Cognitive approach based on artificial intelligence and Internet of vehicles for sustainable development of smart cities

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Abstract:

The arrival of Internet of Things (IoT) as contributes to the development of smart homes and intelligent transportation systems accelerates the construction of sustainable smart cities for the future. And with an estimated 70% of the world's population living in cities by 2050, smart and sustainable cities have become a major policy priority for administrations worldwide.

In this paper, we are proposed a new approach namely as " **Cognitive Artificial intelligence and Internet of vehicle (CAI-IoV-)**, that explain how Artificial Intelligence Powers Smart Cities of Tomorrow, the advancement of information and communication technologies (ICT), artificial intelligence, and the Internet of Things play a crucial role in increasing efficiency in all industrial sectors and enabling innovations such as Intelligent Transport Systems (ITS) and "smart" management for water, energy, and waste. Our approach is widely recognized that building "smart" technologies in an existing smart city or developing a sustainable smart city itself is a best issue that requires better cooperation and greater integration in decision-making by different stakeholders. This is a major area where the Union can provide valuable assistance.

Keywords: Cognition, Intelligent system, Artificial Intelligence, Internet of Things, Internet of Vehicles, Smart City.
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1.Introduction

Technology of communication and information have been dominated for years by the term "smart cities," which seeks to provide a digital environment that stimulates learning and creativity, contributing to providing a sustainable environment that allows for healthy and happy living. Internet of things is increasingly being deployed to enhance functionalities for many businesses. IoT provides communications among heterogeneous devices to enable smart services in different scenarios. Scenarios include smart cities, health care, smart home, environment monitoring, smart agriculture and farming, logistics, and transportations. The digital revolution today is beginning to manifest in facts and in our lifestyle habits. Big Data, social networks, connected objects have not finished disrupting our daily lives. Certainly, technological innovation must have a multidimensional character in terms of actors, domains, and technology. By ensuring a "smart economy," "smart mobility," "smart environment," "smart inhabitants," a "smart way of life," and finally, a "smart administration." By focusing on describing these promises, we choose to focus on the trigger of this movement: data and the new means available to produce, organize, and use them in the service of the city. The question that arises is Why does the world need smart cities?

New technological developments have helped governments realize the dream of smart cities, as developments in the Internet of Things based on device connectivity, data exchange, and the establishment of centralized control systems have contributed to saving energy consumption and improving traffic management. In addition to artificial intelligence applications that analyze a large database of data to enrich the decision-making process, it has already been used in many areas, including the environment, agriculture, financial institutions, health, and educational establishments.

There are many models through which smart cities can contribute to improving the quality of life, including smart grids that use communication technology in managing electrical networks, as they provide information on energy consumption patterns and the provision of smart meters that help improve energy consumption. Modern applications also help provide data on traffic congestion areas to avoid them, improve traffic flow, and use devices to measure and control pollution levels.

There is also a trend towards providing autonomous car fleet networks to provide personal transportation to customers on demand, as well as developing solutions to provide electronic financial services, especially through the most secure "Block Chain" technology for financial and banking accounts.

The rest of the article is organized as follows: The most recent smart cities concepts and components are presented in Section 2. In Section 3, A background of digital technology, Internet of Things (IoT), IA contribution in smart cities are detailed. Section 4 covers the proposed design for sustainable development smart cities. A case study is elaborated in section 5 as a scenario description and an algorithm. Sustainable development is presented in section 6. Finally, Section 7 concludes this article and highlights possible future works.

2. Background in smart cities

There is more than one definition for this term, and sometimes more than one name, such as "digital cities" and "ecological cities," and they differ depending on the goals set by those responsible for their development. In general, "smart cities" look to the future economically and socially. If you are able to engage in your activities from your site using technology, this contributes to improving resource efficiency, improving the standardof living, providing good and fast services, moving easily, and providing a safe and less polluted environment, all of which indicate that you are living in a city that has the major characteristics for smart cities.

The intelligent city has a wide range of electronic and digital technologies that enable its devices to communicate. Two closely related technologies, the Internet of Things (IoT) and big data (BD), enable the transformation of traditional cities into smart cities [3]. Smart cities have been equipped with heterogeneous electronic devices based on the Internet of things (IoT), which is a worldwide network of physical objects using the Internet as a communication network [3]

A more precise definition of sustainable smart cities can be identified by the International Telecommunication Union, which has clearly stated that it is an innovative city that uses information and communication technologies to improve quality of life, operational efficiency, urban services, and competitiveness. These benefits should be reflected in satisfying the needs of current and future generations in economic, social, environmental, and cultural aspects, so that any city acquires an intelligent character. The European Union has defined a more vision for smart cities, where it is based on six elements, namely the smart economy, smart people representing human capital, social, transparency, smart participation in decisions, smart transport based on modern technology, smart environment, and smart life that gives importance to health conditions, individual safety, housing, good educational facilities, and having social connections between individuals.

Szpilko, D., et all (2023) describe the influence of artificial intelligence (AI) in smart cities, and based on the most cited articles on artificial intelligence in the smart city area[13]. The authors in [3]]are reported the construction of a systematic review involving biometric aspects, oriented to the identification of the main applications of the information security and smart cities concept.

(Nitin Liladhar Rane et al,l 2023) takes a holistic approach, utilizing a combination of Artificial

Intelligence (AI) and Internet of Things (IoT) to. optimize resource allocation, improve safety protocols, , thereby enhancing overall project efficiency[14], but the authors in [8] are presented a comprehensive review of smart cities and how the vision of IoT and machine learning has changed the conventional way of understanding things and devices. In [15], Authors focused on information security for smart cities and applies bibliometric analyses to identify the main authors and their influences on information security and the smart city area.

2.1. Key features of smart cities

According to Rudolf Giffinger in [1], smart cities can be classified according to six main criteria, related to regional and neoclassical theories of urban growth and development and respectively based on theories of regional competitiveness, transport economy and information and communication technologies, natural resources, human and social capital, quality of life, and citizen participation in the democratic life of the city [1].

- Smart environment: includes ecological concepts of the city [2], air quality, sustainable resource management through new, more collaborative and environmentally friendly models,

- Smart governance: The smart city relies on efficient telecommunications infrastructures, the production of data requires the implementation of technical devices, sensors, databases, and telecommunications networks.

- Smart citizen: The citizen is an individual heavily involved in the management of the smart city. Indeed, his participation is required, whether in the consultation phase or during the implementation phase. For the success of a smart city, writings distinguish two categories; hardware and software, The first category focuses on the materiality of the phenomenon through the involvement of information and communication technologies, while the software aims to produce "smart" citizens, workers, and officials.

The smart economy: This pillar consists of creating and promoting innovative ecosystems by developing ideas around the concept of the smart city in order to become an attractive and pioneering city on the national and global stage [2].

Smart living: encompasses a set of conditions related to available infrastructure but also to the well-being of citizens (education, culture, security, connected housing). Where citizens can access web or mobile applications to benefit from an urban services platform "my city in my pocket" developed by Orange or "urban pulse" [3].

Smart mobility: is currently the most developed pillar of so-called smart cities. It is characterized by international and local accessibility to the city being facilitated as well as the development of an innovative, safe, and sustainable urban transport system.

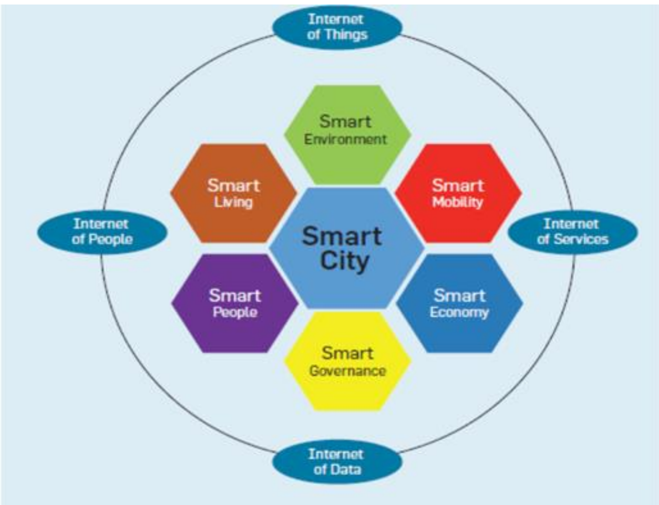

Figure 1. Components of smart cities [3].

3.Smart city Applications and contribution

This section discusses contributions of other domains in Smart City to be more specific:

3.1 Contribution of digital technology in smart city

Digital tools exert a considerable attraction on minds. It must be recognized that human society is evolving and that digital technology plays an important role in it, as digital infrastructures allow access to various services. Today, the race for technologies is accelerating, connectivity is expanding with new networks, new tools, society is developing, and services are becoming more accessible and efficient in quality, price, and time. It should be noted that ICTs are no longer exclusive to the military field, public administration, or large companies, currently they have invaded public places, buildings, apartments, sports facilities, and many others. Digital technology plays a pivotal role in shaping the development and functioning of smart cities in numerous ways: Digital sensors, IoT devices, and other data-gathering technologies enable cities to collect vast amounts of data from various sources such as traffic cameras, environmental sensors, and public infrastructure. This data is then analyzed in real-time to derive valuable insights into urban dynamics, allowing for informed decision-making by city officials, track environmental indicators such as air quality, temperature, and pollution levels. This data informs environmental management strategies, supports sustainability initiatives, and helps cities mitigate the impacts of climate change. Digital technologies help optimize the use of resources such as energy, water, and transportation infrastructure. Smart meters and monitoring systems enable utilities to better manage resource distribution, identify inefficiencies, and reduce waste. For example, smart grids adjust energy distribution based on demand, leading to improved efficiency and reduced costs. Digital platforms and applications facilitate smarter transportation systems, including real-time traffic management, public transit tracking, and ride-sharing services. By integrating data from various transportation modes, cities can improve mobility, reduce congestion, and enhance accessibility for residents. Digital tools like Geographic Information Systems (GIS) and Building Information Modeling (BIM) enable urban planners and architects to visualize, simulate, and optimize urban designs. These technologies enhance the efficiency of infrastructure development, streamline permitting processes, and foster sustainable urban growth. Digital ecosystems foster innovation, entrepreneurship, and economic growth in smart cities. By providing access to high-speed internet, co-working spaces, and innovation hubs, cities can attract talent, support startups, and stimulate job creation in emerging industries such as technology and green energy.

Today, the number of connected objects has increased and is on track to increase even more, this is partly explained by the decrease in technical factors costs and smart cities seem to be one of the development grounds for the internet of things. Given its novelty, the terminternet of things has no precise definition. However, it appears as a logical technology based on the idea that all objects can connect with their environment to simplify tasks, save time, money, and relieve the human brain from memorizing data.

There is no doubt that digital technology has brought a lot to humanity. However, there are several dangers in their unlimited evolution, among them the emergence of a new type of crime. These internet crimes have no geographical boundaries and are therefore difficult to control even by high-tech countries [1]. Therefore, the fight against computer proliferation is simply impossible and we can only better understand the massive phenomenon of cyber piracy. This amplifies the means available to non-state actors (social movements, mafias, terrorist cells) likely to disrupt societies, or even harm the international system. In any society, it is important to define and anticipate guidelines and laws to ensure use and security. It is from the criminal use of ICTs that States are led to legislate. Security in the use of digital networks, particularly the internet, and the business and support activities offered by information systems, involves secure electronic exchanges, the protection of personal data, and the fight against any cyber-related crime. Cybercrime generally refers to all offenses related to the use of new technologies. It specifically concerns "all specific criminal offenses related to information and communication technologies, as well as those whose commission is facilitated or linked to the use of these technologies". For E. Lazar, when we talk about cybercrime, we mean all offenses resulting from the illicit use of information contained in computers, as well as those resulting from the abusive use of virtual space[4]. While in the United States of America, this fight has been legalized by the Patriot Act, offenses related to automated data processing systems[5].

3.2 Contribution of the Internet of Things (IoT) in the smart city:

The Internet of Things has now become a key technology capable of covering several technological domains, from data detection and processing tonetworking and data analysis. It is used in many applications ranging from home security and factory automation to healthcare delivery and autonomous driving. The number of devices connected to the Internet already exceeds the number of people on earth and is expected to reach 50 to 200 billion devices by 2025. The Internet of Things has been defined by the International Telecommunication Union as "a global infrastructure for the information society, which enables advanced services by interconnecting objects (physical or virtual) through existing or evolving interoperable information and communication technologies [6]. The deployment of connected objects for the implementation of smart cities is increasing, and through the introduction of the Internet of Things, the number of sensors has greatly optimized the ability to collect, analyze, and reconstruct data to transform it into information, knowledge, and wisdom. Connected objects bring growth opportunities for market players and for user companies that incorporate them into their strategies[7]. The Internet of Things offers numerous advantages and applications to smart cities, including :

- Improvement of traditional public services such as transportation, traffic, and parking.
- Control and maintenance of public spaces.
- Monitoring the validity of buildings and workplaces.
- Reduce time wasted in administrative transactions in the city.
- Provide the city's energy consumption.
- Smart lighting for the city.

In addition, the various data collected by connected objects allow citizens to better understand the state and evolution of the city. Indeed, intelligent transportation, intelligent energy management systems, and intelligent environmental monitoring are all examples of applications of the Internet of Things for smart cities.

I believe that the smart city is the best solution to the problems that populations often face due to population growth, pollution, inadequate infrastructure, and lack of electricity. The future of IoT is unlimited. It provides solutions in all sectors including manufacturing, fashion, restaurant, healthcare, education etc. IoT applications are launching innovative city programs globally. It provides remote monitoring, management, and equipment control and
creates new knowledge and actions from massive data
stream real-time information. The central characteristic
of a smart city is the degree of integration of information technology and the general application of information assets [8].

3.3. Contribution of Artificial Intelligence (AI) in Smart Cities

The application domain of AI covers a wide range of applications such as toys, scientific research tools, medical diagnosis, and robot control. Furthermore, today's services are based on integrated AI, for example autonomous vacuum cleaners, recommended engines, game engines, car gearboxes, voice recognition, and industrial robots.

3.3.1- Contribution of AI in Smart Homes

Intelligent environments in the smart home area must implement contextual services capable of managing daily activities such as grooming, feeding, drinking, taking medication, and cooking. These systems must be able to interface with hundreds or even thousands of sensors [6]. Furthermore, they must be able to handle large and rich data, which is very challenging for the AI learning and prediction process. In general, contextual services are added to smart homes using AI-based systems. These systems must be able to learn activities from user behaviors, i.e., when the user moves and performs actions in the smart home. When these actions are learned, the system must be able to detect the "learning situation" with a high degree of probability and it must be able to execute the learned actions autonomously, such as remote control of lighting, alarm systems, entertainment systems, as well as timer-triggered services are included in smart homes [6]. However, smart homes provide an additional layer to home services controlled by adding artificial intelligence, context prevention, and communication addresses. By using this layer, smart homes are able to offer smarter services and intelligently control elements such as lighting, air conditioning (heating, ventilation,and air conditioning), household appliances, security locks for gates and doors. Most controlled households use Smartphone to interface the user with their service. A more user-friendly approach is to allocate artificial intelligence, context detection, and communication capability in consumer devices. An example could be a microwave oven that downloads cooking recipes directly from the manufacturer's server, then takes care of the cooking process. Another example could be an air conditioner that learns the user's preferred climate from preferences, then adapts its behavior accordingly [9].

3.3.2 Machines learning and deep learning Contribution in smart cities

Machine learning is the only field used widely in smart city deployment. Machine learning extracts meaningful information from the massive amount of smart city data. Analysis of big data in smart cities needs techniques using machine learning. Machine learning helps clean the data, and various techniques help train the data. Deep learning is a particular machine learning type that expresses the world as a hierarchy of nested concepts, achieving high power and flexibility. Each idea is associated with a more straightforward concept and a more abstract representation. The whole objective of Deep Learning is to solve problems characterized by High dimensionality, which has no rules. In recent years, advances in hardware, software, and integrated systems enabled billions of smart devices to connect to the Internet. This ecosystem is jointly called the Internet of things. Many people are actively moving to cities, and primary resources become increasingly short. The goal here is to make the Infrastructure smarter to effectively use the contracted resources. They want to use modern technology to solve many pressing problems, such as waste of water, energy consumption, traffic jams, etc.[8].

3.4 Internet of Vehicles Contribution in Smart Cities

In a smart city scenario, many physical objects, or more precisely "smart" objects with their own processor, computing power, and communication can interact with each other. These smart objects build a safe and intelligent environment through increased interconnection and interoperability are also called the Internet of Things (IoT).

As part of the IoT objectives, many objects of this type will be connected vehicles or cars that can communicate and interact wirelessly with different types of devices connected to the Internet, devices in the car (intra-vehicle) or outside the car (inter-vehicles). This leads to a specific and personalized type of IoT called Internet of Vehicles (IoV) which enables unified management in intelligent transportation.

The concept of smart cities has emerged as a strategy to mitigate the challenges of rapid and continuous urbanization while offering a better quality of life to its citizens. Smart cities are characterized by intensive use of digital technologies and various forms of interactions (e.g., human-to-human, human-to-machine, machine-to-machine) that generate huge volumes of data commonly referred to as Big Data.

IoV can be considered as a convergence of mobile Internet and traditional IoT. As a huge network of interactions, IoV technology refers to dynamic mobile communication systems or models that communicate between vehicles and other objects as illustrated in Figure 2, using V2V (vehicle-to-vehicle), V2R (vehicle-to-road), V2I (vehicle-to-infrastructure), V2B (vehicle-to-building), V2H (vehicle-to-home), V2X (vehicle-to-everything), V2G (vehicle-to-grid). It also enables information exchanges between V2D (vehicle-to-device), V2S (vehicle-to-sensor), and D2D (device-to-device). The deployment of IoV in smart cities enables information sharing and collection of Big Data vehicles, roads, infrastructures, buildings, and their environment. The IoV ecosystem can provide services for intelligent transport applications to guide and supervise vehicles, and provide various multimedia and mobile Internet application services [10].

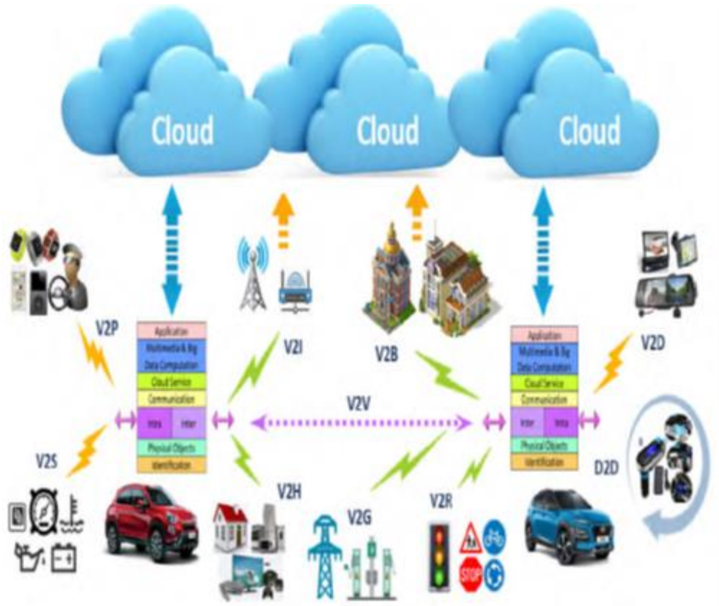

Figure 2- Universal-IoV- In a smart city

Source : L-M. Ang et al., 2019, p- 6475.

3.4.1 Communication Interaction between IoV Modules

Communication models Interaction in the IoV ecosystem can be classified into two categories: (1) intra-vehicle interaction models; and (2) inter-vehicle interaction models. Figure 3 shows a diagram of the various intra-vehicle and inter-vehicle interaction models.

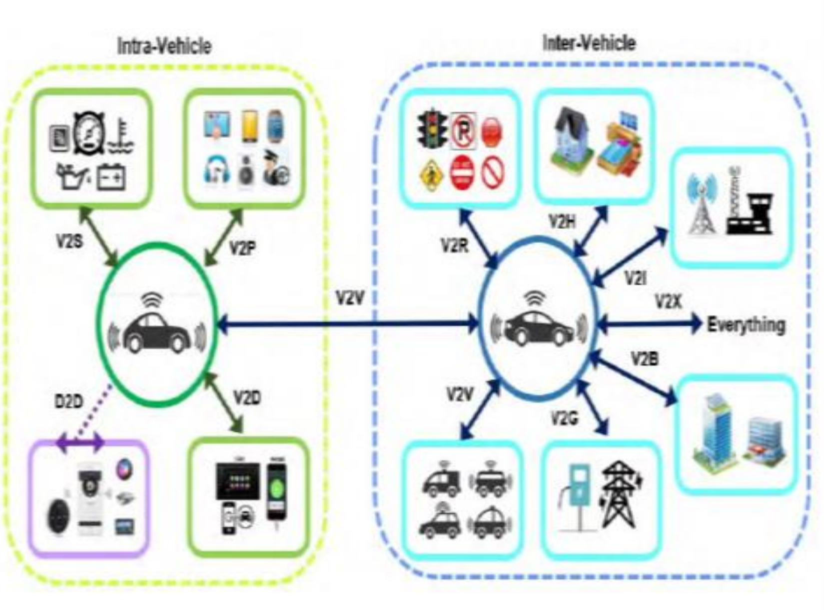

Figure 3. Interaction of IoV models [10]

Source : L-M. Ang et al., 2019, p- 6479.

4.Proposed Approach: Cognitive Artificial intelligence and Internet of vehicle (CAI-IoV-)

In a smart city, IoT sensors are deployed across the city to collect real-time data on various aspects of urban life, such as traffic, air quality, energy consumption. Integrating Artificial Intelligence (AI), Internet of things and the Internet of Vehicles (IoV) into smart city infrastructure requires a comprehensive architectural framework that facilitates seamless communication, data exchange, and decision-making across interconnected systems. The data collected by IoT or IoV sensors is then analyzed by artificial intelligence algorithms to extract useful insights and make smart decisions: as machine learning algorithms analyze traffic data to predict congestion patterns and recommend alternative routes. AI systems analyze weather data and energy consumption to optimize operations of smart electrical grids. AI models predict air pollution peaks and recommend mitigation measures to protect public health.

This section presents the main elements of the new architecture named " Cognitive Artificial intelligence and Internet of vehicle Approach" (CAI-IoV-A) . The following figure shows a diagram of the CAI-IoV elements and the components of the building blocks in its layers. Our architecture includes then (10) main layers: seven(07) layers for IoV parte : the identification layer, the physical objects layer, the inter-intra devices layer, the communication layer, the Cloud services layer, the multimedia and Big Data computing layer, and the application layer, and three (03) layers for AI parte: data collection layer, data processing layer and decision making layer; figure 4 shows the representation of the proposed infrastructure.

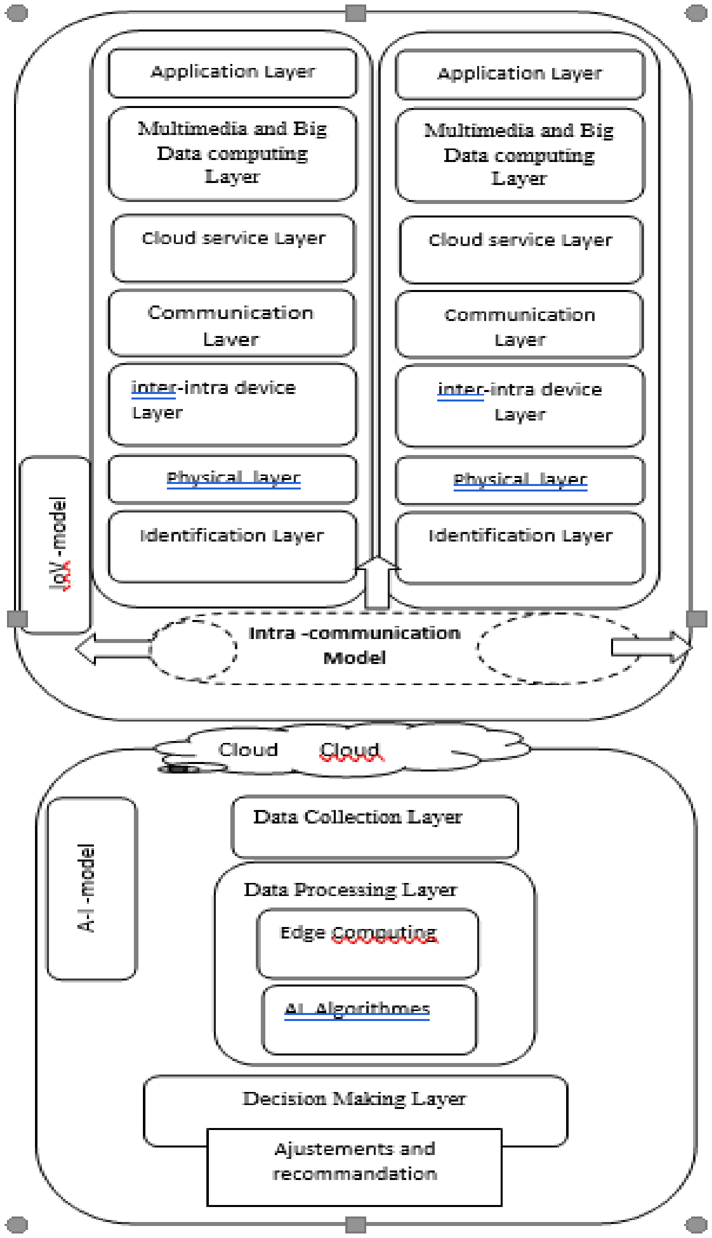

Figure 4 Architecture of Our Approach CAI-IoV

Identification Layer: Within the CAI-IoV ecosystem proposed, identification methods serve to give each object a clear identity. In general, objects in the ecosystem can be classified into two types: vehicles and non-vehicle objects. The identification layer has two important components (naming and addressing). However, two or more objects may have the same object ID in the network and the name may not be globally unique. Thus, addressing schemes (e.g., IPv4, IPv6) can also be used to uniquely identify object identities. For vehicle objects, the object ID could be the Vehicle Identification Number (VIN) which is a unique code, including a serial number, used by the automotive industry to identify individual motor vehicles.

Physical Objects Layer: gathers data from all objects (vehicles and non-vehicles) within the CAI-IoV ecosystem and transmits the data to the intra-inter devices layer for further processing. Here, we focus on AI-IoV where objects are classified into non-vehicle objects and vehicle objects.

Layer Inter-Intra Devices: is a unique layer that cannot be found in traditional IoV architecture. This layer, along with the communication layer, allows the AI-IoV architecture to support all types of interaction models, including V2V, V2R, V2I, V2B, V2H, V2X, V2G, V2P, V2D, V2S, and D2D. The combination of the Inter-Intra Devices layer and the Communication layer within the CAI-IoV is to connect different objects and heterogeneous networks to provide specific services.

Communication Layer: The communication layer within the IoT is to connect different and heterogeneous objects within the network to provide specific services. Its goal is to achieve low-power communications in noisy communication channels and multi-hop networks.

Cloud Service Layer: can be formed from private Cloud or public Cloud. Cloud virtualization technology provides a parallel computing environment to enable scalability of IoV applications. The Cloud provides hardware computing platforms, infrastructure, and software services to client IoV systems. The hardware infrastructure provides scalable servers and storage to offer high reliability and fast computing response. An important component of the software services provided by the Cloud is the access center to control access by authorized users to ensure IoV system security.

Multimedia and Big Data Computing Layer: consists of three sub-layers:

Data preprocessing, Big Data computing, and intelligent transport sub-layers. This layer contains threecomponents: (1) hardware; (2) software; and (3) multimedia component using the divide and conquer paradigm. The hardware component includes a variety of computing components ranging from data centers to parallel GPU platforms. The software component includes library functions for the intelligent transport system (ITS), including security, navigation, real-time traffic information, etc. Other computing components include the Cloud platform that allows smart objects to send their data to the Cloud for real-time processing and then provide results to end users from the extracted large data. The third software component is for multimedia and Big Data processing.

Application Layer: represented by intelligent applications, ranging from security and traffic efficiency to multimedia entertainment info applications and Web applications.

Layers of AI parte :

Data Collection Layer: IoT and IoV Sensors: Vehicles equipped with various sensors (e.g., GPS, cameras, LiDAR) collect real-time data on traffic flow, road conditions, and vehicle status. Smart **Infrastructure:** Roadside sensors, traffic cameras, and environmental monitors capture additional data on urban conditions, such as air quality and weather.

Data Processing Layer: The centralized AI system receives the real-time data from the IoT sensors and processes it using machine learning algorithms. Edge Computing: Distributed edge computing nodes process data locally, reducing latency and enhancing scalability for time-sensitive applications. AI Algorithms: Machine learning models analyze incoming data to extract insights, predict traffic patterns, optimize routes, and detect anomalies.

Decision-Making Layer: Based on the analysis, the AI system determines the optimal adjustments needed to alleviate congestion. This could include changing traffic light timings, adjusting signal priority for different traffic lanes, or recommending alternative routes.

-Centralized AI Platform: A centralized AI platform aggregates and analyzes data from various sources to generate actionable insights and make informed decisions.

-Traffic Management System: AI-powered traffic management systems dynamically adjust traffic signals, reroute vehicles, and optimize traffic flow based on real-time conditions.

-Predictive Maintenance: AI algorithms predict maintenance needs for infrastructure and vehicles, optimizing maintenance schedules and reducing downtime.

Adjustments Recommendation: The AI system generates recommendations for adjusting traffic lights along the congested artery to improve traffic flow. These recommendations take into account the current traffic conditions, anticipated traffic patterns, and potential impacts on surrounding areas.

Applications include basic management systems such as automotive navigation, traffic signal control systems, container management systems, automatic license plate recognition, or radars for monitoring applications such as security video surveillance systems to more advanced applications that integrate live data and feedback from a number of other sources such as guidance and parking information systems.

5. Scenario description

Our scenario treat IoT sensors detect significant congestion on a major city artery. The data is transmitted to a centralized AI system, which analyzes real-time information and recommends adjustments to traffic lights to alleviate congestion.

Simultaneously, vehicles equipped with IoV technologies receive notifications about trafficconditions and receive instructions to follow alternative routes.

1.Initialize TrafficLightController:

•Set congestion threshold to 100 (Example threshold for congestion)

•Create AIController instance

•Create TrafficControlCenter instance

2.Begin monitoring_traffic:

a. Repeat the following steps indefinitely:

i. Collect vehicle_density from IoT sensors. ii. If vehicle_density is greater than congestion_threshold, go to step b.

iii. Wait for 5 seconds.

b. Analyze traffic:

i. Call AIController's analyze_traffic function with vehicle_density.

ii. Proceed to step 3.

3.AIControlleranalyze_traffic(vehicle_density):

a. If vehicle_density is greater than 100: i. Recommend adjustments by calling recommend_adjustments(vehicle_density). ii. Proceed to step 4.

4.TrafficControlCenter adjust_traffic_lights(adjustments): a. Update traffic light timings based on adjustments:

i. Set green light duration to adjustments['green_duration'].

ii. Set yellow light duration to adjustments['yellow_duration'].

iii. Display the updated durations for green and yellow lights.

5.Fin.

6. Sustainable Development: A smart city should seek to increase its attractiveness by reducing its ecological footprint and offering a better quality of life through the fluidity of its services and shared governance. For Michel Angers, this notion of sustainable development is crucial in the very foundation of the smart city: "There are all kinds of ways to make savings in terms of sustainable development, both environmentally, socially, and economically. For example, there is no doubt that the Internet of Things allows different municipalities to reduce greenhouse gas emissions." In this regard, he refers to optimizing garbage collection routes, buses that can be tracked in real time, or truck engines that automatically stop when vehicles are not moving, all thanks to geolocation and artificial intelligence.

The population is increasingly sensitive to the importance of encouraging decisions that are in line with the key concepts of sustainable development. Michel Angers believes that this trend is also noticeable for smart cities: "More and more, especially among young families, the choice will be towards technology. A city that is digitally connected with its citizens is a significant incentive." The UMQ, in collaboration with the CEFRIO, has developed an online self-diagnostic tool to help municipalities in Quebec determine their level of maturity in terms of digital intelligence. So far, more than 200 municipalities have benefited from it. The example of Montreal: Of course, when we talk about integrated systems, the Internet of Things, and data collection, cyber security and ethical issues quickly become a concern. "Montreal has developed a partnership with the Quebec Institute of Artificial Intelligence and signed the Montreal Declaration for Responsible Artificial Intelligence as part of an approach to use AI in an ethical and responsible manner for the benefit of

Montrealers," explains Mélanie Gagné, from the media relations division at the City of Montreal.

To successfully carry out connected technology projects, transparent and collaborative governance can have a concrete impact because by placing the citizen at the center of reflections, the chances of success are increased. In the same vein, Montreal recently launched Dreaming Montreal 2020 - 2030, a citizen consultation that will serve as the foundation for the next waves of development in smart city matters. "The City hopes that citizens will participate in large numbers," says Ms. Gagné.[12]

7. Conclusion

To develop a smart city, there must be willingness, convergence, and support from several stakeholders, such as the public administration, businesses, economic actors, and especially the population, where the citizen plays an important role in the success of this approach.

The Smart City project aims to optimize city management in order to improve the quality of life of its citizens. This requires direct involvement of various stakeholders in the city, including, but not limited to, transportation, energy, urban planning, water, security, health, and logistics services, among others. Information technologies would be at the heart of Smart City design and would include aspects related to data acquisition (sensors, etc.), data transmission (wireless networks, etc.), data management (storage, Cloud, big data, etc.), and optimization of city activities (artificial intelligence, analysis, etc.).

Several initiatives are being put forward to attract innovative companies and diversify the economy, promote active urbanism, and preserve heritage; not to mention achieving sustainable management of transportation, eco-districts, and underground infrastructure: sewers, electricity, fiber optics... all within a governance framework of transparency and citizen consultation.

In short, becoming a smart city means innovating while implementing a range of technological tools in the service of the city. The challenge remains the harmonious integration of economic, sociological, and environmental components, in order not to lose the identity of each city. Ultimately, a smart city is about considering the city differently; the digital revolution carries a considerable potential for transforming urban services and city governance modes. The future scope is very encouraging and promising seeing the rapid growth in smart devices, sensors, artificial intelligence, and emerging 5G and 6G technologies will help deploy these smart buildings for the welfare of residents and have the potential to change the way we realize smart cities today.

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