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EDGE COMPUTING'S ROLE IN AUTONOMOUS VEHICLES AND SMART CITIES

Devesh Kumar
Department of Electrical
National Institute of Technology, Kurukshetra
Haryana, India

Abstract-**In recent years, there has been an increase in the use of computing in smart cities. These applications continue to generate large amounts of data and require high latency processing power. While edge computing is an attractive tool that can compensate for tight latency issues, its deployment also presents new challenges. In this study, we highlight the role of edge computing in realising the smart city vision. First, we analyse the evolution of the edge computing paradigm. We then reviewed the recent literature focusing on computing applications in smart cities. In addition, we identify and discuss the key needs to support smart cities and the recently reported integration of edge computing. Finally, we discuss some important open challenges and their causes, as well as suggestions for the future.**

Index Terms—**Smart cities, Internet of Things, Mobile cloud computing, Cloudlet, Fog computing, Mobile edge computing, Micro data centers.**

I. INTRODUCTION

The unprecedented breadth of micro sensing technologies offers the extraordinary breadth of the smart city vision. Smart city makes citizens more prosperous, safe and secure. There are many ways to define a smart city, so there is no definition of a smart city. Generally speaking, these terms refer to advances related to information and communications technology (ICT) systems that enable citizens to achieve a better life through smart services. Smart city services are limitless and can cover many different processes, resulting in more reliable, safe, secure and innovative cities and providing unique business opportunities. Contributors to smart cities include platform developers, research groups, governments, citizens, service providers and application developers. The urban population is expected to increase in the future, which will greatly affect the development of smart cities. In addition, the rapid increase in population will cause more problems in urban infrastructure due to the growth of data produced by different devices such as smartphones, GPS, smart sensors and smart cameras. One way to solve big problems in computing and storage is to use expensive hardware, especially in computing with sufficient resources. Cloud computing began to be used to eliminate the need for expensive computer hardware. It is a powerful system designed to improve quality of experience (QoE) by providing efficient and flexible on-demand products and services. The basic features of cloud computing such as scalability, flexibility, multi-tenancy, sufficient storage capacity and service providers enable it to be adopted in other countries. Recently, cloud computing with almost unlimited resources has emerged as a promising solution for solving high computations related to smart cities. However, its limitations include high latency, context-insensitive behaviour, and lack of mobility support, which would prevent it from being used in real time. In addition to these shortcomings, cloud computing also suffers from low processing time due to the large load of smart city equipment. Edge computing, on the other hand, extends cloud computing resources to the edge of the network and provides content awareness, low latency, mobility support, scalability, and more. Therefore, edge computing is effective to solve the limitations of cloud computing in realizing real-time smart city. Figure 1 shows a high definition of the Internet of Things (IoT)-based smart city environment powered by edge computing. IoT-based smart environment uses connected smart IoT devices and sensors to improve public living standards. In addition, IoT can be defined in many ways as it is related to various technologies and concepts in the literature. In general, the topic of IoT emerged from research projects.

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Fig. 1: An overview of edge computing enabled smart city.

Smart transportation system - Smart transportation aims to realize new management solution, advanced transportation, autonomous driving and in-car infotainment service. 1) Smart transportation: Giang et al discussed the development of smart transportation applications using fog. They discussed the needs, state-of-the-art technology and research issues regarding the use of cloud computing to enable smart transportation. Although the authors discuss the need to increase the capacity and knowledge of the elements in the air-assisted vehicle network, they did not take into account the transit service and safety , which are important in connected vehicles. While streaming video, the car will change the connection from one path to another. Therefore, cloud traffic applications need to be designed with migration support in mind. Similarly, attention should also be paid to safety to prevent accidents and physical damage.2) Software-defined vehicular network supporting 5G: The author proposed a software-defined vehicular network (5G-SDVN) architecture supporting 5G. The design has three planes such as data transmission. aircraft, aircraft communications, aircraft-to-vehicle proximity group (VNG) communications, and aircraft control via cell phone use. The authors' main contributions include exploring VNGs using real-world data and integrating Software Defined Networking (SDN) with mobile applications to enable appropriate modeling. Additionally, the design model provides the benefits of efficient information sharing, ubiquitous mobile communication, and reliable collaboration. In addition to these benefits, SDN also enables the separation of control logic from the underlying system; This provides greater freedom to add functionality (i.e. intelligence) to the network without addressing changes to the equipment. However, the conceptual design provides significant results does not take into account the nature of the transition service. 3) Cost-optimized edge-assisted transportation: This work considers a smart city scenario in which vehicles run applications that retrieve information from the environment and send it from on-road units (RSUs) to the edges of computing servers. To increase efficiency and analysis. The business edge connects to the RSU and extends to the cloud via the network. It is very difficult to maintain the connection between the vehicle and the RSU in the vehicle network. On the other hand, the computing power of edge servers is also limited. Therefore, it is important to send RSUs for effective resource management and uninterrupted connectivity. The purpose of this article is to minimize the transmission cost of the network while meeting the requirements for optimizing traffic. The problem is formulated as a hybrid problem, where the aim is to minimize the total cost associated with RSU deployment, the cost associated with the power unit angle assigned to each RSU, and the price associated with the RSU distance. The cell in which it operates (divided into target cells). One RSU can serve many brains. Therefore, only cells adjacent to the RSU cell should be considered instead of distant cells, which increases the cost.

TABLE I: Summary of existing surveys and tutorials with their primary focus

Reference	Smart city	Internet of Things	Mobile edge computing	Cloudlet	Fog computing	Edge computing evolution
Bilal *et al.* , [36]	✗	✓	✓	✓	✓	✗
Shaukat *et al.* , [37]	✗	✗	✗	✓	✗	✗
Ai et al.,[38]	✗	✓	✓	✓	✓	✗
Mouradian et al. , [39]	✗	✗	✗	✗	✓	✗
Hu et al. , [40]	✗	✓	✗	✗	✓	✗
Taleb et al. , [41]	✗	✗	✓	✗	✗	✗
Abbas et al. , [24]	✗	✓	✓	✗	✗	✗
Roman et al. , [42]	✗	✗	✓	✓	✓	✗
Mao et al. , [43]	✗	✗	✓	✗	✗	✗
Khan et al. , [44]	✗	✗	✓	✓	✓	✗
Hassan et al. , [45]	✗	✓	✓	✓	✓	✗
Yu et al. , [46]	✗	✓	✓	✓	✓	✗
Gharaibeh et al. , [47]	✓	✗	✗	✗	✗	✗
Lim et al. , [48]	✓	✓	✗	✗	✗	✗
Alavi et al. , [49]	✓	✓	✗	✗	✗	✗
Silva et al. , [50]	✓	✓	✗	✗	✗	✗
Our Survey	✓	✓	✓	✓	✓	✓

II. LITERATURE REVIEW

The Role of Edge Computing in Autonomous Vehicles and Smart Cities

Edge Computing in Autonomous Vehicles:

Integrating cutting-edge computing into autonomous vehicles has received great attention in the recent research literature. To solve problems related to latency, flight decision, and communication efficiency, edge computing has become an important technology that enhances the capabilities of the autonomous car. In my seminal work, I have conducted a comprehensive research review demonstrating the benefits of edge computing for autonomous vehicles. I emphasize the importance of reducing delays, improving decision-making processes, and improving communication between vehicles and infrastructure. This investigation was not just a simple investigation, it also laid the foundation for the next investigation. I have taken this discussion one step further by focusing on cloud computing as a unique form of edge computing to support driving. The article explains the advantages of using cloud computing to bring computing devices closer to the vehicle, reduce latency, and increase communication efficiency. This study reveals the potential of cloud computing to solve critical problems in transportation.

Edge Computing in Smart Cities:

In the context of smart cities, the integration of edge technologies helps increase the efficiency and effectiveness of cities. It provides a comprehensive review of climate integration in smart cities. This article takes an in-depth look at the role of the cloud in optimizing various smart city applications, including traffic management, utilities, and utilities.

To complement this review, I have conducted a study focusing on the widespread use of cloud and edge computing in smart cities. Covering areas such as smart transportation, environmental care and healthcare, the survey shows how edge computing can increase the expansion and efficiency of smart city services. This study provides an overview of the various uses and impacts of edge computing in the context of urban development.

Cross-Domain Integration:

The intersection of cutting-edge computing and in-vehicle connectivity creates an integrated system that supports autonomous vehicles and smart cities. I explored this integration in my research and demonstrates the potential to create an integrated ecosystem that can combine vehicle management information and smart spaces in the city. The article outlines the challenges and opportunities associated with ensuring effective communication and knowledge sharing across fields. Aiming at the challenges and opportunities of deploying edge intelligence for autonomous vehicles in smart cities, it provides insight into the performance, safety and scalability of urban transportation solutions. This study highlights the need for collaboration between edge computing and self-management, providing a clear understanding of the challenges associated with the integration of these technologies to solve urban transportation problems.

In summary, the literature review shows the important role of edge computing. Recent research based on significant studies and research demonstrates the potential for joint collaboration to provide a better understanding of the challenges and opportunities associated with the use of technology in these areas.

III. METHODOLGY

REQUIREMENTS - This section outlines and explains core requirements to turn the vision of edge computing enabled smart cities into reality. These requirements (illustrated in figure 6) include scalability and reliability, resource management, interoperability, sustainability, elasticity, context-awareness, security, and business models. Early information is required for a timely solution.

Expectations of city residents are increasing, but the budget is not. To improve services while increasing efficiency, local governments are inspired by the "smart City" model. The idea is to combine new technologies such as the Internet of Things (IoT), artificial intelligence, and machine learning (AI/ML) to quickly identify and fix problems affecting public safety, public interest, and environmental safety. For example, traffic management, transport management, timely maintenance of the lake and garbage collection, improvement of street lighting, identification of insufficient bag trust and response to emergencies such as chemical or gas.

Smart city has matured:

The first smart city projects were limited to technology at that time. Wi-Fi and LTE 4G networks limit the devices that can be transferred. Since edge servers do not have the ability to perform analysis, data from the edge must be sent to the cloud for processing. Travel delays prevent timely responses, such as turning on parking lot ventilation in response to dangerous carbon monoxide.

Smart city solutions currently advancing on a large scale:

- High efficiency. Off-the-shelf graphics processing units (GPUs) can be integrated into compact edge devices suitable for roads, parking lots and more. Some data is faster to process at the edge and can save bandwidth.
- Better connectivity. Compared to Wi-Fi and 4G networks, 5G networks are faster and can connect more devices, up to 1 million devices per square kilometer (0.38 square miles).
- Decentralized cloud architecture. Applications based on packaged products can be deployed across multiple clouds, data centers, and edges. In reality, the work takes place much closer to the surface.
- Fast construction. According to the DevSecOps approach, codes can be used continuously and together. Built-in automatic security. New features are rolled out in a day, sometimes in less than an hour.

Fig. 6: Edge computing enabled smart cities requirements

The Red Hat Way-
With Red Hat® open source technology and its partner ecosystem, you can create a hybrid cloud for smart city energy. A hybrid cloud may include one or more clouds, data centers, and edge devices near roads, city buildings, and transportation hubs.
- Build smart city applications with Red Hat OpenShift®. Deploy the application across multiple clouds and dozens of edge locations to create consistent application development and performance. Red Hat Enterprise Linux® provides a consistent system across all environments and allows custom images to be deployed to the edge.
- Manage distributed platforms (global and one or more clouds) for Kubernetes using Red Hat OpenShift and Red Hat Advanced Cluster Management. Manage applications running up to 10,000 edges on a single connection with IBM Edge Application Manager.
- Use IoT sensors from any vendor, such as IP cameras, environmental sensors, chemical sensors, vehicle meters or parking sensors. Red Hat's open application programming interface (API) lets you mix and match sensors to avoid vendor lock-in.
- Use smart technology with AI/ML-optimized GPUs like the NVIDIA EGXTM AI platform. The
GPU worker allows workloads to run on Red Hat OpenShift or perform edge computing from drivers on Red Hat Enterprise Linux using the GPU itself.
- Set up IoT sensors to send to nearby devices. Here the custom engine determines which files are processed locally and which files are sent to the cloud. For example, if the sensor on the garbage bin sends a message to the nearest truck, the information never leaves the side. For example, telemetry data from city buses in a region can be sent to the cloud to provide machine learning models for predictive maintenance.

Application: Smart City Solutions from Red Hat and NVIDIA
Red Hat and NVIDIA have partnered to create cloud solutions to improve transportation, pedestrian traffic and property maintenance. A combination of edge and cloud. At the edge, applications running on NVIDIA EGXTM extract metadata from the live video stream sent by connected cameras. Edge devices stream accurate data to the cloud for analysis and visualization. This analytics application runs on multiple Red Hat OpenShift clusters that can scale up and down as needed. Cloud applications are built on micro services-based packages and can be ported to other clouds.

IV. RESEARCH AND TRENDS STATISTICS

Figure 2 illustrates edge computing and smart cities research trends showing the exponential increases in the numbers of publications in both domains. Apart from the research publications trend, according to statistics, the percentages of people living in cities were 29% and 50% in the years 1950 and 2008, respectively, which is expected to reach 65% in 2040. Approximately 1.3 million people are moving to cities every week. In 1975, there were three megacities, but currently there are 21 mega cities having a population more than 10 million. Moreover, the number of megacities in 2025 is expected to increase by one city in Africa, two in Latin America, and five in Asia. Furthermore, cities utilize

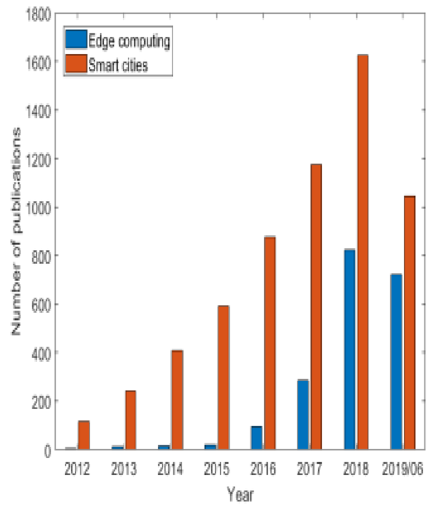

Fig. 2: Number of published articles on edge computing and smart cities.

approximately 60%-80% of the world energy and generate 50% of greenhouse gas emissions. The considerable rise in the number of smart cities in the foreseeable future will likely to increase smart cities market share. It has been predicted that the smart cities market share will increase at a Compound Annual Growth Rate (CAGR) of 18.4%. The smart cities market share will reach USD 717.2 billion by 2023 compared to USD 308 billion in 2018. The major players of the smart city service providers include Toshiba (Japan), Schneider Electric (France), Siemens (Germany), Hitachi (Japan), Ericsson (Sweden), Huawei (China), Cisco (US), Oracle (US), IBM (US), Microsoft (US), among others. On the other hand, the number of smart IoT devices enabling smart city applications is expected to reach 500 billion by 2030. Grand View Research, Inc. estimates the market share of edge computing to reach USD 3.24 billion by 2025 at a CAGR of 41.0%. Smart health-care is expected to witness the highest CAGR growth in the period from 2017 to 2025. Health-care is expected to exceed the market share of USD 326 million. The potential players in edge computing market are SAP SE, Microsoft, Intel Corporation, International Business Machines (IBM), Huawei Technologies Co. Ltd, Amazon Web Services, Inc (AWS), Hewlett Packard Enterprise Development LP, General Electric, Cisco Systems, Inc, among others. Edge computing in the market is expected to continually increase. Apart from edge computing market, the rapid rise in IoT based smart cities and edge computing research is evident from the statistics and research trends. These technological advancements in edge computing, IoT, and smart cities have revealed captivating research and development opportunities for manufacturers to enhance their market shares.

V. CASE STUDIES

This section presents the latest integration and case studies on the smart city frontier. This section provides an overview of the research data by listing objectives, participating organisations, referrals and countries. A. Barcelona Smart City Barcelona Smart City is Barcelona Smart City is a collaboration between Barcelona City Council, Prismtech, i2cat, Technical University of Catalonia, Barcelona Supercomputer Center, Schneider Electric, Plat. one, Sense fields and CISCO, aiming to realize smart programs. Project partners are focusing on five applications, including electronic monitoring/equipment management, access control and rack telemetry, event video, traffic management and optional communications link. In order for smart cities to be realized, many IoT-oriented devices need to be installed, which causes problems in offices and spaces. In this case, the number of delivery counters in the Barcelona Smart City exceeds 3,000. On the other hand, fog computing has proven to make instant decisions, autonomous work power, warranty management, local data analysis and complete the complex process to help the car move. B. #SmartME #SmartME is a program that aims to transform the city of Messina into a smart city. The project was initiated by a research team from the University of Messina. The main goal of the #SmartME project is to create a smart city economy where all citizens can contribute to infrastructure development through hardware sharing. The #SmartME framework consists of three layers: application layer, Stack4Things layer (for cloud computing platform usage) and city layer. Stack4Things is a framework developed by the University of Messina that aims to enable administrators to manage IoT devices without tracking their location. Stack4Things' main functions include object virtualization, IoT coverage, remote management and modification, and cloud orchestration. Applications built on the #SmartME infrastructure include #SmartME Parking, #SmartME Lighting, #SmartME Çukurlar, #SmartME Airport, #SmartME Taxi, #SmartME Art and #SmartME Trash. A. The Visualization of the Most Safe, Robust and Effective Smart City Applications Using Fog Computing (WATCH) project is funded by INNOVATE UK. Construction began on November 1, 2017 and is expected to be completed in 2020. The main organizations of the project are London Future Intelligence Ltd and London South Bank University in the UK. The aim of the project is to implement paper users in smart cities by providing integrated equipment, local operation and communication using new micro data center and telecommunications. Additionally, they will leverage software-defined networking and network function virtualization (NFV) to create islands of connected devices. This creates the cloud, which is a small cloud at the edge of the network (i.e. edge computing). The main goal of the project is to use edge computing to improve intelligent surveillance.This study presents recent research on the frontiers of smart city applications. We discussed the mission, the organizations involved, and their current distribution. From this section, we conclude that there is a need to develop effective simulation tools to implement and demonstrate the superiority of smart city application. For example, IoTIFY is a cloud-based online network simulator that can simulate smart waste management, smart parking, smart lighting, smart traffic lights, and smart transportation. We need to create new, high-performance simulators to test computing and other new technologies in smart cities.

VI. CONCLUSION AND FUTURE OUTLOOK

Edge computing is a promise made in talks that can support smart cities by incorporating time and storage. Generally, cloud computing is used to provide computing and storage to smart devices. However, cloud computing's centralized latency paves the way for computing and storage services to be moved from centralized remote locations to the edge of the network. On the other hand, real-time smart city application requires real-time monitoring services. Edge usage is required to activate the current application.

However, the use of edge computing in smart cities poses significant challenges. This research takes a holistic view of edge computing adoption in smart cities. To this end, we will first introduce the evolution of edge conversations and discuss the evolution of technology towards edge computing. Additionally, the participation process and the results of different interview methods are presented. Second, significant advances have recently been reported and measured rigorously using different metrics. In addition to recent progress, we have distributed data and created classification based on different aspects such as edge analysis, edge intelligence, resources, caching, management, features, capabilities, and security. In addition, many requirements were put forward to implement the smart city from the edge of IT. We have also published some research on enabling computing in smart cities. Additionally, many open research problems are discussed in detail and their causes and possible solutions are noted.We expect network connectivity to be widely used in the development of smart cities in the future. Now millions of items have been sent to the city. Trillions of smart devices and sensors will be added in the future. All of these devices produce traffic data that requires real-time monitoring service. Edge computing can enable real-time analytics by providing low-latency resources on demand. Additionally, data transmission between end devices and edge servers requires new communication with advanced devices. On the other hand, the development of smart cities needs to be stable and reliable. Different people such as telecom operators, computer service providers, cloud service providers and IoT service providers will intervene to implement smart cities through new technologies. An important question is how to optimize this interaction to get the best results and improve service quality? Network slicing is the answer, and it can be used to improve service quality and increase revenue. This allows the creation of multiple communication channels (so-called slices) on top of the physical infrastructure of different service providers. The main players in network connectivity supporting smart cities are SDN and NFV. SDN provides separation between the control plane and the data plane, while NFV allows the use of general-purpose devices to perform different functions. Separating the control plane from the data center simplifies network management and provides greater flexibility in adding new features to the network. A smart city based on network connectivity will provide multiple slices for different smart services. Different articles discuss the development of smart cities as a network connection. These slices have different needs and must share the same physical structure for efficient operation. Dedicating an end-to-end network to a slice is expensive. Therefore, many slices must be merged at the same time. However, since it is difficult to manage the resources of existing resources, new management methods are needed. Different organizations are also trying to make smart applications through networking. For example, this presents a network slicing-based testbed using edge computing at the Port of Hamburg. Additionally, many organizations are working on the AutoAir project in the UK to develop an edge computing and connectivity-based testing platform for connectivity and driving. To summarize, edge computing and networking will become essential solutions for smart cities in the future.

VII. REFERENCE

[1]. Ahmed E. ,Yaqoob I. , Gani A. , Imran M., and Guizani M.(2016) ,"Internet-ofthings-based smart environments: state of the art, taxonomy, and open research challenges," IEEE Wireless Communications,(vol. 23, no. 5, pp. 10–16).

[2]. Xie J. , Tang H. , Huang T. , F. R. Yu, Xie R. , Liu J. , andLiu J. (2019), "A survey of blockchain technology applied to smart cities: Research issues and challenges, in press," IEEE Communications Surveys Tutorials.

[3]. Eckhoff D. and Wagner I.(2018), "Privacy in the smart city—applications, technologies, challenges, and solutions," IEEE Communications Surveys Tutorials, (vol. 20, no. 1, pp. 489–516).

[4]. Ianuale N., Schiavon D., and Capobianco E. (2016), "Smart cities, big data, and communities: Reasoning from the viewpoint of attractors," IEEE Access, (vol. 4, pp. 41–47).

[5]. Rostirolla G., R. d. R. Righi, J. L. V. Barbosa, and C. A. da Costa (2018), "Elcity: An elastic multilevel energy saving model for smart cities," IEEE Transactions on Sustainable Computing, (vol. 3, no. 1, pp. 30– 43).

[6]. Ramaprasad A., Sanchez-Ortiz A., and Syn T.(2017), "A unified definition ´ of a smart city," in Springer International Conference on Electronic Government, St. Petersburg, Russia, (pp. 13–24).

[7]. Mehmood Y., Ahmad F., Yaqoob I., Adnane A., Imran M., and Guizani S.(2017), "Internet-of-things-based smart cities: Recent advances and challenges," IEEE Communications Magazine, (vol. 55, no. 9, pp. 16– 24).

[8]. Buyya R., C. S. Yeo, Venugopal S., Broberg J., and Brandic I.(2009), "Cloud computing and emerging it platforms: Vision, hype, and reality for delivering computing as the 5th utility," Future Generation computer systems, (vol. 25, no. 6, pp. 599–616).

[9]. Bilal K., S. U. R. Malik, S. U. Khan, and A. Y. Zomaya (2014), "Trends and challenges in cloud datacenters," IEEE Cloud Computing, (vol. 1, no. 1, pp. 10–20).

[10]. Lehrig S.,Eikerling H., andBecker S. (2015), "Scalability, elasticity, and efficiency in cloud computing: A systematic literature review of definitions and metrics," in Proceedings of the 11th

ACM International Conference on Quality of Software Architectures, Montreal, QC, Canada,(pp. ´ 83–92).

[11]. Al-Dhuraibi Y., Paraiso F., Djarallah N., and Merle P.(2018), "Elasticity in cloud computing: State of the art and research challenges," IEEE Transactions on Services Computing, (vol. 11, no. 2, pp. 430–447).

[12]. Delgado V.(2010), "Exploring the limits of cloud computing," Master's thesis, KTH Information andCommunication Technology, Stockholm, Sweden.

[13]. Ahmed E., Ahmed A., Yaqoob I., Shuja J., Gani A., Imran M., and Shoaib M.(2017), "Bringing computation closer toward the user network: Is edge computing the solution?" IEEE Communications Magazine, (vol. 55, no. 11, pp. 138–144).

[14]. Shi .W,Cao J.,Zhang Q.,Li Y.,andXu L. (2016), "Edge computing: Vision and challenges," IEEE Internet of Things Journal, (vol. 3, no. 5, pp. 637–646).

[15]. Ji W., Xu J., Qiao H., Zhou M., and Liang B. (2019), "Visual iot: Enabling internet of things visualization in smart cities, in press," IEEE Network.

[16]. M. A. Rahman, M. M. Rashid, M. S. Hossain, Hassanain E., M. F. Alhamid, and Guizani M. (2019), "Blockchain and iot-based cognitive edge framework for sharing economy services in a smart city," IEEE Access, (vol. 7, pp. 18 611–18 621).

[17]. Atzori L.,Iera A., and Morabito G.(2017), "Understanding the internet of things: definition, potentials, and societal role of a fast evolving paradigm," Ad Hoc Networks, (vol. 56, pp. 122–140).

[18]. Miraz M.,Ali M., Excell P., and Picking R. (2018), "Internet of nano-things, things and everything: future growth trends," Future Internet, (vol. 10, no. 8, p. 68).

[19]. Al-Fuqaha A., Guizani M., Mohammadi M., Aledhari M., andAyyash M. (2015), "Internet of things: A survey on enabling technologies, protocols, and applications," IEEE Communications Surveys & Tutorials, (vol. 17, no. 4, pp. 2347–2376).

[20]. Internet of things definition. [Online; Accessed: 019, April 1]. [Online]. Available: https://www.postscapes.com/internet-of-things-definition/

[21]. N. K. Giang, Leung V., and Lea R. (2016), "On developing smart transportation applications in fog computing paradigm," in Proceedings of the 6th ACM Symposium on Development and Analysis of Intelligent Vehicular Networks and Applications, Malta,(pp. 91–98).

[22]. Taleb T. , Dutta S. , Ksentini A. , Iqbal M. , and Flinck H. (2017), "Mobile edge computing potential in making cities smarter," IEEE Communications Magazine, (vol. 55, no. 3, pp. 38–43).

[23]. Huang C., Lu R., and K. R. Choo (2017), "Vehicular fog computing: Architecture, use case, and security and forensic challenges," IEEE Communications Magazine, (vol. 55, no. 11, pp. 105–111).

[24]. Huang X., Yu R., Kang J., He Y.,and Zhang Y. (2017), "Exploring mobile edge computing for 5g-enabled software defined vehicular networks," IEEE Wireless Communications, (vol. 24, no. 6, pp. 55–63).

[25]. Premsankar G.,Ghaddar B.,DiFrancesco M., and Verago R. (2018), "Efficient placement of edge computing devices for vehicular applications in smart cities," in IEEE/IFIP Network Operations and Management Symposium, Taipei, Taiwan,(pp. 1–9).

[26]. Smart city infographic. [Online, Accessed Nov. 10, 2018]. [Online]. Available: https://www.postscapes.com/anatomy-of-a-smart-city/

[27]. MARKETSANDMARKETS. Smart cities market. [Online, Accessed Nov. 13, 2018]. [Online]. Available: https://www.marketsandmarkets.com/Market-Reports/smart-cities-market-542.html

[28]. G. view research. Market research report. [Online; Accessed 2019, April 1]. [Online]. Available: https://www.grandviewresearch.com/ industry-analysis/edge-computing-market

[29]. Yannuzzi M.,van Lingen F.,Jain A., O. L. Parellada, M. M. Flores, Carrera D., J. L. Perez, Montero D., Chacin P., A. Corsaro ´ et al. (2017), "A new era for cities with fog computing," IEEE Internet Computing, (vol. 21, no. 2, pp. 54–67).

[30]. Sellebraten M. (2018), Fog computing in barcelona smart city. [Online; Accessed Oct. 16, 2018]. [Online]. Available: https://www.marketsandmarkets.com/Market-Reports/smart-cities-market-542.html

[31]. smartme. [Online; Accessed Oct. 20, 2018]. [Online]. Available: http://smartme.unime.it/

[32]. Watch. [Online; Accessed Oct. 20, 2018]. [Online]. Available: https://gtr.ukri.org/projects?ref=103845

[33]. Smart city simulation. [Online; Accessed Jan. 4, 2019]. [Online]. Available: https://iotify.help/network/smart-city/simulation.html

[34]. Yaqoob I., Ahmed E., I. A. T. Hashem, A. I. A. Ahmed,Gani A., Imran M., and Guizani M. (2017),

"Internet of things architecture: Recent advances, taxonomy, requirements, and open challenges," IEEE Wireless Communications, (vol. 24, no. 3, pp. 10–16).

[35]. Foukas X., Patounas G., Elmokashfi A., and M. K. Marina (2017), "Network slicing in 5g: Survey and challenges," IEEE Communications Magazine, (vol. 55, no. 5, pp. 94–100).

[36]. Kaloxylos A. (2018), "A survey and an analysis of network slicing in 5g networks," IEEE Communications Standards Magazine, (vol. 2, no. 1, pp. 60–65).

[37]. Zhang S., Quan W., Li J., Shi W., Yang P., andShen X. (2018), "Air-ground integrated vehicular network slicing with content pushing and caching," IEEE Journal on Selected Areas in Communications, (vol. 36, no. 9, pp. 2114–2127).

[38]. Rost P., Breitbach M., Roreger H.,Erman B. (2018), C. Mannweiler, R. Miller, and I. Viering, "Customized industrial networks: Network slicing trial at hamburg seaport," IEEE Wireless Communications,(vol. 25, no. 5, pp. 48–55).

[39]. Chaabnia S. and Meddeb A. (2018), "Slicing aware qos/qoe in software defined smart home network," in IEEE/IFIP Network Operations and Management Symposium, Taipei, Taiwan,(pp. 1–5).

[40]. Boussard M.,Thai Bui D.,Douville R., Justen P., Le Sauze N., Peloso P., Vandeputte F., and Verdot V. (2018), "Future spaces: Reinventing the home network for better security and automation in the iot era," Sensors,(vol. 18, no. 9, p. 2986).

[41]. A. E. Kalør, Guillaume R., J. J. Nielsen, Mueller A., and Popovski P. (2018), "Network slicing in industry 4.0 applications: Abstraction methods and end-to-end analysis," IEEE Transactions on Industrial Informatics, (vol. 14, no. 12, pp. 5419–5427).

[42]. Afolabi I., Taleb T., Samdanis K., Ksentini A., andFlinck H. (2018), "Network slicing and softwarization: A survey on principles, enabling technologies, and solutions," IEEE Communications Surveys Tutorials, (vol. 20, no. 3, pp. 2429–2453).