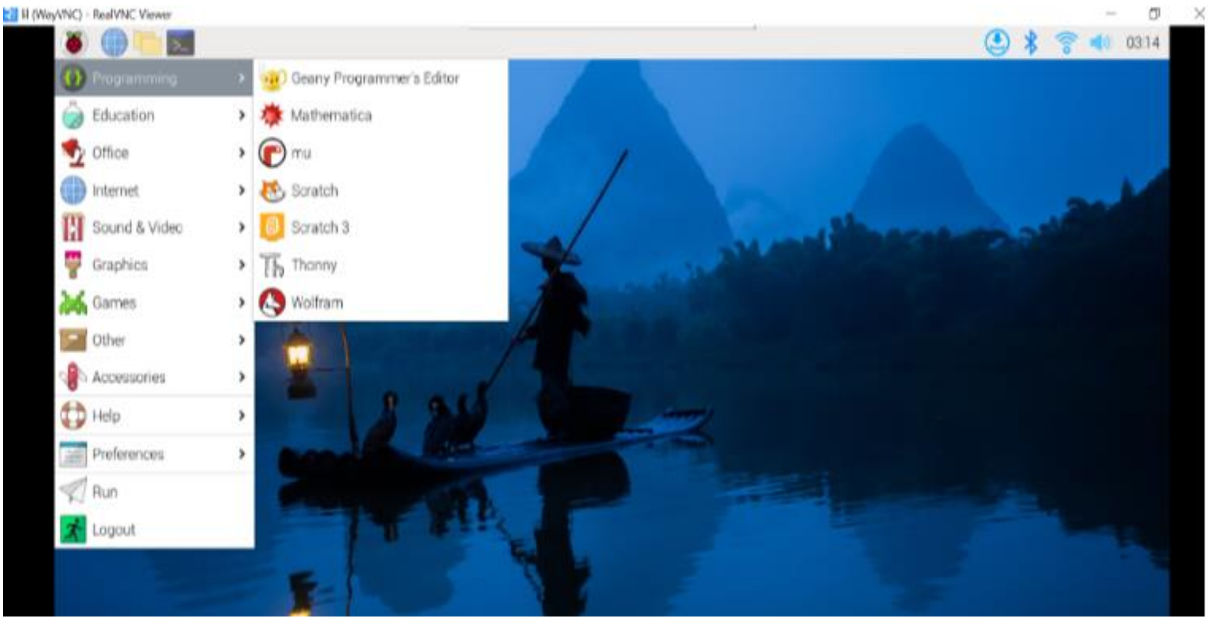


Figure III.21:Raspberry pi interface.

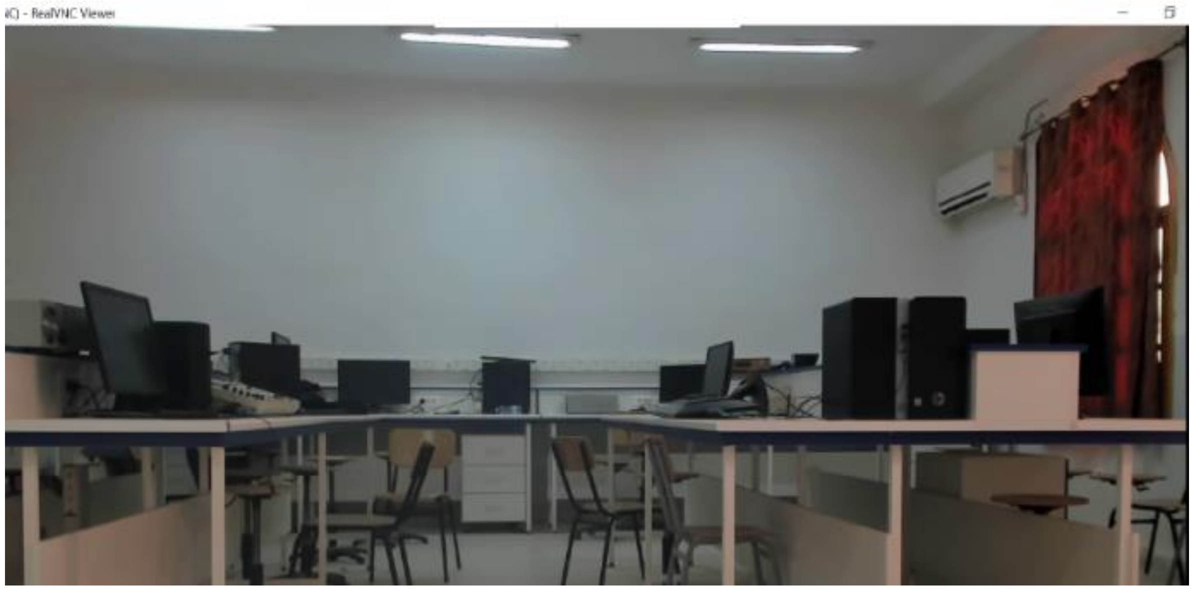


Figure III.22:Camera picture.

### 2) The solutions that have been taken to overcome these challenges

To address the challenges encountered during the development and implementation of the vehicle security, maintenance, and automation project, several solutions were implemented. These solutions aimed to ensure system reliability, ease of use, and time efficiency.

Below are the solutions adopted to overcome the challenges:

Using the Arduino Mega board, instead of the Raspberry Pi card to reduce costs. This choice makes the system more economical and accessible to a wider range of users. Additionally, it accelerates the programming process due to our prior experience in this field, the availability of Arduino Mega, and its faster response time in controlling physical devices such as sensors, which is vital for vehicle automation and security. Moreover, the wide availability of libraries used in programming for Arduino platforms further facilitated software development, reducing the time required to write instructions from scratch. These solutions significantly accelerated the software development process and minimized the time needed to write instructions from scratch.

### 3) Ideas to expand and improve the project in the future

Here are some ideas to expand and improve the project in the future:

1. Adding GPS for vehicle location tracking.
2. Replacing Arduino with an electronic card that meets the project's needs.
3. Adding a device for measuring both current and voltage to monitor the vehicle's battery.
4. Adding a gas sensor in case the vehicle is equipped with a gas system.
5. Adding a service for contacting vehicle recovery trucks in case of breakdowns.

6. Communication service withvehiclerepair services.
7. Online payment service.
8. Maintenance reminder service for important vehicle maintenance dates.
9. Contracting with government institutions to obtain a larger database, such as the Department of Energy and Mines in the state of Ouargla.
10. Obtaining information about vehicles and their owners.
11. Contracting with public and economic institutions.

**4) Final results of the project:**

After conducting research, tests, and necessary software development on the device to achieve the desired results and objectives, we arrived at the following conclusions:

Figure III.23:Final project.

Here we have a vibration sensor that detects vibrations and sends signals to the circuit breaker automatically. It has two values: either one or zero.

Figure III.24:Vibration sensor SW-420.

After a vibration is detected in the vehicle, the vibration sensor captures a signal that automatically cuts off the current to the relay JCC-3FF, as shown in the image below:

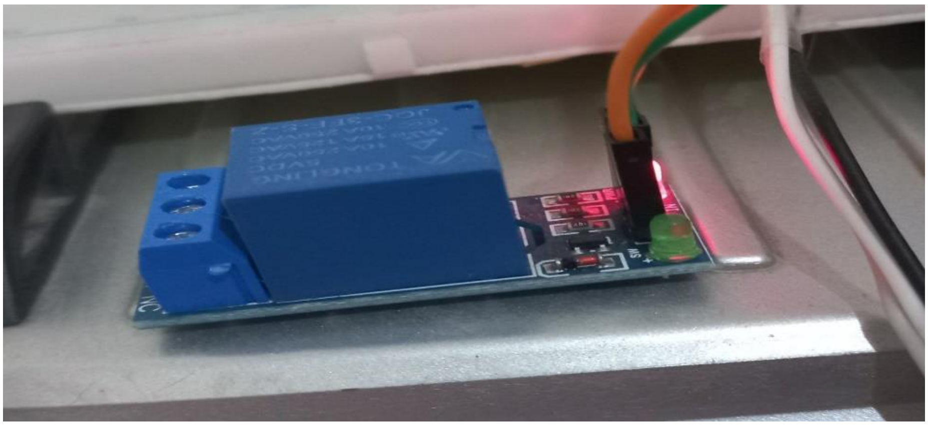

Figure III.25:Relay On.

A surveillance cameraESPCAM-32is installed on the side of the car. In case of danger, it captures an image or video clip of the car's surroundings.

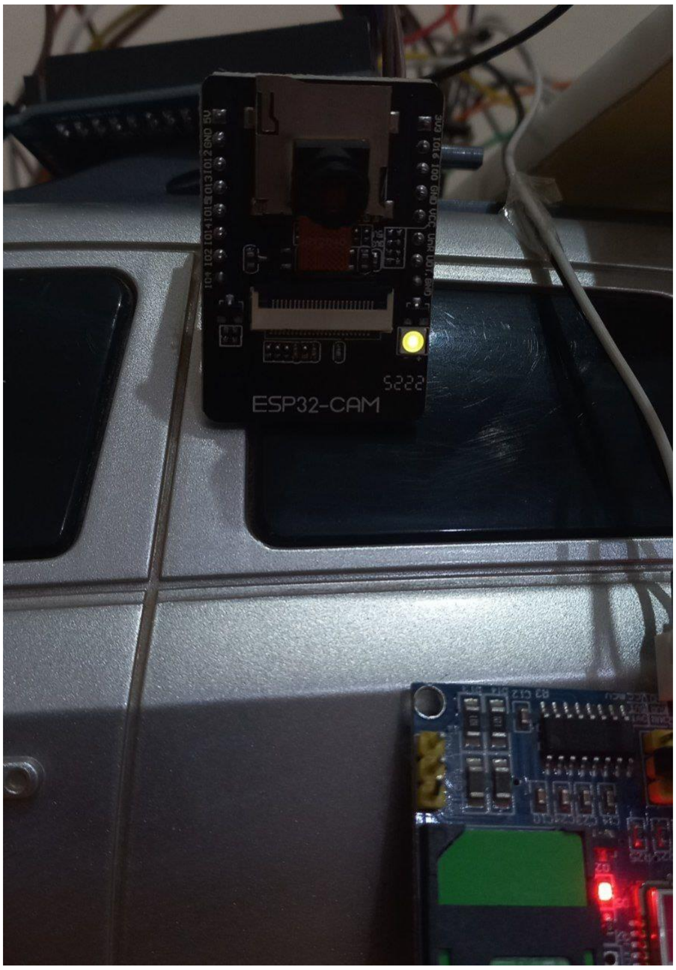


Figure III.26:Camera ESPCAM-32 ON.

The temperature sensorDHT11 periodically captures the engine temperature and displays it on the screen LCD I2C, updating the values each time. Additionally, the buzzer triggers an audible alert when the temperature exceeds a specified value


Figure III.27:DHT sensor ON.

The display screen periodically shows the temperature and humidity values as shown in the picture below:


Figure III.28:LCD I2C value.

In the following picture there is a Buzzer that issues audio alerts when the temperature rises above the value specified in the code in the Arduino IDE program.

Figure III.29:Buzzer alert.

First, we programmed the data transmission via GSM to a mobile phone number to display vehicle data, including temperature, humidity, vibration status, and the state of the circuit breaker for the fuel pump.

Then, we programmed the system to send a text message to the mobile phone number indicating the presence of vibration in the vehicle.


Figure III.30:SMS containing vehicle data.


Figure III.31:Vibration detected SMS.

In the following images, we illustrate the user interface of MyCar application, including the home page, user page, and the page for adding car information for sale.

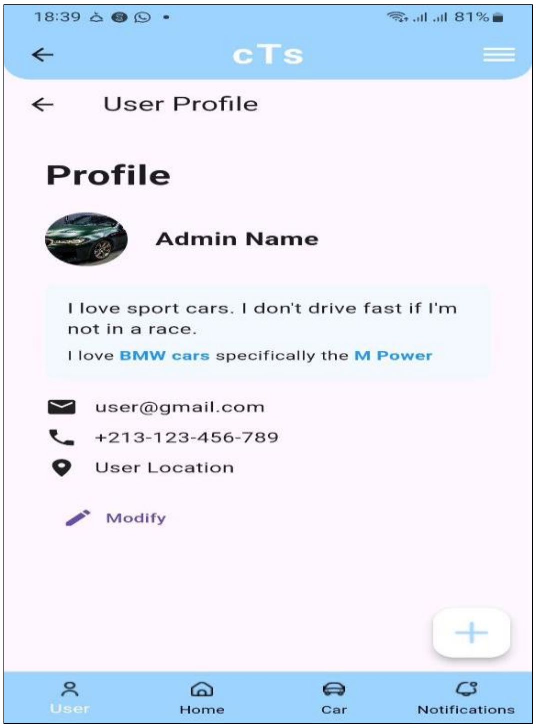


Figure III.32: User page application.

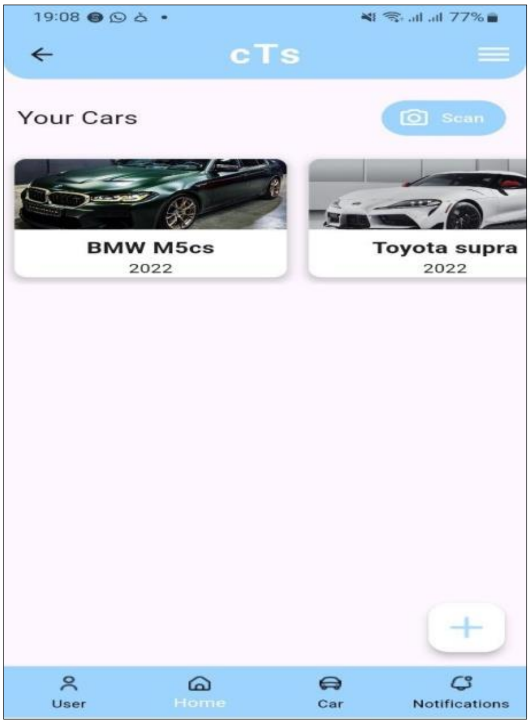


Figure III.33: Home page application.

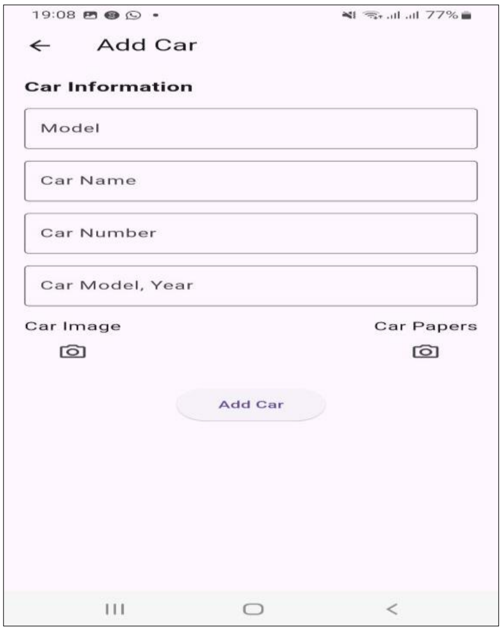


Figure III.34: Addvehicle page application.

While developing the mobile application, due to time constraints, we used the BLYNK app, which allows remote data monitoring and control. We linked it to our device to display temperature, vibration status, and to remotely control the relay, as shown in the images below.

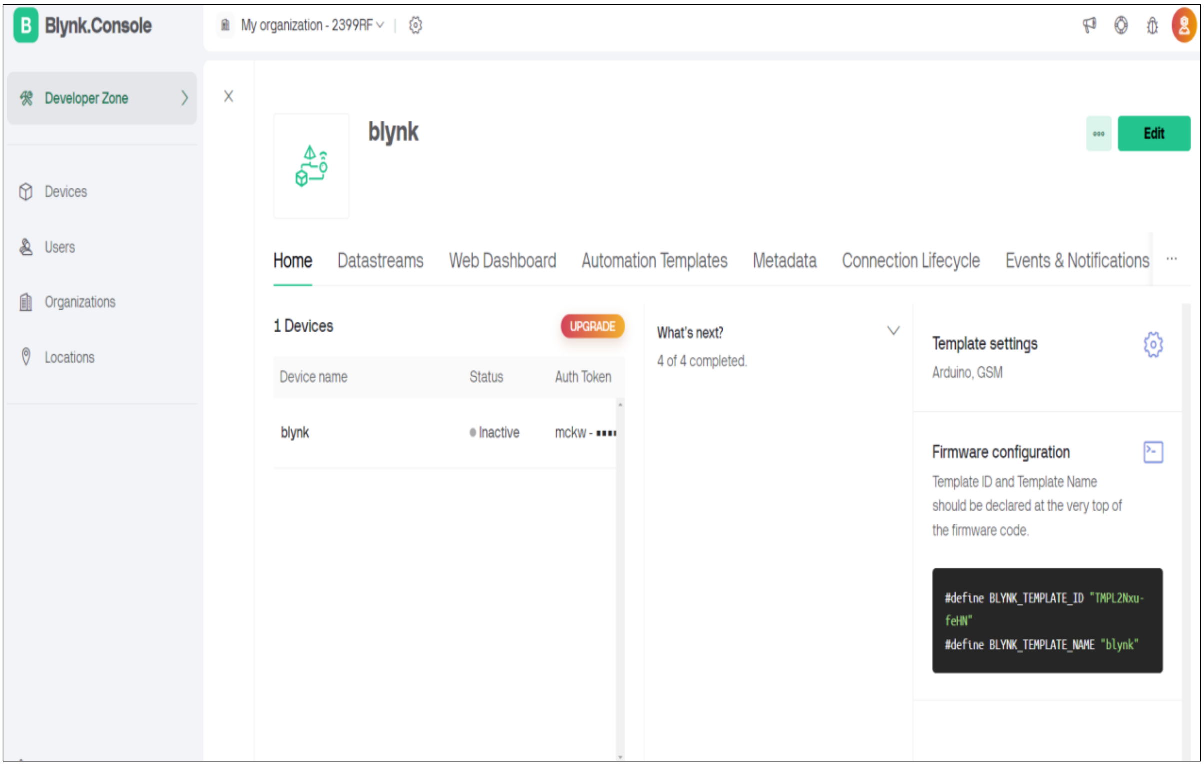


Figure III.35: BLYNK application.

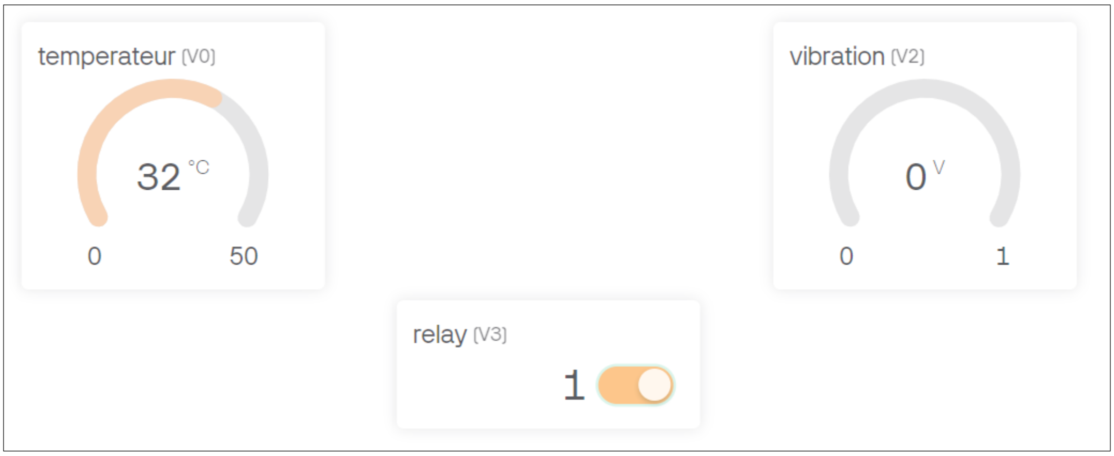


Figure III.36: Data in blynk.

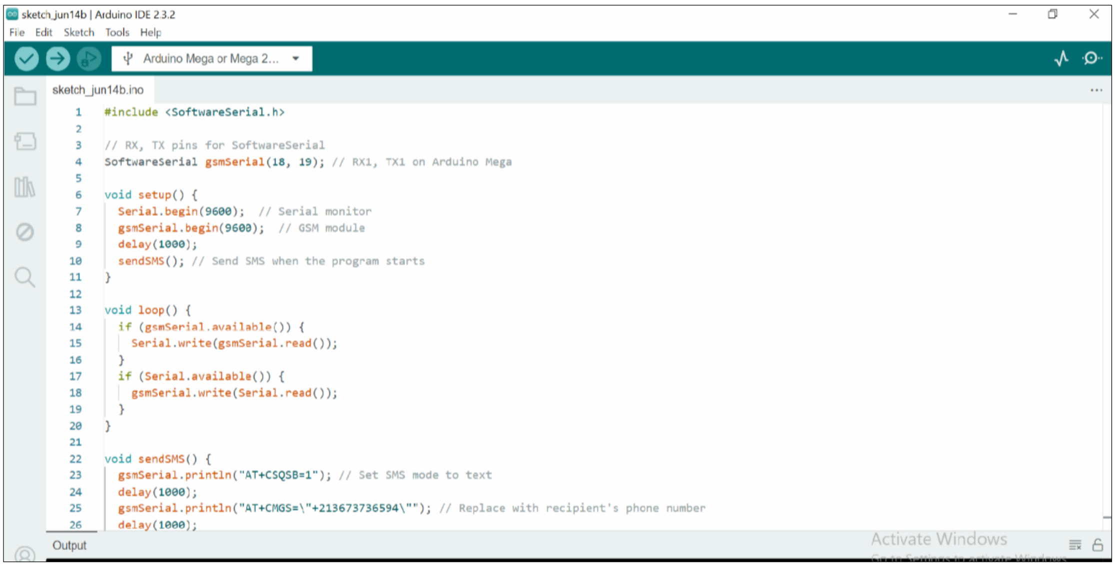


Figure III.37: Testing GSM in ArduinoIDE.

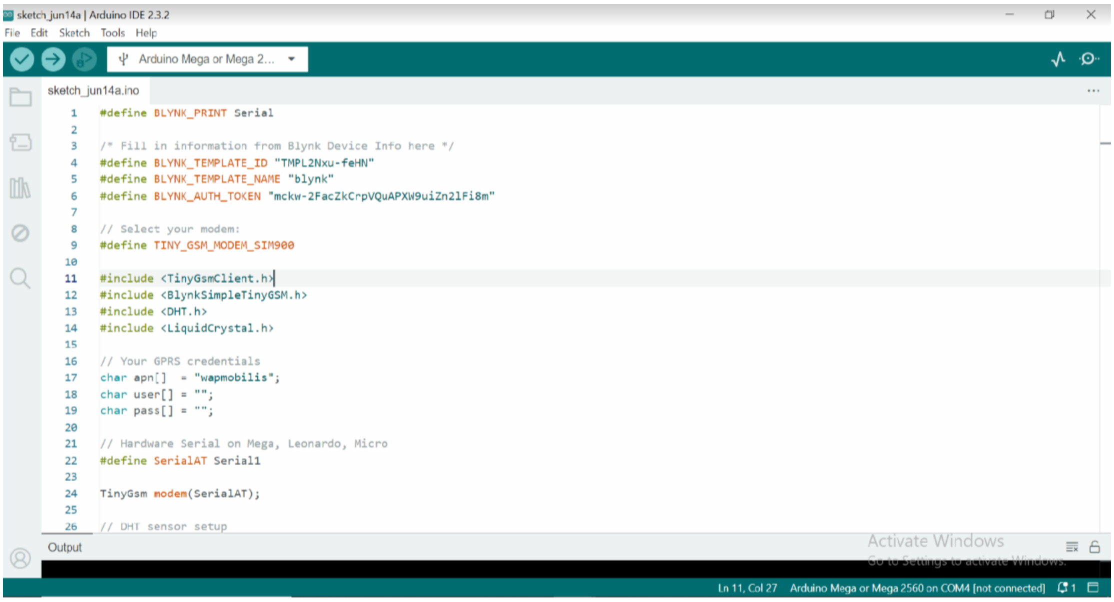


Figure III.38: Testing code in ArduinoIDE.

## Conclusion

In conclusion, the chapter "Enhancing Vehicle Security, Maintenance, and Services through IoT Solutions" highlights the significant impact of the Internet of Things (IoT) on the automotive industry. By using connected devices, cameras, and remote control features, IoT enhances vehicle security, maintenance efficiency, and service effectiveness. These technologies protect vehicles from theft and cyber threats and enable predictive maintenance, reducing downtime and costs.

IoT strategies improve safety and convenience by continuously collecting and

analyzing data, allowing for the anticipation and resolution of issues before they escalate. The integration of physical devices with digital interfaces lays the foundation for future advancements in automotive technology, such as autonomous driving and advanced driver assistance systems (ADAS).

Thus, IoT plays a crucial role in enhancing vehicle security, maintenance, and services, contributing to greater operational efficiency, higher customer satisfaction, and a smarter, more connected future.

# General Conclusion

# General Conclusion

The purpose of this project is to create a smart vehicle system to monitor and control the engine remotely, provide early warnings before the engine overheats, and offer various services and communication between vehicle owners in an innovative way, all through a mobile application. Additionally, preventing vehicle theft was also an important factor. All objectives have been successfully achieved; as the system yields the expected results.

Users can control the system device by sending instructions and receiving alerts through the application. This allows users to track and display the vehicle's coordinates on the application using their mobile phone.

The smart vehicle security and tracking system uses the SIM 900 (GSM modem) to facilitate communication between the mobile station and the microcontroller, enabling the sending and receiving of instructions.

To halt the vehicle when the driver encounters any problems, the system uses a circuit breaker RELAY JCC-3FF that cuts off the fuel pump, preventing the vehicle from starting to avoid theft in case a vibration is detected by the vibration sensor.

There are many smart security systems for vehicles available in the market at high prices. The smart vehicle security system offers a lower cost compared to other systems, with costs dependent on the designer. Typically, vehicle security systems without tracking can be found on the market, but this system provides security, privacy, and multiple features.

The system uses an SW-420 as a security measure. If the car door is forcibly opened, the system sends an alert to the mobile phone, successfully concluding this security step.The system uses a surveillance camera ESPCAM-32 to monitor the vehicle's surroundings and capture photos or videos remotely, successfully concluding this step.The system uses a temperature sensor DHT11 to monitor the temperature periodically, sending audible BUZZER and visual alerts LCD I2C when the engine temperature rises to take early actions and perform early maintenance as well.The system uses a circuit breaker RELAY JCC-3FF to stop the vehicle when the driver encounters a problem or if it is being stolen. The red circuit breaker LED indicates the vehicle's stopping status upon detecting objects, successfully concluding this step.

The system uses the SIM900A modem to send and receive messages and also to send data to the application. Instructions are sent from the system to the application and received from the application as well, successfully concluding this step.

The system achieves the results of a smart car system providing security to the car, in addition to providing a remote management system for the engine, early maintenance, and services available in the application.

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