Application of IoT in 5G Wireless Communication: A Detailed Review

Bharti Bhardwaj, Vanita, and Suresh Kumar(✉)

University Institute of Engineering and Technology, MD University, Rohtak, Haryana, India
sureshvashist.uiet.ece@mdurohtak.ac.in

Abstract. Internet Of Things (IoT) based wireless technologies have gained a lot of popularity recently all around the world and 5G technology has emerged as a particularly difficult and intriguing research field. This article examines 5th Generation (5G) wireless technologies based on IoT. Internet in 5G is the coming future. Cutting-edge Wi-Fi infrastructure and automation will be enabled by this. Recent cellular networks, such as LTE, will be insufficient or inefficient in meeting the needs of connection to more than one devices with higherrate of data transmission, increased capacity, and lower latency. High-quality service with minimal disruption. 5G technology is the most promising solution to these all issues. This paper gives an in-depth study of the obstacles and future objectives of several communication businesses in the context of 5G. Many features of 5G systems are thoroughly discussed and examines in depth emerging and enabling technologies, which enables the IoT. Control techniques, wider area with low power networks and security considerations are also considered. This paper discusses the role of augmented reality in the 5G future. It also goes into details of IoT application areas in 5G.

Keywords: IoT · Wireless sensor network · 5G system · Security · LTE

1 Introduction

IoT is a system in which physical objects-gadgets are connected to each other and can be remotely controlled. Here vehicles, different structureshaving hardware, programmable sensors and system connected tonetworks are involved. All this helps to collect and analyse information. The IoT allows items to be sensed and give access to control them at a remote location across connected system foundation, making them available for more reconciliation of physical things into digital based infrastructures and giving better proficiency, accuracy, precision at lower costs [1].

1.1 Basics of IoT

Devices containing sensors, computer power, software, and other technologies are referred to as IoT. These devices may connect with one another through the Internet or another communication network. IoT is now being used in 5G system research. In

A. K. Luhach et al. (Eds.): ICAICR 2021, CCIS 1575, pp. 269–279, 2022.
https://doi.org/10.1007/978-3-031-09469-9_23

this study, a wireless sensor network was analyzed in order to make decisions based on a trained network. In order to create a dependable and adaptable solution for 5G wireless system, the study employs wireless network model for 5G system in the current IoT system [2, 3]. The main constituents of IOT are shown below in Fig. 1.

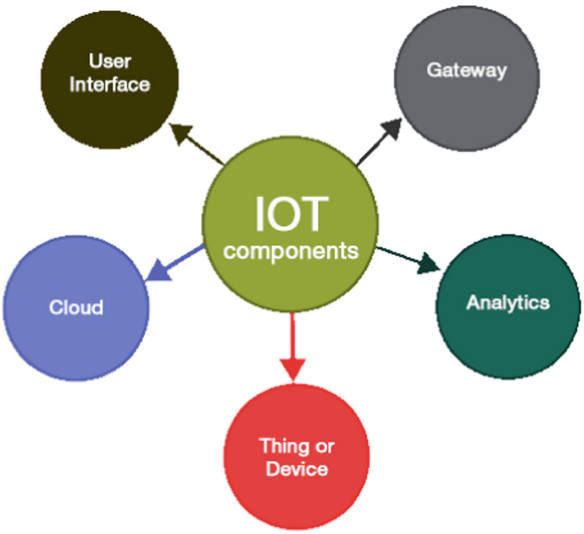

Fig. 1. Major components of IoT

1.2 Need of IoT

Sensors and other IoT devices are most often utilized in the industrial, transportation, and utility sectors. They have also found uses in agriculture, infrastructure, and home automation, contributing to the digital transformation of certain organizations [4]. Secure and pleasant environment is the goal of IoT [5]. This aspires to connect every possible object to the internet, as much as feasible, the IoT links us all.The various networks connected via IoT are shown in Fig. 2.

Embedded computer equipment would be affected by the internet. A recent developed universe of Information Technology (IT) has been created by IoT. In the server room, PCs, and PDAs, data mechanization has not slowed down. Currently, it can be found in every object around us. The vast majorities of the devices we use every day are either now linked or will be in the near future. Many different types of valuable data will be available for them to discover and sell with the help of technologically smart program. The use of media, databases, and apps in our daily lives is becoming more pervasive. Our lives will be covered in a type of technological net or skin as a result. Unexpectedly one may even claim, “No Net, No Planet.

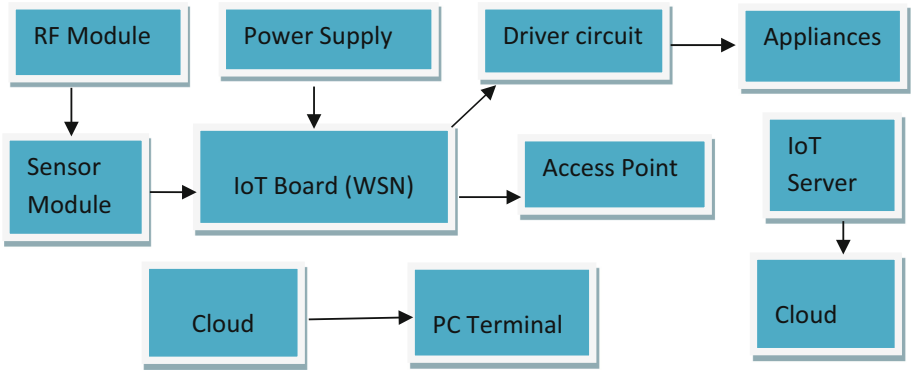

Fig. 2. IoT with network

1.3 Sensor Network Using Wireless Systems

Sensor network with wireless systems or WSN is a network that are scattered over a large area and monitor and record environmental parameters before transferring data to central point [6]. Humidity, wind speed, and temperature and direction are just a few of the variables that WSNs can track. A network of sensors that collect and transfer data on physical or environmental components like sound pressure, motion velocity, or pollutants to a central location is characterized as a self-configured and infrastructure-free wireless sensor network.

Sensors with built-in Wi-Fi may keep tabs on a variety of environmental parameters and relay that data to a central location for analysis [7]. WSNs may be used to collect data on environmental parameters as noise levels, pollution levels, humidity levels, and wind speeds.

2 Applications of 5G in Various Wireless Systems

2.1 Terrestrial Microwave

Wireless microwave networking technique, terrestrial microwave employs line-of-sight communication between transmitters and receivers which are on earth using 5G network [8]. For cost reasons, microwave transmitter and receivers are often located far above the earth on towers or mountaintops.terrestrial microwave link is shown in Fig. 3.

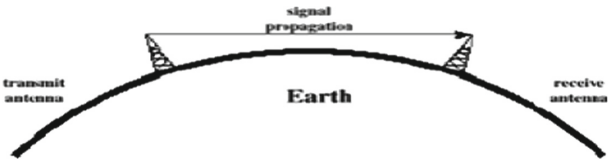

Fig. 3. Terrestrial microwave

In order to transfer data, pairs of Earth-based transmitters and receivers employ line-of-sight communications to establish a terrestrial microwave network.

2.2 Cellular and PCS Systems

For those who want a wireless phone service that is both personal and mobile, PCS (personal communications services) is the answer [9]. "Digital cellular" has been coined to describe it (although cellular systems can also be digital). To provide adequate coverage for a large region, PCS, which is also designed for mobile users, utilises a plethora of antennae. The signal from the phone of a user is received by an antenna in the vicinity and sent them to the base station of that network as the user travels about. The phone is slightly smaller than a cellular phone. There are now more than 230 million users who can access PCS, according to Sprint. Figure 4 shows a block diagram of cellular and PCS systems.

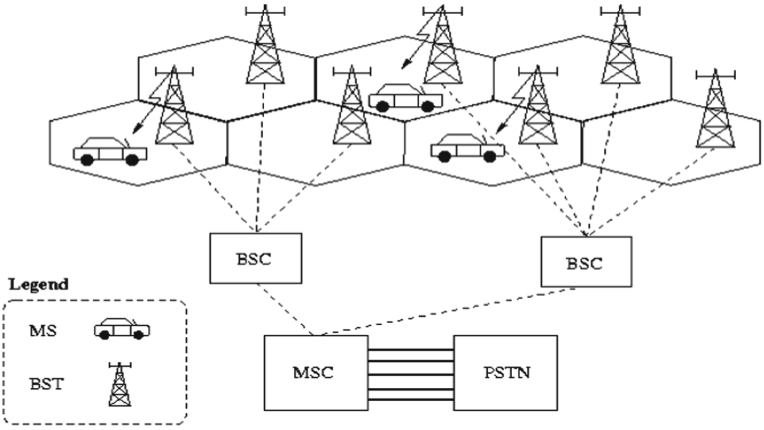

Fig. 4. Cellular & PCS systems

2.3 Radio and Spread Spectrum Technologies

Telecommunications and communication using radio frequenciesuses techniques of spreading a signal with a given bandwidth in the frequency domain, creating a signal with a broader bandwidth [10, 11]. Thus signal structure resembling noise is used to widened a low band signal on a wide frequency band in a spread spectrum approach as shown in Fig. 5.

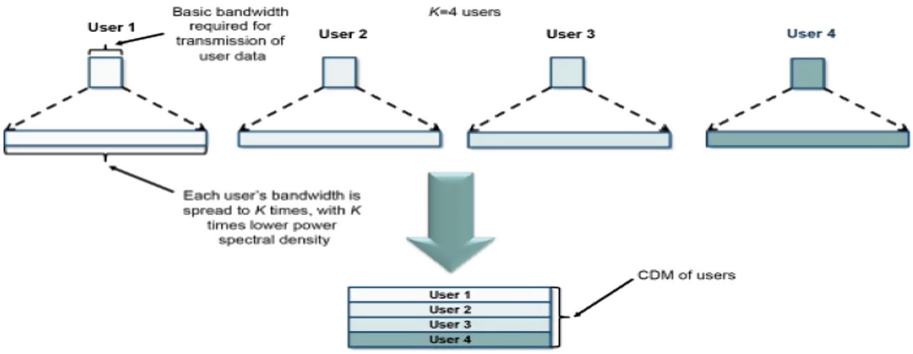

Fig. 5. Radio & spread spectrum technologies

2.4 Free Space Optical (FSO) Communication

Data may be sent wirelessly across long distances using a modulated optical beam aimed towards free space, without the need of conventional optical technologies such as fibre optics. Light (or smoke) signals were employed in ancient times to communicate information [12]. Infrared laser light can be used to build point-to-point optical communications in free space, but LEDs can also be used for low-data-rate communication over short distances [13]. Communications between spacecraft can be made using free-space optics depicted below in Fig. 6.

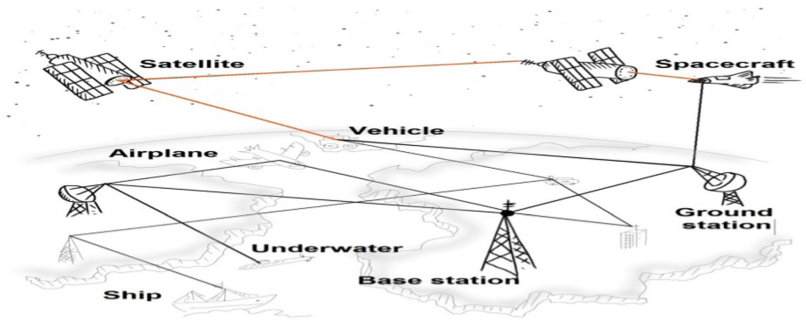

Fig. 6. Free space optical communication

This type of free-space optical communication is known as Infrared Data Association (IrDA). When it comes to optical wireless communications applications, FSO technology is included [14].

2.5 Communication Satellite

One kind of communications satellite is a transponder-based artificial satellite that transmits data from a remote transmitter to a receiver located in another part of the world.

Communications satellites are used for television, telephone, radio, the internet, and military purposes [15]. Passive satellites and active satellites are the two main types of communication satellites. Satellites using passive technology don't use their own sent energy to amplify reflected signals, so that a part of the complete energy is received by thereceiver. Due to the satellite's high altitude and consequent free-space route loss, the radio signal it transmits is quite feeble when it reaches Earth. On the other hand, active satellites boost the received signal before sending it back to the ground station. Despite being the first satellites for communications, passive satellites are now rarely used. Figure 7 shows a communication satellite.

Fig. 7. Communication satellite

3 Challenges and Vision oF 5G IoT

As cellular technology has progressed over the years, it has become more common. Since 1G was introduced, there have been a number of challenges in design of physical & network layers and the areas in which they are used. In light of all of these issues with current networks, 5G has ushered in a major shift in wireless technologybased on IoT [16]. The research difficulties on 5G technology, according to the study, are mostly focused on the following topics.

- In order for real-time networks to function, data must be sent at a rate of 110 GBPS, which is ten times faster than existing technology.
- As opposed to LTE networks, latency must be 10 times lower in order for it to function.
- Using MIMO antennas and millimetre wave technology, 5G networks may achieve high bandwidth and spectrum efficiency, while cognitive radio allows users to access both licenced and unlicensed spectrum bands, respectively [17].
- Forlow-cost sensors and devices, as well as low-cost deployment, should be part of IoT.
- As technology improves so will the amount of power it consumes, demanding greater battery storage and backup.
- Energy usage in 5G networks, which are capable of massive connections and high data speeds, might fall by over 90% if green technologies are adopted [18].

Wireless communication firms and academic institutions are launching & collaborating, research initiatives in many areas of 5G in response to the seven primary concerns

listed above. 5G wireless technology is expected to be widely available by 2025 thanks to research and field testing by some of the world's major cellular, semiconductor, and service companies. At a number of world-class research organizations, 5G research and experimentation is taking place. Long-distance communication, longer battery life, the capacity to talk to billions of devices, and faster internet speeds are all anticipated to be satisfied by new cellular technology advances. IoT in a 5G framework has the potential to be most transformative technology in information technology industry, according to experts. 5G technology is expected to be widely available by 2025, a study has shown.

4 Latest Research Work

An in-depth talk by Ali A. Zaidi was given on the aspects of NR OFDM numerology that are required for eMBB, IoT, and MBSFN. The 3rd Generation Partnership Project is presently standardising NR (3GPP). It has been authorised using 3GPP in NR physical layer architecture to accommodate a wide range of situations and deployments.

His presentation at the Mobile World Congress focused on the impact of PTM on 5G network slicing, which allows for network resources to be dynamically adjusted accommodatingvarious services while considering user density.It is possible that 5G PTM broadcasts may be designed to break with the present paradigm of 4G Long Term Evolution, where firstly PTMbroadcast transmissions were planned as an additional and pre-positioned service.

Morteza Hashemi presented a mmWave design operating at less than 6 GHz. Our technology takes advantage of the spatial correlations between the mmWave and sub-6 GHz interfaces for beamforming and data transfer. Because of spatial correlations with the sub-6 GHz frequency region, our extensive tests in both indoor and outdoor environments show that analogue beamforming may be implemented in mmWave without incurring a substantial overhead [19].

By using 5G millimetre wave installations, Dmitrii Solomitckii claims that amateur drones might be tracked We believe that the projected 5G infrastructure contains all of the components essential for drone monitoring and identification. It's consequently important to consider density of base stations as well as their directional antennae & available bandwidth when designing new technologies and systems. Our ray-based modelling techniques are used to quantify the effects of these variables [20].

LTE, which uses OFDM for synchronous communication, and machinetype DUE, which use a different waveform when executing asynchronously, were the focus of Conor Sextan's study. In the synchronous OFDM case, offset-QAM achieves an average rate marginally higher than the baseline case and around 43% higher than the asynchronous OFDM situation [21].

Specifically, Godfrey A. Akpakwu focused on 5G mobile networks, which are predicted to manage exponential traffic growth and allow the Internet of Things, in a thorough analysis of emerging. When developing a context-aware congestion management mechanism, the constraints & open research paths relevant to deployment of large-scale to crucial IoT applications are also highlighted [22].

To help people better comprehend the current stage of IoT development, Jie Lin gave a discussion. Also, it studies the relationships between IoT and fog/edge computing, as

well as the difficulties related to this type of IoT. Cyber-physical systems and IoT play a crucial role in achieving an intelligent cyber-physical world, which is the focus of this research study. This is followed by a discussion of the current state-of-art in Internet of Thing designs, technology, and security and privacy concerns. To better understand fog computing-based IoT, authors of this study look at the connection between fog computing and IoT as well as some of the challenges associated with this kind of IoT [23].

Energy management and smart city issues were briefly discussed by W. Ejaz. Finally, they provide a single framework for Internet of Thing based smart city energy-efficient scheduling and optimization. For example, they address how to prolong the life of low-power gadgets using energy harvesting in smart cities and its associated issues. Two examples are given. One focuses on maximising energy efficiency in smart homes, while the other addresses wireless power transmission for IoT devices in urban environments [24].

New mobile technologies on cloud-based IoT systems have unique security and privacy requirements. Hence, J. Zhou created an efficient aggregation without public key homomorphism encryption. Finally, number of intriguing open issues & possible concepts are presented to stimulate more study in this burgeoning fields [25].

Research and design challenges for IoT and machine-to-machine communications necessitate fundamental network paradigm shifts to meet the predicted high traffic and low latency requirements. The massive deployment of tiny cells in the millimeter-wave spectrum is one of these possibilities. 5G will be the most intelligent and dominating wireless technology yet as a result of the many smart features and applications that will be included into future wireless networks [26].

5 Research Gaps

5G technology is designed to deliver data rates up to 20 Gbps and much lower latency for a more immediate response. Even with the users moving around, it provides an overall more uniform user experience so that the data rates stay consistently high. 5G offers downloading speed of 20 Gb/s (gigabits per second) and uploading speed of 10 Gb/s respectively. Significant problem that the emerging nations suffer is security management. With uncertainty about existing safeguards, the cybersecurity protections available to citizens and governments amid 5G rollout is a matter of concern. The existing studies reveal that providing security reduces overall performance by 7% to 20%. Another issue is its accessibility 24×7. Presently, users need access to information any time at any location. Another key challenge with 5G is its short range. Trees and buildings cause significant signal obstruction, necessitating numerous cell towers to avoid signal path losses. The present work aims at improving the performance of the network by expanding the capacity of 5G connectivity and addressing signal path challenges.

6 Future Scope

In the future, academic institutions and the telecoms industry will focus on 5G and beyond initiatives. IoT research might improve social services in low-income nations

and the rest of the world. These study categories include millimeter wave communication technologies as well as other 5G physical layer research areas like as security and data traffic management. For our analysis, we have included NR, LPWAN networks, as well as high-tech sensors capable of supporting 5G networks. Additional numerology values are included in the physical layer specification for 5G New Radio (NR) in addition to the standard values. Cloud computing and augmented realities, along with the ramifications for 5G (IoT), have also been discussed in detail. Cyber security and privacy are major problems with 5G networks. We looked at the rise in cyber attacks and the corresponding decrease in cyber security and privacy measures in-depth.

7 Conclusion

The integration of 5G with IoT enables to connect as many devices as possible into single network. Several applications that have fueled the Internet revolution include smart agriculture, internet-enabled vehicles, smart manufacturing, smart healthcare, smart cities and many more. NR, MIMO, millimeter wave connectivity and cloud computing are proposed in the 5G IoT architecture. The present work provides a detailed review of IoT, its applications in 5G technology and the upcoming issues in the technology. Several technologies that are critical to the IoT have been overlooked in the present paper on 5G. Cyber security and privacy are major problems with 5G networks. The other issues of concern are its accessibility, short range and reduced performance. These can be resolved by compensating signal path losses and by incorporating effective techniques that increases the capacity of 5G.

References

1. Hashemi, M., Koksal, C.E., Shroff, N.B.: Out-of-band millimeter wave beamforming and communications to achieve low latency and high energy efficiency in 5G systems. IEEE Trans. Cummun. (2017). ieeexplore.ieee.org. https://doi.org/10.1109/TCOMM.2017.2771308
2. Zaidi, A.A., Baldemair, R., Moles-Cases, V., He, N., Werner, K., Cedergren, A.: OFDM numerology design for 5G new radio to support IoT, eMBB, and MBSFN. IEEE Commun. Stand. Mag. **2**(2), 78–83 (2018). https://doi.org/10.1109/MCOMSTD.2018.1700021
3. Gomez-Barquero, D., Navrátil, D., Appleby, S., et al.: Google Scholar. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=3.%09David+Gomez-Barquero%2C+David+Navrátil%2C+Steve+Appleby%2C+and+Matt+Stagg%2C+"Point-to-Multipoint+Communication+Enablers+for+the+Fifth+Generation+of+Wireless+Systems"%2C+IEEE+Communications+Standards+Magazine%2C+March+2018.&btnG. Accessed 06 Dec 2021
4. Sexton, C., et al.: Enabling asynchronous machine-type D2D communication using multiple waveforms in 5G. **5**(2), 1307–1322 (2018). ieeexplore.ieee.org. https://doi.org/10.1109/JIOT.2018.2806184
5. Akpakwu, G., Silva, B., Hancke, G.P., Abu-Mahfouz, A.M.: A survey on 5G networks for the Internet of Things: communication technologies and challenges (2017). https://ieeexplore.ieee.org/abstract/document/8141874/. Accessed 08 Dec 2021
6. Lin, J., Yu, W., Zhang, N., Yang, X.: Zhang, H., Zhao, W.: A survey on internet of things: architecture, enabling technologies, security and privacy, and applications, **4**(5), 1125 (2017). ieeexplore.ieee.org. https://doi.org/10.1109/JIOT.2017.2683200

7. Solomitckii, D., Gapeyenko, M., Semkin, V., Andreev, S., Koucheryavy, Y.: Technologies for efficient amateur drone detection in 5G millimeter-wave cellular infrastructure (2021). https://ieeexplore.ieee.org/abstract/document/8255736/. Accessed 08 Dec 2021
8. Medjahdi, Y., Traverso, S., Gerzaguet, R., et al.: On the road to 5G: comparative study of physical layer in MTC context (2017). https://ieeexplore.ieee.org/abstract/document/8110615/. Accessed 08 Dec 2021
9. Al-Falahy, N., Alani, O.Y.: Technologies for 5G networks: challenges and opportunities. It Professional (2017). ieeexplore.ieee.org. https://doi.org/10.1109/MITP.2017.9
10. Hong, W., Baek, K., Ko, S.: Millimeter-wave 5G antennas for smartphones: overview and experimental demonstration. IEEE Trans. Antennas Propag. (2017). https://ieeexplore.ieee.org/abstract/document/8012469/. Accessed 08 Dec 2021
11. Dawy, Z., Saad, W., Ghosh, A., Andrews, J.G., Yaacoub, E.: Toward massive machine type cellular communications (2021). https://ieeexplore.ieee.org/abstract/document/7736615/. Accessed 08 Dec 2021
12. Wang, Y., Lin, X., Adhikary, A., Grovlen, A., et al.: A primer on 3GPP narrowband Internet of Things (2017). https://ieeexplore.ieee.org/abstract/document/7876968/. Accessed 08 Dec 2021
13. Pierpoint, M., Rebeiz, G.-M.: Paving the way for 5G realization and mmWave communication systems (2016). https://www.keysight.com/us/en/assets/7018-05254/article-reprints/5992-1578.pdf. Accessed 08 Dec 2021
14. Bockelmann, C., et al.: Massive machine-type communications in 5G: physical and MAC-layer solutions (2021). https://ieeexplore.ieee.org/abstract/document/7565189/. Accessed 08 Dec 2021
15. Wang, H., Fapojuwo, A.O.: A survey of enabling technologies of low power and long range machine-to-machine communications. IEEE Commun. Surv. Tutor. (2017). https://ieeexplore.ieee.org/abstract/document/7962157/. Accessed 08 Dec 2021
16. Ejaz, W., Naeem, M., Shahid, A., et al.: Efficient energy management for the internet of things in smart cities. IEEE Commun. Mag. (2017). ieeexplore.ieee.org. https://doi.org/10.1109/MCOM.2017.1600218CM
17. Zhou, J., Cao, Z., Dong, X., et al.: Security and privacy for cloud-based IoT: challenges. IEEE Commun. Mag. (2017). https://ieeexplore.ieee.org/abstract/document/7823334/. Accessed 08 Dec 2021
18. M. Elkhodr, S. Shahrestani, Cheung, H.: The internet of things: new interoperability, management and security challenges, **8**(2), 85–102. arxiv.org preprint arXiv:1604.04824 (2016). https://doi.org/10.5121/ijnsa.2016.8206
19. Nokia: LTE evolution for IoT connectivity. Google Scholar. https://scholar.google.com/scholar?q=20.+Nokia,+%60%60LTE+evolution+for+IoT+connectivity,%27%27+Nokia,+Espoo,+Finland,+White+Paper,+2017,+pp.+1_18.&hl=en&as_sdt=0,5. Accessed 08 Dec 2021
20. Painuly, S., Kohli, P., Matta, P., Sharma, S.: Advance applications and future challenges of 5G IoT. In: 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS) (2020). https://ieeexplore.ieee.org/abstract/document/9316004/. Accessed 08 Dec 2021
21. Gupta, N., Sharma, S., Juneja, P.K., Garg, U.: SDNFV 5G-IoT: a framework for the next generation 5G enabled IoT. In: 2020 International Conference on Advances in Computing, Communication & Materials (ICACCM) (2020). https://ieeexplore.ieee.org/abstract/document/9213047/. Accessed 08 Dec 2021
22. Zafeiropoulos, A., et al.: Benchmarking and profiling 5G verticals' applications: an industrial IoT use case. ieeexplore.ieee.org. https://doi.org/10.1109/NetSoft48620.2020.9165393
23. Soos, G., Ficzere, D., Varga, P.: Towards traffic identification and modeling for 5G application use-cases. Electronics (2020). mdpi.com. https://doi.org/10.3390/electronics9040640

24. Kohli, P., Painuly, S., Matta, P., Sharma, S.: Future trends of security and privacy in next generation VANET. In: 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS) (2020). https://ieeexplore.ieee.org/abstract/document/9316043/. Accessed 08 Dec 2021
25. Sharma, S., Agarwal, P., Mohan, S.: Security challenges and future aspects of fifth generation vehicular adhoc networking (5G-VANET) in connected vehicles. In: 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS) (2020). https://ieeexplore.ieee.org/abstract/document/9315987/. Accessed 08 Dec 2021
26. Painuly, S., Sharma, S., Matta, P.: Future trends and challenges in next generation smart application of 5G-IoT.In: 2021 5th International Conference on Computing Methodologies and Communication (ICCMC) (2021). https://ieeexplore.ieee.org/abstract/document/9418471/. Accessed 08 Dec 2021