Evolution of 5G: Security, Emerging Technologies, and Impact

Varun Shukla, Poorvi Gupta, Manoj K. Misra, Ravi Kumar, and Megha Dixit

Abstract The review paper aims to generalize the important facts and issues of Fifth Generation (5G) in the coming future with its emerging technologies. 5G the fifth generation superfast wireless network, which is supervised and engineered for the rapid increase in the network speed. The paper rundowns through the key requisites that are gigabytes per second data rates to end user, increment in number of connected devices and latency rate below per micro second. This paper presents a review on emerging technologies like Massive MIMO technology, Spectrum Sharing (SS), Interference Management (IM), and Device-to-Device communication (D2D). To bring a new technology into reality across the globe, some important factors and challenges like fiber infrastructure, availability of base stations, low data speed, and high rates, etc., are discussed in this paper. The intent of this article is an exclusive study of 5G in all aspects considering security issues and emerging technologies (and their respective impact) like Internet of Things (IoT), Filtered OFDM (f-OFDM), Artificial Intelligence (AI), Virtual Reality (VR), and Augmented Reality (AR), etc.

Keywords Data communication · Device-to-device (D2D) · Fifth generation (5G) · Internet of things (IoT) · Security

Organization of the paper: Introduction is given in Sect. 1. Section 2 talks about customized need (Indian Perspective) and Emerging Technologies. Some challenges in implementation of 5G are discussed in Sect. 3. Advanced technologies used in

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5G are discussed briefly in Sect. 4. Section 5 is all about the security concerns and conclusion and future scope is given in Sect. 6.

1 Introduction

A 5G technology has become the demand of the present era. It will be the machinery linking billions of devices together. For the effective evolution of Fifth Generation (5G) network, there is a need of an outlay which will help in enhancing the economic benefits of the network. The enormous change in speed of Fourth Generation (4G) to Fifth Generation (5G) and high-intent screens of 5G must guide the regular internet users to engage e-commerce activities and enhance more purchase online. A 5G wireless networks have acquired massive attention in both academic and industry alike which will enable a huge vertical application by associating heterogeneous devices and machines [1, 2]. The challenges faced by the technical officials while developing 5G network after 4G LTE (Long Term Evolution)) are: 1–10 GBPS (Giga Bits Per Second) in real time network, low latency rate i.e. 9–10 ms (milliseconds), high bandwidth & spectrum density, low cost and longer battery life as shown in Fig. 1.

Many explicate methods and customized processes are required for 5G and Internet of Things (IoT) such as Machine-to-Machine (M2M), compatibility with IP addressing and Low-power WAN (LPWAN), etc. In the present smart world, technologies are getting enhanced day by day with a new concepts like Big Data, IoT, M2M, etc. 4G will not be that capable of lifting the requirements mentioned by automation technology. Emergence of Industrial IoT (IIoT) has to be handled very prudently with respect to automated smart control systems [3].

Comparatively 5G consumes more power than 4G and the reason is that 5G works at high speed and low latency. If the device is connected with Wi-Fi then the power consumption can be reduced. Battery consumption is also a subject of particular device and processor. The task of providing a rapid entry to reinforce

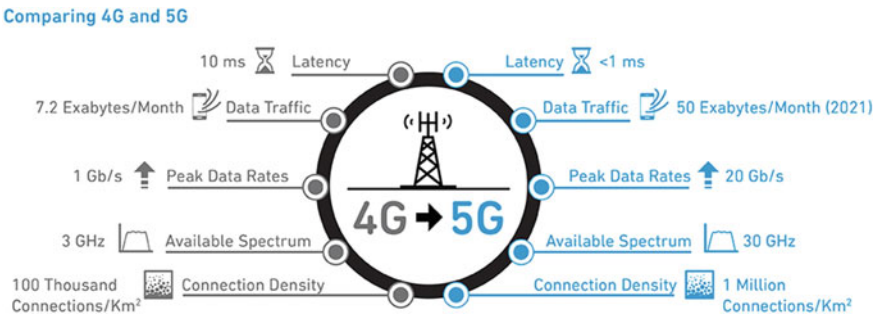

Fig. 1 Comparison of 4G and 5G

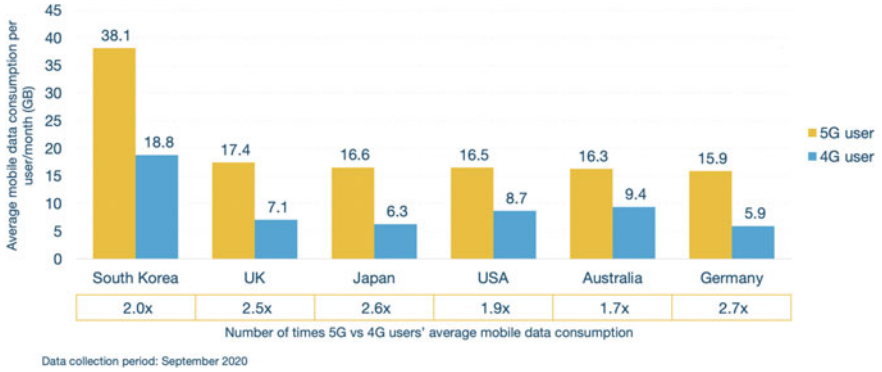

Fig. 2 Comparative data usage of 4G and 5G with respect to various countries

multiple devices for transmitting trivial data is an eminent challenge. The traffic from sensors is latency-sensitive and requires an ultra-resilient communication link. Extreme data rates for the users and subtle latency for the machines have to be supported. It is important to mention that 4G communications rely on Orthogonal Frequency Division Multiplexing (OFDM) [4].

Emerging technologies specified further lead to a synchronized procedure of enduring 5G as the key to make the digital world more convenient considering all aspects of development. These technologies not only enhance the system speed but also help in reduction of the sustaining problems which occur due to the incorporation of new technology into work. 5G will drive the future advancement of the internet. User will be able to download a 15 GB movie file in just 6 s, an autonomous car travelling at up to 100 km per hour will be capable of receiving a stop signal in case of any danger detected with virtually zero latency. Many more users by 2025 are expected to avail internet services in comparison to last 5 years and this tremendous growth will be significant. The data of September 2020 is shown in Fig. 2 and it clearly demonstrates the popularity of 5G over 4G and needless to say that it will bring many opportunities.

It is also interesting to mention that different service providers in India (considering three major market players: Reliance Jio, Airtel, and Vodafone Idea) have different plans for 5G and its related services as shown in Fig. 3 [5].

2 Customized Need (Indian Perspective) and Emerging Technologies

Technology in this modern era keeps on changing in every next generation. As India being a developing country, we need an efficiently successive transformation to lead in the technical world via establishing 5G with a smooth procedure. Considering the present scenario in India, after the utilization of 4G, now people are in full swing to

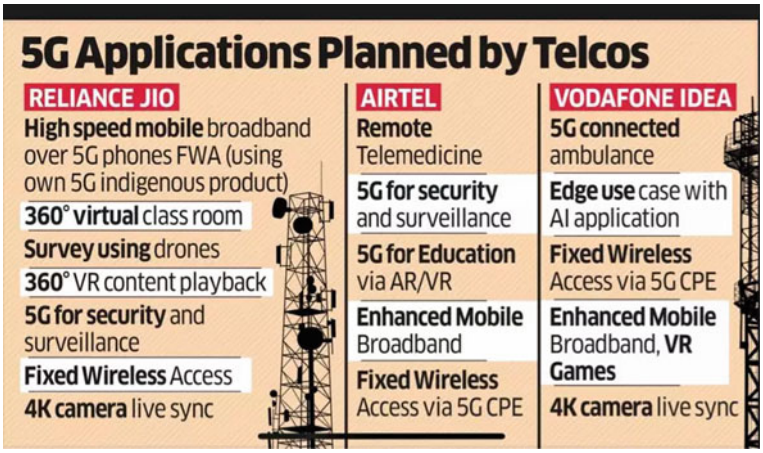

Fig. 3 Comparing the plans of service providers in India

switch to 5G in a progressive manner. 5G not only provides accuracy and improvised speed but includes enormous IoT where billions of devices will be connected at a time on the network with high speed and virtually zero latency. Therefore, presently the main aim is to understand challenges occurring in transformation to 5G [6]. Total 5G connections are expected to 11% by 2025 according to GSMA intelligence, Ericson report as shown in Fig. 4 [7].

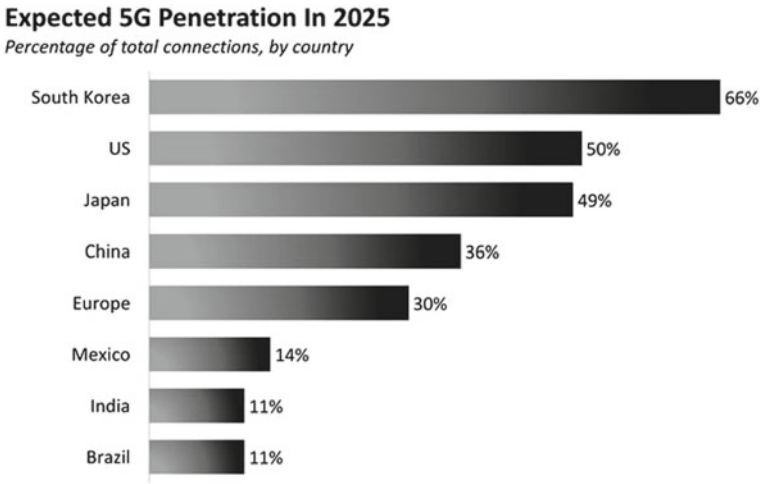

Fig. 4 Expected increment in connections by 2025 with respect to various countries

2.1 Massive MIMO Technology

Massive Multiple Input Multiple Output (MIMO) is an advanced form of MIMO technology as it is a technique of adding a greater number of antennas for multiple output at the base stations which enhances focus energy and hence provides better efficiency. The MIMO technology is a part of LTE-A and is based on the concept of structural multiplexing [8]. Spatial multiplexing is a significant technique of transmitting independent channels separated in space for a more frequent and smooth use of 5G. Massive MIMO has the potential to upgrade the radiated energy efficiency by 100 times and simultaneously increases the capacity of the order of 10 or more [9, 10]. Basically, the radiated energy efficiency from the base antennas is based on the principle of coherent superposition. The expense of transmitted power gets increased as the zero forcing is used to suppress the leftover interference between the terminals [11]. The prime concern of making a consistent and speedy network, reduced latency proves to be a basic demand in the wireless communication whereas massive MIMO permits a prominent decrease in the latency by avoiding fading dips. Massive MIMO has a dominating advantage of low power consumption and less costly components which will help in globalizing 5G especially in developing and under-developed countries [12]. A conceptual illustration for massive MIMO is shown in Fig. 5.

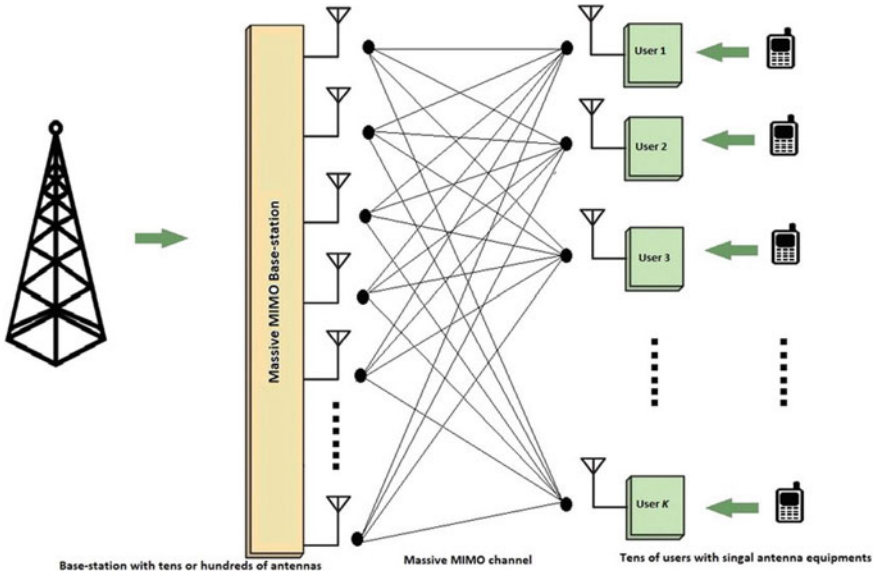

Fig. 5 Illustration of massive MIMO

2.2 Spectrum Sharing

Spectrum sharing is defined as the use of the same frequency band by two or more users (applications) on a nonexclusive basis under a defined sharing arrangement in communication technology [13]. The government of India's Department of Telecommunications (DoT) has also provided information on the rules for spectrum sharing, which allow the use of already available spectrum as well as future frequency bands [14]. In addition to spectrum sharing, the government of India needs to treat the available spectrum with respect to service providers extremely carefully (for the efficient deployment of 5G) as illustrated in Fig. 6.

Spectrum sharing allows users to share a single frequency band with variable priority. The most basic challenge in spectrum sharing is determining when and when it is feasible. This is achieved through spectrum sensing and prediction. Sharing has developed as a practical solution to the spectrum constraint in recent years due to the restricted infrastructure faced by mobile operators due to increased competition. Spectrum sharing has reduced average revenue per user, but capacity demands have increased [15, 16]. Spectrum sharing reduces overall investment and is suited for low traffic areas where network development and maintenance are simple. Smooth multi-operator spectrum sharing benefits dynamic and asymmetric traffic. The most important: obstacle for fairness, data openness, and service quality agreements is building trust between operators [16].

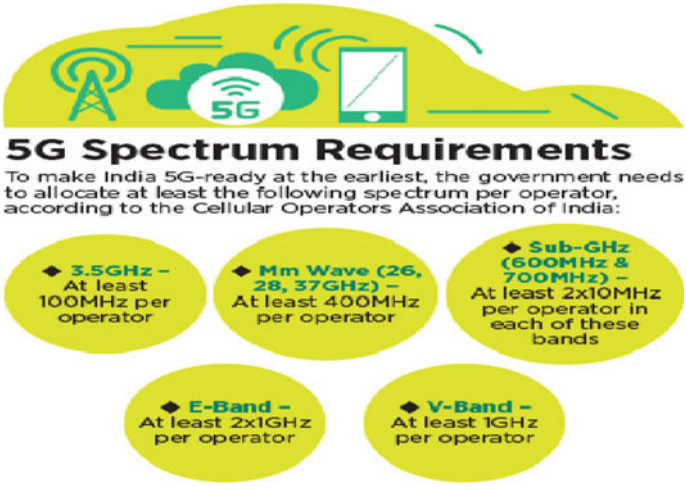

Fig. 6 Necessary divisions for effective spectrum utilization in India

2.3 Interference Management

In the present scenario when work from home becomes an inseparable part of life, wireless traffic increases and hence responsible for Co-Channel Interference (CCI). Whereas densification of network is contemplated as a significant tool to boost traffic capacity and user throughput. Simultaneously when the density and load of the network grow, receiver terminals in the network suffer from high CCI, peculiarly at the boundaries of cells. CCI proves to be the major aspects of averting the further enhancement and development of 4G cellular systems, therefore schemes for interference management are vital [17].

2.4 Advanced Receiver

At the early stage of wireless technology development, the detection of interference was done with respect to thermal noise only. Practically, the interference is detected strongly by the neighboring cells in the communication system. However, the detection of interference via thermal noise weakens the performance capability of the overall system proceedings. Interference randomization techniques were brought into work, but it was profitable only to a moderate level considering quality barriers [18]. The reason being Advance receivers proved to be a better alternative for interference management is least performance loss. Advance receiver proved to be more advantageous because of its characteristic of modulation constellation, symbol detection and decoding as well [17].

2.5 Joint Scheduling

During the releases of LTE versions (8th and 9th), only interference randomization was scrutinized through scrambling of transmitted signals. In the release of 10th and 11th versions (LTE-Advanced), the availability of sufficient headroom for performance enhancement at the edges of the cell was also acknowledged [17].

2.6 Device to Device Communication (D2D)

The cellular users and base stations are interconnected through D2D and that's why D2D technology proves to play an evident role in 5G expansion [19]. The actual work of D2D is to establish interference management in Heterogeneous Network (HetNet). Whereas, HetNet functions as a multi-tier network, which contains high-power nodes. D2D completes the basic requirement for a proper 5G communication

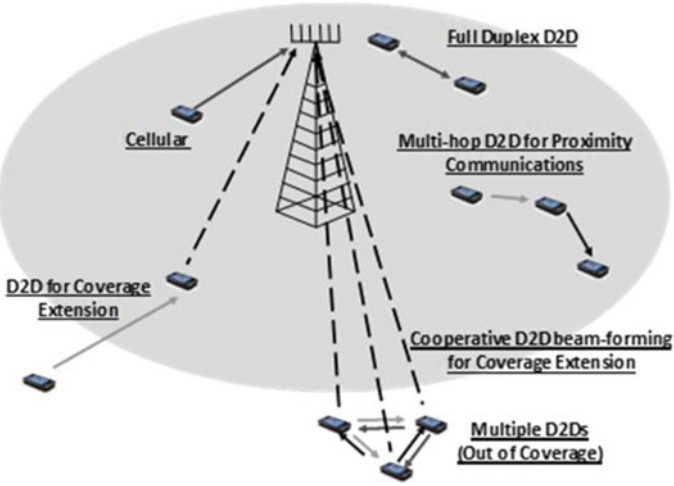

Fig. 7 Extension of coverage

i.e., low end-to-end delay, less power consumption, high spectrum efficiency and high data rates without any system failure but simultaneously compromises the interference management [20–22]. A coverage extension concept using D2D is shown in Fig. 7.

3 Challenges in Implementation of 5G

To bring 5G revolution, the network framework of 4G LTE needs to be secured in the coming time. Technical experts need to present the best possible service as the upcoming technology (5G) has an edge for its promising characteristics and Return on Investments (RoI) [23]. Globally, the challenges faced in implementation of 5G are low latency requirements, building complex and dense network, coverage issues and dealing with new security issues and keeping operating and maintenance cost low. Some challenges from Indian perspective are given below:

Fiber Infrastructure. Fiber infrastructure is one of the significant challenges and its growth will help carrying out 5G more conveniently in India. The significant contribution of fiber infrastructure is to remit increased data range and enhance voice calling capabilities. Because of paucity of fiber cable base in India, people face call drop problems which stipulates the nations low expenditure in fiber and backhaul framework [24, 25]. Only 20% of towers in the country are backhaul in contrast with 80% in countries like China and Korea where they specifically focus on making policy that signifies to fiber categorization [26].

Regulatory Bodies in Telecom Sector. Since the betterment of broadband over last years, in India the telecom sector had overlooked the standard opportunities in mapping out consistent broadband plans. This sector is highly affected by the proceeding delays and their related issuance issues [26].

Low Speed of Data and High Rates. India ranks at 89th position out of 147 countries in terms of average Internet speed of 6.5 mbps (megabits per second) only. Current data speed provided by companies in India is not uniform distinctly in rural areas [26]. The data rate prerequisite for 5G is one Tbps (Terabits per second) so it can be said that India is far behind in terms of average speed and it is mainly because of lack of fiber base.

Availing More Base Stations. More base stations require more antennas and more towers (space and infrastructure) which in turn need more intense radiation and high transmission power. Installing more base station specifically in high population areas is a very tough task as people see it as a danger for living things.

High Consumption of Power. 5G is a technology which consumes comparatively more power than 4G as it provides more network speed and it leads to faster battery drain with respect to usage time. It is a very serious issue for end user's perspective and presently many modifications are going on for the better battery performance.

4 Advanced Technologies Used in 5G

4.1 Internet of Things (IoT)

The International Telecommunication Union's (ITU) vision of IoT is "from anytime, anyplace connectivity for anyone and we will now have the connectivity for anything" [27]. IoT improvises to manage the track inventory more conveniently which lessen ups the human errors. IoT also assists better cost management and optimized resource planning. For example, temperature-monitoring sensors can be utilized for better crops production and send alerts when any unwanted situations occur [28]. In present scenario, IoT implementation (globally) should be capable of providing low latency, high security and complete coverage. In the present situation, 4G is not that efficient to handle this tremendous growth with respect to required Quality of Service (QoS). The sensors used in IoT and its formation should be preferably economic also. As we are coping with IoT systems and it is expected around 80 billion of IoT devices are linked over network [29]. In short, the aim of IoT is to "plug and play smart object" with the following benefits.

- Minimum user interaction
- Proactive maintenance
- New enhanced services
- Utilisation improvement
- Cost reduction.

4.2 Artificial Intelligence (AI)

AI is a technology which helps the users to access the e-commerce activities via supervised marketing decisions and tracking various products simultaneously [30]. The benefits of AI over 5G are expected to be very productive and significant. The main aim of the integration of AI and 5G is to decrease capital expenditure, amplifying network performance and building new revenue streams [31].

4.3 f-OFDM

The term stands for 'Filtered Orthogonal Frequency-Division Multiplexing', which perform division of waveform to numerous sub bands that could be of different bandwidth. Efficiency and protection against interference in fading (simpler channel) equalization are the benefits of f-OFDM. In LTE specifications 10% of system bandwidth is reserved as guard bands to minimize the adjacent channel leakage ratio, avoiding over lapping of sub bands and fulfill spectrum mask requirements. By applying f-OFDM the baseband OFDM signal can be shaped with ultra-narrow sub region and can meet the requirement of LTE spectrum along with other bandwidth related requirements [32, 33].

4.4 Virtual Reality (VR) and Augmented Reality (AR)

VR and AR come out to be the driving forces in the commercial market globally [34]. Presently the standards of 4G abide from restrictions like latency, speed and bandwidth and considering these concerns, 5G is almost ready to unlatch the full proficiency of VR and AR technologies. These weaknesses can be reduced by enhancing network speed and lower latency. According to time trade research 85% of users go for shopping in physical stores and many features of physical shopping cannot be exchanged by e-commerce but AR and VR can create user experiences that are much closer to physical shopping. VR and AR with 5G have the capability to bring the huge change in the e-commerce activities in the upcoming years subject to smooth and efficient deployment of 5G [35]. A brief description is given in Table 1.

5 Security Issues in 5G

5G systems must adopt security features to enhance level of trust among subscribers [36]. Some of the important aspects are discussed below:

Table 1 Usage of recent technologies in 5G

S. No.	Technology	Impact	Advantages of 5G
1	(IoT)	Upgrade user acquaintance, manage orders more productively	Transfer of data by IoT devices will be made more favorable
2	Artificial intelligence (AI)	Performing e-commerce activities and order products online	Easy and quick access of information to acknowledge the particular context in a better way
3	f-OFDM	Enable spectrum slicing and coexistence of multiple sub bands	More substantial to frequency selective fading comparatively to single carrier systems
4	Virtual and augmented reality	Enhanced interaction with reality	Make physical shopping easier and improvise latency requirements

Inter Operator Security: In previous 2G/3G and 4G networks, some critical loopholes were found based on SS7 architecture and diameter protocols etc. 5G must adopt inter operator security along with the inclusion of more trustworthy proxy servers.

Key and Authentication: It will be better if 5G systems always use the public key of available home network for the required encryption. The entire network and devices must be mutually authenticated and the data transmission beyond the domain of current service provider or in case of wi-fi calling, the feature of secondary authentication must be added.

5G and IoT: The IoT devices using 5G consists of various hardware and software and it leads to security problems because many of them may be vulnerable to Man in the Middle Attack (MITM), replay attacks and password guessing attacks etc. Some of these devices will also transfer the personal information of user such as name, Date of Birth (DoB), contact number of user and credit card details etc. which in turn creates security vulnerabilities. Table 2 describes possible attacks in 5G with brief description [37].

6 Conclusion and Future Scope

A comprehensive review with respect to evolution of 5G and associated security issues, emerging technologies and impact is done in this paper. The expectations from 5G, market opportunities and expected growth are discussed. It is also very interesting to see that various service providers have different plans related to 5G services. The Indian 5G market is expected to grow 11% by 2025. The use of massive MIMO, spectrum sharing and interference management will be the key factors. Issues

Table 2 Possible security attacks with reason

S. No.	Attack type	Reason
1	Eavesdropping	Intruder can eavesdrop the transferred message and it will be helpful for launching other attacks
2	Traffic analysis	Intruder can observe the ongoing traffic in order to predict other useful parameters
3	Replay attack	Intruder can intercept the ongoing communication and can perform delay or deceitful retransmission
4	MITM	Intruder can be there between the ongoing transmission of two devices and modifies the messages [38]
5	Impersonation attack	Intruder can find the identity of any legitimate participating entity and send malicious messages on its behalf
6	Denial of service (DoS) attack	Intruder can prevent the legitimate entities from using the available resources [39]
7	Database attack	In 5G-IoT based systems, intruder can enjoy the fact that the database is managed through various servers and due to this, so many attacks in this category are possible
8	Malware attack	Intruder can run malicious program in a targeted system so that many unauthorized activities can be performed
9	Insider attack	An insider means existing user of a trusted system can use the available information maliciously and it can lead to other potential attacks also
10	Physical access	An intruder can access to an IoT device physically and some sensitive information (like passwords, session keys etc.) can be accessed directly

related to D2D communication needs to be planned carefully. The growth of fiber infrastructure and regulations imposed by Telecom Regulatory Authority of India (TRAI) will be the deciding factors in India. The growth of IoT is also dependent on 5G and the use of VR and AR will be even more interesting in the overall deployment of 5G. As long as security issues of 5G are concerned, there are some serious risks.

Inter operator security, key management along with security attacks are some of the very important points. Security attacks include a wide variety like MITM, DoS or physical access to IoT devices, etc. The success of 5G will be based on the fact that how these security issues are addressed keeping the overall complexity as minimum as possible. Needless to mention that the future of 5G will be very promising and it has the potential to develop new jobs and market opportunities. The amalgam of 5G and IoT will provide new level of user experience and it will definitely benefit the entire society at large. We also invite research fraternity to throw more light on 5G and associated technologies with related security issues as it is going to hit the market very soon and it can be the fruitful result of this paper.

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

1. Oughton EJ, Lehr W, Katsaros K, Selinis I, Bubley D, Kusuma J (2021) Revisiting wireless internet connectivity: 5G vs wi-fi 6. Telecommun Policy 45(5):1–15
2. Fang H, Wang X, Tomasin S (2019) Machine learning for intelligent authentication in 5G and beyond wireless networks. IEEE Wirel Commun 26(5):55–61
3. Temesvári ZM, Maros D, Kádára P (2019) Review of mobile communication and the 5G in manufacturing. Procedia Manuf 32:600–612
4. Nagul S (2018) A review on 5G modulation schemes and their comparisons for future wireless communications. In: Conference on signal processing and communication engineering systems, pp 72–76
5. Gupta A, Raghav K, Dhakad P (2019) The effect on the telecom industry and consumers after the introduction of reliance jio. Int J Eng Manag Res 9(3):118–137
6. Puri S, Rai RS, Saxena K (2018) Barricades in network transformation from 4G to 5G in India. In: 7th international conference on reliability, infocom technologies and optimization (trends and future directions), pp 695–702
7. Ericsson Mobility Report: 5G subscriptions to top 2.6 billion by end of 2025. Available at: https://www.ericsson.com/en/press-releases/2019/11/ericsson-mobility-report-5g-subscriptions-to-top-2.6-billion-by-end-of-2025
8. Shafique K, Khawaja BA, Sabir F, Qazi S, Mustaqim M (2020) Internet of Things (IoT) for next-generation smart systems: a review of current challenges, future trends and prospects for emerging 5G-IoT scenarios. IEEE Access 8:23022–23040
9. Wang J, Wang G, Li B, Yang H, Hu Y, Schmeink A (2021) Massive MIMO two-way relaying systems with SWIPT in IoT networks. IEEE Internet Thing J 8(20):15126–15139
10. Gupta A, Jha RK (2015) A survey of 5G network: architecture and emerging technologies. IEEE Access 3:1206–1232
11. Larsson EG, Edfors O, Tufvesson F, Marzetta TL (2014) Massive MIMO for next generation wireless systems. IEEE Commun Mag 52(2):186–195
12. Chataut R, Akl R (2020) Massive MIMO systems for 5G and beyond networks—overview, recent trends, challenges, and future research direction. Sensors 20(10):1–35
13. Kibria MG, Villardi GP, Ishizu K, Kojima F, Yano H (2016) Resource allocation in shared spectrum access communications for operators with diverse service requirements. EURASIP J Adv Signal Process 2016(Article Number 83):1–15
14. Spectrum sharing guidelines 2021. Department of telecommunications, Ministry of communications, Government of India. Available at: https://dot.gov.in/spectrummanagement/spectrum-sharing-guidelines-2021
15. Ahmed F, Kliks A, Goratti L, Khan SN (2018) Towards spectrum sharing in virtualized networks: a survey and an outlook, cognitive radio, mobile communications and wireless networks (part of the EAI/Springer innovations in communication and computing book series), pp 1–28
16. Customer data: designing for transparency and trust, analytics and data science. Harvard Bus Rev. Available at: https://hbr.org/2015/05/customer-data-designing-for-transparency-and-trust
17. Nam W, Bai D, Lee J, Kang I (2014) Advanced interference management for 5G cellular networks. IEEE Commun Mag 52(5):52–60
18. Xu Z, Xu G, Zheng Z (2021) BER and channel capacity performance of an FSO communication system over atmospheric turbulence with different types of noise. Sensors 21(10):1–14
19. Adnan MH, Zukarnain ZA (2020) Device-To-Device communication in 5G environment: issues, solutions, and challenges. Symmetry 12(11):1–22

20. Alzoubi KH, Roslee MB, Elgamati MAA (2019) Interference management of D2D communication in 5G cellular network. In: Symposium on future telecommunication technologies, pp 1–7
21. Xu Y, Liu F, Wu P (2018) Interference management for D2D communications in heterogeneous cellular networks. Pervasive Mob Comput 51:138–149
22. Wei L, Hu RQ, Qian Y, Wu G (2014) Enable device-to-device communications underlaying cellular networks: challenges and research aspects. IEEE Commun Mag 52(6):90–96
23. Westberg E, Staudinger J, Annes J, Shilimkar V (2019) 5G infrastructure RF solutions: challenges and opportunities. IEEE Microwave Mag 20(12):51–58
24. Fiber investments key to success of 5G in India. Available at: https://telecom.economictimes.indiatimes.com/tele-talk/fibre-investments-key-to-success-of-5g-in-india/2452
25. Boateng ON, Xedagbui FEB, Adekoya AF, Weyori BA (2020) Fiber optic deployment challenges and their management in a developing country: a tutorial and case study in Ghana. Eng Rep 2(2):1–16
26. Sharma S (2018) Problems in implementing 5G in India and solutions for it. Int J Manag Appl Sci 4(5):78–82. Available at: http://www.iraj.in/journal/journal_file/journal_pdf/14-469-153303674878-82.pdf
27. Madakam S, Ramaswamy R, Tripathi S (2015) Internet of Things (IoT): a literature review. J Comput Commun 3(5):164–173
28. Kshetri N (2018) 5G in e-commerce activities. IT professional 20(4):73–77
29. Chettri L, Bera R (2020) A comprehensive survey on internet of things (IoT) toward 5G wireless systems. IEEE Internet Things J 7(1):16–32
30. Davenport T, Guha A, Grewal D, Bressgott T (2020) How artificial intelligence will change the future of marketing. J Acad Mark Sci 48:24–42
31. Haidine A, Salmam FZ, Aqqal A, Dahbi A (2020) Artificial intelligence and machine learning in 5G and beyond: a survey and perspectives. Moving broadband mobile communications forward—intelligent technologies for 5G and beyond, pp 1–21
32. Taher MA, Radhi HS, Jameil AK (2021) Enhanced F-OFDM candidate for 5G applications. J Ambient Intell Hum Comput 12:635–652
33. Figueiredo FAPD, Aniceto NFT, Seki J, Moerman I, Fraidenraich G (2019) Comparing f-OFDM and OFDM performance for MIMO systems considering a 5G scenario. In: IEEE 2nd 5G world forum, pp 532–535
34. Flavián C, Sánchez SL, Orús C (2019) The impact of virtual, augmented and mixed reality technologies on the customer experience. J Bus Res 100:547–560
35. Attaran M (2021) The impact of 5G on the evolution of intelligent automation and industry digitization. J Ambient Intell Hum Comput 1–17.
36. Khan R, Kumar P, Jayakody DNK, Liyanage M (2020) A survey on security and privacy of 5G technologies: potential solutions, recent advancements, and future directions. IEEE Commun Surv Tutor 22(1):196–248
37. Wazid M, Das AK, Shetty S, Gope P, Rodrigues JJPC (2020) Security in 5G-enabled IoT communication: issues, challenges, and future research roadmap. IEEE Access 9:4466–4489
38. Shukla V, Chaturvedi A, Srivastava N (2019) A secure stop and wait communication protocol for disturbed networks. Wirel Pers Commun 110:861–872
39. Shukla V, Mishra A (2020) A new sequential coding method for secure data communication. In: IEEE international conference on computing, power and communication technologies, pp 529–533