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B5G Applications and Emerging Services in Smart IoT Environments

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ABSTRACT

So far, the communication standard development requires specific parameters to achieve the requests of the desired application, most frequently, the connection speed rate. On the other hand, the term Beyond the Fifth Generation (B5G) symbolizes certain specifications required to succeed the future-proof of the Fifth Generation (5G), i.e., the predicted high-level parameters, such as ultra-reliable low-latency communications, massive machine-type communications, and improved mobile broadband, which are essential for the expected high-level future applications; consequently, 5G wireless (cellular) networks must be reconsidered precisely and in-depth to cope with the applications' required high-level standard parameters in B5G. Therefore, it is crucial to develop novel wireless access configurations and technologies that utilize additional spectrum. However, this alone is not sufficient for now. Incorporating technologies such as software-defined networking, cloud computing, machine learning, 3D networking, and network function virtualization into B5G networks is imperative due to raised concerns regarding decentralization, transparency, interoperability, privacy, and security. This page provides a comprehensive overview of B5G's design, functionality, and security, as well as its relationship to cloud computing. Furthermore, the proposed study examines the techniques employed for data transmission in B5G applications, such as Vehicle-to-Vehicle (V2V), Device-to-Device (D2D), and Machine to Machine (M2M) transmissions. Lastly, the proposed study focuses on essential technology based software services, such as healthcare, smart grid, tourism, and agricultural services. These services use the advantages of B5G communication networks and cloud computing. So, the proposed work collects all the necessary information for researches and developers in one article, supported by the most up-to-date references.

KEYWORDS

Fifth Generation (5G); Beyond the Fifth Generation (B5G); Vehicle-to-Vehicle (V2V); Device-to-Device (D2D); Machine to Machine (M2M); cloud computing; Internet of Things (IoT); smart grid

Based on the former five wireless communication generations, a new mobile network generation appears every decade, which is a serious indication that the Fifth Generation (5G) and Beyond the Fifth Generation (B5G) system will control the mobile world in the next ten years[1]. The predicted data traffic in the future is expected to be 10 000 folders more than the current being applied. According to ERICSSON[2], the linked Internet of Things (IoT) devices connected via Machine to Machine (M2M) are predicted to reach 75.4 to 100 billion by 2025. Huawei estimates that by 2025, there will be 2.8 billion B5G subscribers.

The B5G era began in the second half of 2019 with the deployment of B5G infrastructure, where standalone and non-standalone modes used deployment networks. The non-standalone network is the most used mode by deployed B5G networks, relying on present Core Networks (CNs) and Long-Term Evolution (LTE) radio access to provide better coverage and more controlled management of mobility[3]. The standalone mode that includes a B5G Core Network (B5G-CN) and a B5G New Radio (B5g-NR) should be included in the eventual deployment strategy. Compared to the earlier generations, B5G is recognized for its fast data transmission and minimal latency. Moreover, B5G is more capable of supporting bandwidth-intensive services like entertainment, enabled education using Virtual Reality (VR), Augmented Reality (AR), healthcare services, extensive Internet of Thing (IoT) manufacturing applications, and enabled smart city.

Furthermore, the capacity for autonomous vehicles to communicate with one another in real-time would be highly beneficial. For a long time, the Fourth Generation (4G) has delayed IoT and M2M infrastructure due to 4G, high latency, and stagnant download speeds. Consequently, the cumulative impact of any latency is projected to rise as more devices connect to networks, where B5G and cloud computing are strongly advised to be advantageous.

Two possible applications of B5G with cloud computing are enhancing radio station accessibility and facilitating on-demand cloud services in a three-dimensional environment. These applications might potentially be utilized in satellites, airborne,

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and land-based systems. Users will perceive that their queries are being instantaneously handled by a distributed network of devices. IoT applications are a potential growth area for B5G networks because the improvements in the physical layer technologies are insufficient to achieve service performance objectives, where the essential component of the B5G is efficient physical resources Software-Defined Networking (SDN), Multi-access Edge Computing (MEC), and Network Functions Virtualization (NFV) are all examples of B5G intelligence at the network's edges. To ensure the delivery of anticipated services with the required level of excellence, network operators may employ virtualization to partition the resources provided by switching and routing facilities. Massive Machine-Type Communication (mMTC) slicing is most suitable for services that require infrequent signaling and limited network data interactions, such as intelligent meters. On the other hand, Ultra-Reliable Low-Latency Communication (URLLC) slicing is best suited for services with strict latency requirements, such as self-driving cars. Edge computing refers to installing a processing node or a Data Center (DC) near mobile devices, which performs some computational tasks for mobile devices. In addition, edge computing is regarded as helpful for services that process critical data in real time and demand a lot of processing power.

Nevertheless, mobile devices have limited processing capacity due to design challenges and/or the high cost of the restrictions. Even though B5G deployment has begun and the new network continues to confront obstacles, the most crucial criterion is still obtaining the uniformity, particularly when establishing B5G upgraded services. As a result, it is expected to start noticing B5G's demonstration of carrier services, communications equipment, and gadgets in the following years.

B5G technology offers eight unique characteristics, which are: ultra-fast speeds of up to 10 gigabits per second, ultra-low latency (1 ms), colossal capacity (enormous bandwidth), numerous connected devices, consistent availability, and coverage everywhere, where low energy usage and good battery life designed for the targeted applications because B5G customs less energy than previous generations of mobile wireless technologies[4].

Furthermore, IoT is one of the primary drivers of B5G technology, as IoT will likely be developed dramatically in the future, thanks to B5G's new architecture. The Internet of Things (IoT) is anticipated to have a substantial impact on the design of communication technology. Additionally, the emergence of B5G will bring about a revolution in cellular networks and the IoT. However, it will also face considerable challenges[5].

Device-to-Device (D2D) communication is another critical technology that B5G must support. It should permit devices to exchange data without centralized control from a base station or network[6]. However, significant concerns were addressed before the domination of the B5G technology, as B5G must, for example, enable D2D communication and intelligent automobile services (one of the IoT applications)[7], provide a stable network, security, and assure privacy[8]. While D2D communication improves cellular reuse and minimizes interference with femtocells and microcells, it can also compromise system performance by sharing radio resources inside the D2D network[9]. Furthermore, B5G must offer network availability and reliability at all time and in all locations, where privacy and security are two main concerns that B5G must overcome when maintaining the availability, mining that the increase in data transfers and the number of users, B5G security and privacy risks also increase[10]. To achieve the B5G goals and vision, B5G must provide almost error-free and such high-precision data transmission, which is problematic, particularly when considering the user's mobility, mainly in a doubly dispersive fading channel that requires a complicated equalization[11]. These challenges are generally addressed to satisfy the demand and to meet the B5G technology's objectives.

The European Telecommunications Standards Institute (ETSI), the 3rd Generation Partnership Project (3GPP), and two B5G standardization organizations have developed supplementary components for MEC. However, it remains uncertain which services can take advantage of these features and to what extent. Furthermore, B5G is currently not offered as a separate configuration that incorporates MEC. However, the deployment of MEC is expected to commence in the next years. Interface requirements for related interfaces are still worked up. Otherwise, it is worth mentioning that new apps, some of which do not appear to be inventive, have been implemented. For instance, an app that can use a smartphone to remotely lock car doors, stop, or start the car engine. The change is that the same abilities are now available through apps that work over the Internet and through cloud computing rather than through commuters on the considerably faster B5G highway.

Last but not least, it is essential to establish that the primary objective of this work is to aid academics and developers with an interest in B5G technology in understanding the B5G architecture, applications, and services. In order to do this, the paper consolidates all pertinent material into a single piece, and the referenced information is up-to-date.

The rest of the paper conducts comprehensive research focused on B5G technology. Section 1 provides an overview of the B5G system architecture and its enabling technologies. Section 2 reviews B5G communication applications, including enhanced Mobile Broadband (eMBB), IoT, D2D, Vehicle-to-Vehicle (V2V), and M2M communications. In Section 3, B5G emerging services such as healthcare, smart grid, tourism, and agriculture are discussed in detail. Finally, Section 4 concludes the paper with a summary of findings and future insights.

1 B5G Architecture

The existing mobile network design supports voice and standard mobile broadband services due to upgrading 3GPP versions, complex interfaces, and many components used, which verified inefficiently flexible to enable differentiated services. The B5G mobile system represents the highest point of advancement in mobile communication network technology, providing new modes of communication and widespread connectivity. Beyond the significant improvement in performance compared to previous generations (1G to 4G), B5G is anticipated to facilitate the emergence of novel forms of connection and applications. These encompass widespread connection, extensive video downloads, remote control with tactile feedback, and automotive communications.

Conversely, B5G has developed a reduced data transmission speed to cater to a wide range of purposes, such as sensors and applications related to the Internet of Things[12]. Basically, it can handle various applications, from low-bandwidth applications to high-bandwidth applications with low latency. Although the B5G network was built on legacy networks initially, it is now considered a heterogeneous system that must include relays, picocells, microcells, and macrocells. Ten gigabits per second (Gbps) is the maximum B5G speed, which is faster than 4G by about 10 to 100 times, as shown in Fig. 1.

In addition, the B5G wireless cellular network relies on mobile

Fig. 1 Comparison between 3G, 4G, 5G, and B5G information rates.

small cell systems and mobile relays, both of which are essential components.

1.1 B5G advantage

A notable advantage of the B5G new architecture is the upholding of a wide application range based on the ubiquitous physical network. The forces that are driving the network architecture transformation are as follows[13].

1.1.1 Multiple standards, site kinds, and services incorporated into complex networks

B5G networks may enable co-existing access to several standards, such as Wi-Fi, LTE, and B5G, and manage diverse site sizes, such as pico, micro, and macro base stations, to deliver various services with varying performance requirements. Multi-connectivity technologies are integrated based on the traffic and mobility needs of the User Equipment (UE) to maximize mobility continuity and transmission rate[14].

1.1.2 Service anchor placement on-demand

Deploying a Radio Access Network (RAN)'s real and non-real-time resources either on-site or in the access cloud is dependent on service requirements, network resource allocations, and the availability of optical fiber cables, which necessitates the ability to locate the service gateway on the CN side of the access cloud[15].

1.1.3 Flexible network function orchestration

Different levels of service are required based on the network's operations, so, in B5G, network capabilities will co-ordinate based on service parameters to improve the network efficiency significantly and simplify the network functionality. The B5G network architecture is versatile and efficient in meeting a wide range of mobile service requirements. With the leading technologies of End to End (E2E) network slicing, on-demand deployment of service anchors, component-based network functions, and B5G considerably diversifies category access, transport, and CNs. At the same time, the underlying physical infrastructure is supported by SDN and NFV[16].

1.2 B5G network architecture

Business application, business enablement, and infrastructure resource are the three levels that comprise the overall Next Generation Mobile Network (NGMN) architecture. The 5G network architecture includes characteristics that enable value, an easy-to-use Software-Defined Networking (SDN) and Network Functions Virtualization (NFV) framework, and all the administrative responsibilities needed to coordinate the 5G system. It also includes network capabilities for both mobile and stationary devices. Application Programming Interfaces (APIs) are offered at crucial points to help with value generation, various use cases, and business models.

The Public Private Partnership (5G PPP) architecture, the European Information and Communication Technology (ICT) sector, and the European Commission are collaborating to develop the 5G infrastructure. Many stakeholders are involved in this endeavor, including research institutions, ICT manufacturers, telecommunications operators, service providers, and Small and Medium-sized Enterprises (SMEs). Five levels comprise the architectural approach to 5G infrastructure: functional and resource levels, the network operating system level, the service level, and the E2E secure service orchestrator level[17].

There are architectures presented by the vendors, with Huawei proposing E2E network slicing to accommodate a variety of B5G services[17]. The physical architecture of the future system design is based on NFV and SDN, which comprises sites and three-layer DCs, which are: a central office DC nearest to the base station, a local DC, a regional DC, and all connected via transport networks.

Slicing relates to distinct modules are Radio Access Network (RAN), CN, or both, which discrepancies in the structures suggested by various organizations. The basic paradigm of B5G is a service-driven system structure that aspires to flexibly and effectively meet a wide range of mobile service requirements, minding that NFV and SDN are critical technologies for enabling physical infrastructure support. The following section will discuss the conceptual components of a B5G network.

1.2.1 Radio access network

In most cases, Infrastructure networks are referred to as CN and RAN. The physical layer of the new B5G RAN improves on LTE in the following ways:

Massive MIMO: Massive Multi-Input Multi-Output (MIMO) is a new way to increase spectral efficiency in wireless communications networks. MIMO allows multiple users to use the same time-frequency resource of the same bandwidth. Thousands of antennas could be used in B5G networks[18].

Beamforming: By allowing several users and antennas to share much more data simultaneously, massive MIMO arrays with beamforming can make substantial use of the spectrum. In B5G networks, millimeter waves (high-frequency waves) are projected to play a crucial role[19].

Millimeter-wave: In all circumstances, especially in dense urban, millimeter-wave technology can meet the challenge of B5G distance and capacity[20].

Due to plug-and-play deployment and flexible orchestration, the B5G control plane design considerably offers a robust framework for B5G E2E network slicing and simplifies the development and implementation of new services. In the B5G design, separating the control and user planes simplifies the CN structure.

1.2.2 Cloud computing

Cloud computing facilitates resource sharing by virtualizing physical infrastructure deployed to fulfill requests for applications, heterogeneous computer infrastructures, and platforms (servers, networks, storage, services, and applications are examples of shared physical resources). Service Providers (SPs) and Infrastructure Providers (InPs) make up the cloud computing ecosystem (SPs). The InPs oversee and run the physical architecture, while the SPs rent resources to deliver services to end-users. The same approach may apply to B5G networks to construct virtualized wireless systems, with network operators leasing resources from InPs. The InPs may, for example, hold the existing cellular infrastructure as well as radio resources. The Mobile Virtual Network Operator (MVNO) rents InP's resources, generates and runs virtual resources, and allocates them to subscribers for different services. This opens up new avenues for innovation, rapid development, and service delivery that were previously unavailable. Cloud computing also improves RAN architectural flexibility, scalability, and resource usage. A Cloud-

RAN, also known as a Centralized-RAN (C-RAN), is a type of RAN that uses cloud computing to enable flexible and scalable RANs that can quickly address capacity and coverage challenges. The base station's baseband processing unit is detached from the analog unit (Remote Radio Heads (RRHs)) and relocated to the cloud in C-RAN (referred to as the Baseband Unit (BBU) pool). A BBU pool is for a collection of RRH in a specific location.

1.2.3 Core network

The B5G CN consists of both forwarding devices and a visualization layer. Network virtualization enables networks to be more adaptable and automatically react to the demands of the services and traffic that pass through them. Both SDN and NFV are significant enablers for network virtualization and are complementary technologies. The essential elements of system slicing are the composition of the network structure and its virtualization. Infrastructure-as-a-service is used to create slicing, which means the possibility of leasing distinct infrastructure parts that address different requirements to meet the requirements of different slices. Virtualization and absolute isolation of the foundation resources (storage, processing, radio, and network) between slices are required, as is the flexibility to allow different forms of virtualized control operations over the resources depending on service needs[21].

1.2.4 Network functions virtualization

Replacing specialized network appliances such as load balancers, routers, and firewalls with virtualized instances that operate as software on commercially accessible hardware are known as network functions virtualization. NFVs aim to show how networks and services are created and delivered, where NFV is a significant enabler of the next B5G infrastructure since it helps virtualize the network's varied equipment. Network slicing and virtual network architectural components, which allow several virtual systems to be constructed on top of a shared physical structure, will be possible with NFV in B5G. E2E B5G networks, containing CNs, RANs, and network management systems, will eventually be built using NFV[22,23].

1.2.5 Software-defined network

In B5G, there exists a clearly defined programming interface (API) that facilitates the separation of the control and data planes between the SDN controller and the switches. The controller is able to exert direct control over the state of the data plane elements due to the existence of a well-defined API. OpenFlow serves as the most renowned instance of such an API. Currently, networks also include vertical integration[24].

1.2.6 B5G physical-layer security

The 5G network design and optimization are developed to enhance the Physical Layer Security (PLS) scenario. The traditional approaches of improving PLS networks have failed to adapt to the demands of resource management, feature integration, and technology implementation in modern time. Therefore, Artificial Intelligence (AI) and Machine Learning (ML) based approaches for the design and optimization of PLS have demonstrated superior effectiveness compared to traditional security systems[25]. Moreover, B5G networks will be more intelligent and resilient, significantly improving system performance compared to previous security technologies. Moreover, node/antenna selection, resource allocation, and signal analysis are discussed as research possibilities for secure system optimization and designs challenges.

PLS is less computationally expensive and uses limited resources than complicated encryption approaches since it does not rely on the computing capability of eavesdropping equipment. PLS may accomplish safe communication even when system hackers have potent computer capabilities. In addition, PLS is highly suited for distributed processing networks and dynamic system setups.

PLS offers the advantage of decreasing computing expenses and resource usage compared to complicated cryptography approaches since it does not rely on the processing capability of eavesdropping devices. Based on the principles of information theory[26], PLS can provide safe and reliable communication, even in the presence of malevolent actors with access to high-performance computers in a network. This results in a technique for safeguarding confidential information that depends on the inherent characteristics of the communication channel, such as noise, fading, and interference, rather than the computational ability of potential attackers. The security assurances it provides are independent of the eavesdropper's processing capabilities.

PLS has excellent performance in dynamic system designs and scattered processing networks, in addition to its numerous other advantages. Thus, in order to ensure data security, the PLS technique collaborates with computationally intensive high-layer technologies. Security performance is assessed by optimizing the disparity in performance between lawful channels and wiretap channels[27]. This rationale is logical because PLS is designed to enhance the quality of the signal received by the intended receiver or degrade the performance of the wiretap channel compared to the open channel. Consequently, standard metrics such as secrecy rate, secrecy capacity throughput, and secrecy rate can be employed to assess PLS effectiveness. To optimize the power line system, it is necessary to allocate transmission power based on the conditions of both the intended receiver and the eavesdropper channels. This is because transmission power impacts the quality of the signal received by both the intended receiver and the eavesdropper. However, power distribution in PLS is a complex matter, as it mostly relies on the transmitter's understanding of the intended receiver, similar to the Channel State Information (CSI) obtained by an eavesdropper.

Furthermore, most PLS optimization functions are non-convex due to the use of logarithmic subtraction in assessing security performance. Increasing transmission power improves the capacity and dependability of the primary channel[26]. In addition, the process of optimizing worldwide non-convex power allocation does not adhere to conventional methodologies. Several researches have tried to construct and solve optimization problems to achieve enhanced security levels[28]. Inefficient power allocation, rather than enhancing the secrecy capacity of the primary channel, might decrease the Signal-to-Interference-plus-Noise Ratio (SINR) of an unintended receiver.

However, the direct performance measures do not consider the reduction in SINR experienced by an unintentional receiver. Therefore, the security method cannot provide a negative transmission rate. As such, secrecy performance can be improved by decreasing power allocation. Secure communication systems face difficulties adhering to prevailing Quality of Service (QoS) limitations. PLS has been extensively studied in mainstream research to evaluate its practical security performance against eavesdropping. This includes design strategies such as physical-layer authentication, secret key generation, wiretap coding, multi-antenna approaches, and relay cooperation. The paper also discusses significant technologies, technological challenges, and strategies to mitigate them. PLS has garnered significant research[27–30] focus because of its relevance in optimizing security design and its inherent problems arising from varying assumptions about wireless channel attributes and eavesdropping models, as mentioned in Ref. [29].

1.2.7 Network slicing

Network slicing is used to fit various purposes, such as stationary networks, NFV, SDN principles, and a virtual network design[16]. Network slicing revolutionizes our perception of networks by separating the logical components from the underlying hardware that sustains them. Firewalls, switches, and routers are hardware components that provide communication, computing, and storage on networks. In the context of Software-Defined Networking (SDN), the control plane is capable of being programmed, while the forwarding plane lacks this capability. This offers a configurable interface for apps that utilize networks. For example, a self-driving car may utilize V2X communication, which is sensitive to delays but does not necessarily require exceptional data transfer capacity. Conversely, engaging in streaming content on a digital platform while operating a vehicle requires promptness and demands a substantial data transfer rate. In addition, we showcase edge nodes, a recently introduced component that is crucial for all the latest services.

1.2.8 Edge computing

Many developers continue to use cloud-based hosting and traditional DCs for their apps, but there is a significant trend toward hosting code on the cloud edge. Moreover, B5G's enhanced networking capabilities will be critical in bolstering links between cloud computing centers and edge devices, both critical in today's applications[31], which is happening because edge computing has become dominant, where developers notice a significant difference in latency and dependability when employing their apps and code. Moreover, edge computing reduces latency and stress on the backhaul by bringing content and computing resources closer to users[32]. A tiny DC is placed near the Internet's edge, sensors, mobile devices, end-users, and in edge computing, where the latency for consumers is often >60 ms when apps are installed in traditional DCs or the cloud. Apps that demand high-speed connection time can benefit from ultra-low latency, typically under 15 ms, when backed by localized edge DCs and micro-services. On the other hand, the DC tends to support a massive benefit for connected apps requiring near-instant server connectivity, such as IoT, autonomous vehicles, and remote gaming. In the case of V2V communication, each car's edge computer will be responsible for the vehicle's real-time operation, such as avoiding road accidents and successfully traversing intersections. Nevertheless, some decisions will necessitate the use of ancillary cloud-based data. Decisions about route planning and navigation are likely made in the cloud, which requires implementing efficient computations located to the edge and cloud. Edge computing is crucial for B5G to attain its performance objectives of minimal latency and extensive capacity due to the sluggish transmission of data across the fiber networks connecting tower-based radios to the network core.

1.2.9 Three-dimensional networks (3D)

When establishing wireless networks, the extent of coverage is a crucial Key Performance Indicator (KPI). Prior to the advent of 4G networks, the primary emphasis was on enhancing connection capacity and guaranteeing enough coverage in the two-dimensional plane. 5G imposes more rigorous limits on mission-critical services that necessitate low latency and high reliability (URLLC), enhanced mobile broadband, range expansions, and Operational Expenditures (OPEX) for communication infrastructure, due to its multi-dimensional requirements. To address the demands of emerging B5G services, it is crucial for current networks to have the capability to adapt and expand in order to support various use cases, application scenarios, and traffic situations, rather than depending on a standardized 4G-LTE architecture that may not be sufficient. The economic model based on a static charge per user is not effective in areas with intricate geography or few inhabitants. This includes offshore places, islands, or regions with steep terrain. An essential factor is the shift from Two-Dimensional (2D) to Three-Dimensional (3D) coverage, facilitated by strategically positioning network nodes in both physical and aerial space.

The delivery of B5G New Radio (NR) services might utilize a hybrid network consisting of both terrestrial and Low-Earth-Orbit (LEO) satellite networks. This approach has been extensively studied in several research projects. The SA1 working group within the 3GPP framework is responsible for managing and updating the use cases and system requirements of the 5G ecosystem[33,34]. The study in Ref. [35] analyzed the influence of standardization on the NR specification by including Non-Terrestrial Networks (NTNs) as a crucial component of NR. Release 16 normative work defines improvements for satellites, High-Altitude Platform Stations (HAPSs), and Unmanned Aerial Vehicles (UAVs)[36]. This is done by studying deployment situations, well-defined channel models, and system characteristics. Subsequent revisions of the 3GPP standard will also give priority to the architecture and protocols of the Radio Access Network (RAN).

The 5G-ALLSTAR project, a component of the H2020 program, investigates multi-connectivity technologies that integrate cellular and satellite networks to deliver 5G NR services that are reliable, ubiquitous, and offer a high data transmission rate.

5G CHAMPION[37] is an early initiative that explores the integration of communication systems on Earth and in outer space. Enhancements in techniques for managing interference, sharing spectrum, and integrating millimeter-wave (mmWave) 5G-NR cellular systems with NR-based satellite systems are essential for multi-connectivity. UAVs, which operate without a pilot on board, may offer radio coverage at low altitudes as required[37]. Considerable attention has been given to UAVs and High-Altitude Pseudo-Satellites (HAPSs)[38]. With respect to data traffic management, expanding network coverage, enhancing service quality, improving propulsion and transmission efficiency, optimizing network access, and minimizing latency are all key areas of focus.

Several researches focus on an architecture that integrates traditional terrestrial base stations with non-terrestrial nodes in the air. This design offers on-demand communication, computing, and caching services, regardless of location, in three-dimensional space. In Ref. [39], many mathematical models and architectures were suggested for 3D networks, focusing on communication aspects such as data backhauling and reduced latency. To enhance the movement of user terminals and network components, it is imperative to provide a live migration solution for lightweight virtual machines such as dockers. Additionally, there is a need to enhance NFV/SDN orchestration techniques to efficiently handle a broad range of network node types. The European Telecommunications Standards Institute (ETSI)

Experiential Network Intelligence team explores artificial intelligence uses in B5G networks. This is for end-to-end communication coordination, slice administration, and cost efficiency. Due to AI's proficiency in managing intricate control and decision-making issues, distributed AI techniques offer a means for network functions to acquire knowledge about the network and optimize decision-making. With the emergence of B5G networks, individuals will soon access a virtual reality "massive artificial intelligence" that offers unlimited storage, cognitive powers, and nearly instantaneous services[35].

Hierarchical 3D networks with diverse flying layer types are essential for providing native services in 2D and 3D, including connectivity and intelligent support. Figure 2 illustrates a hierarchical 3D network that aims to consolidate various 3D network nodes situated across ground and air levels. Aerial nodes such as UAVs, HAPSs, LEO or Geostationary Earth-Orbit (GEO) satellites, and Low Altitude Platforms (LAPs) are positioned at various altitudes in the atmosphere. Aerial nodes possess the processing and storage capacity to operate independently as 3D base stations. They can also create swarms, or serve as 3D relays inside hierarchical 3D networks using IAB technology.

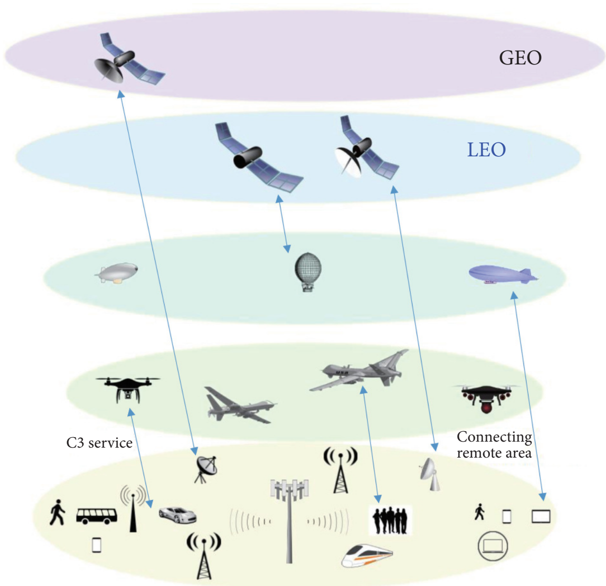

Fig. 2 Design of a hierarchical 3D network system.

Furthermore, B5G might potentially be applied to wireless communication systems because of its versatility, affordability, portability, and suitability for both low- and high-altitude aerial nodes. An instance of this is 3D connection services that support many applications, including weather measures, real-time earth monitoring, land management, agriculture, pollution monitoring, two-way telecommunications (such as interactive 3D video or 3D intelligent services), and remote sensing. 3D multi-connectivity refers to the capability of User Equipment (UE) to create multiple autonomous traffic connections between nodes in a hierarchical 3D network. This enables UE to enhance service performance by dynamically distributing workload among lines.

2 Application of B5G Communication

The B5G is designed to serve massive traffic with ultra-high data rates that enable it to enhance a diverse set of applications. Moreover, B5G will enable various communication applications, including Mobile Broadband (MBB), V2V, D2D, IoT, and M2M. This section will go over the primary applications that B5G technology serves.

2.1 Mobile broadband (small cells)

5G will support a high data rate as the next mobile wireless generation. As a result, a new technology capable of supporting the massive traffic of future cellular networks is required. Small cell technology assists in meeting high data demand by dividing each area into multiple small cells, each with a coverage range of up to 100 m. As a result, by offering good coverage at a high data rate, small cell technology will boost system throughput[40,41]. Small cells are classified into three types: femtocells, picocells, and relays, with coverage ranges of up to 30 m, 100 m, and 100 m, respectively, as shown in Fig. 3. Picocells and relays can be used indoors and outdoors. However, femtocells are exclusively utilized indoors[42,43].

2.2 Internet of Things

The IoT is being developed quickly and provides billions of intelligent devices annually. Fifty billion intelligent devices and sensors could link to the Internet through 2020[44]. Moreover, the B5G generation will include the IoT infrastructure and supply new connectivity interfaces for extraordinary IoT applications[45,46]. Wi-Fi, Bluetooth, and ZigBee wireless transmission technologies

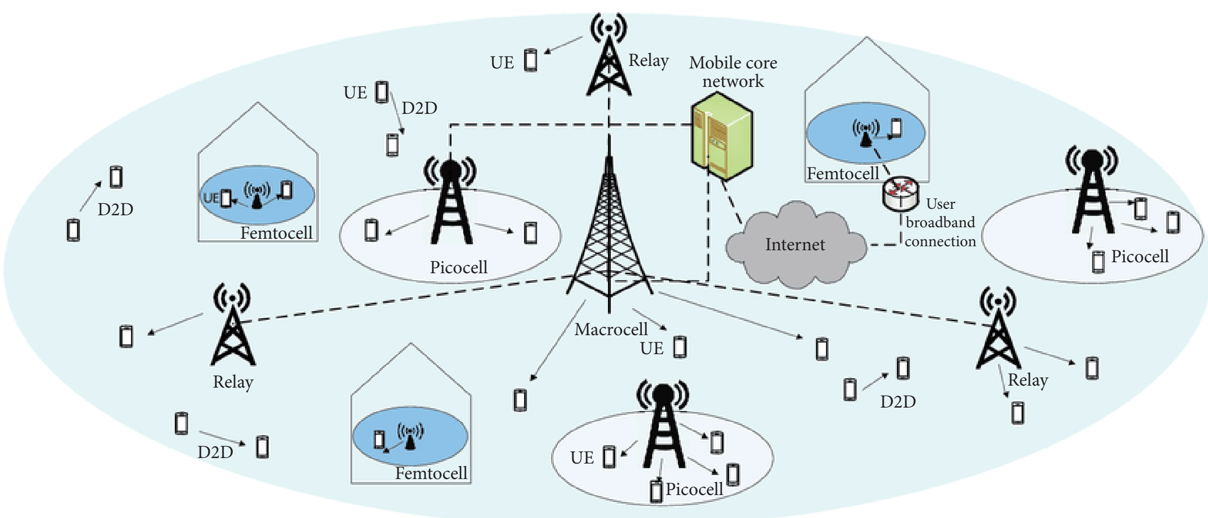

Fig. 3 Small cells types: Femtocells, picocells, and relays.

will enable IoT technology to interface with other technologies such as M2M, D2D, and V2V[47]. Since IoT calls for excessive facts charge, big capacity, and low latency, the modern-day cell structures are inefficient for allowing IoT.

Nevertheless, the B5G machine answers for this mission by having excessive facts charge, low latency, and the cap potential to aid an extra number of connections, as shown in Fig. 4. Furthermore, B5G will assure 99.999% community availability and 100% coverage. Thus, IoT gadgets can talk with the community anytime and anywhere[48]. Moreover, B5G will revolutionize cell networks through assembly necessities, including excessive facts charge of up to 10 Gbit/s, extreme capacity, and ultra-low latency of 1 ms. Researchers and builders are running in extraordinary fields to meet the requirements under B5G standards. In addition, B5G will feature paintings with legacy networks and different Wi-Fi technology like Bluetooth, Wi-Fi, and ZigBee. The launch of B5G will help billions of smart devices and sensors that contribute to increased visitor numbers and potentially process extraordinary fast facts. Hence, such improvement will permit the big-scale deployment of IoT generation. IoT will add more services and will investigate in the next section.

2.3 V2V communication

The wireless data exchange between vehicles is known as vehicle-to-vehicle communication[49]. V2V aims to avoid accidents by permitting transit vehicles to exchange velocity data and position via an ad hoc mesh network, resulting in perceiving neighboring threats 360 degrees, as V2V technology is predicted to be more effective on lane departure warning and blind-spot identification than existing Original Equipment Manufacturer (OEM) embedded systems. One can notify the vehicle's driver when there is a chance of an accident, depending on how the technology is applied.

More Autonomous Vehicles (AVs) will be on the road when they enter the commercial market and progress toward full autonomy. AVs today depend on sensors such as LiDAR and cameras for road monitoring to drive efficiently and safely. In addition, V2V communication can improve the communication between AVs on the road. The V2V link permits AVs to exchange data in real time, allowing for more efficient and safer driving. For example, one AV may obscure a pedestrian on a roadway, but V2V communication enables another AV to transmit the pedestrian's location, as shown in Fig. 5, allowing all nearby vehicles to see them[50].

Vehicle-to-Pedestrian (V2P), V2V, Vehicle-to-Infrastructure (V2I), and Vehicle-to-Everything (V2E) are the four communication modes defined by connected vehicle networks to automate message dissemination (V2X). V2I communication refers to the capacity of AVs to communicate with other computers, such as roadside equipment. The term V2X encompasses both the V2V and V2I paradigms. As autonomous vehicles become increasingly popular, V2I and V2V communications can assist with typical autonomous driving tasks.

As a result of the low latency, high bandwidth, and high throughput, B5G communications are considered the future of V2V communications. They will also link AVs to the IoTs, allowing for a more connected world, as many parts of self-driving automobiles require this technology. Many cutting-edge autonomous driving systems employ Machine Learning (ML) techniques, notably deep neural networks. Deep neural networks are used in autonomous vehicles to perform tasks such as object detection and semantic segmentation, vehicle control and collision avoidance, and route planning optimization. On the other hand, these algorithms require informative data sources, which vehicular communications may provide.

The realization of innovative and intelligent vehicles is founded on incorporating three fundamental basics[50]:

Sensor fusion is the process of car sensors altogether interacting with each other.

Information systems integrate powerful signal processing, high-precision navigation with high-definition mapping, and artificial intelligence.

A linked vehicle's network is a technology smoothing

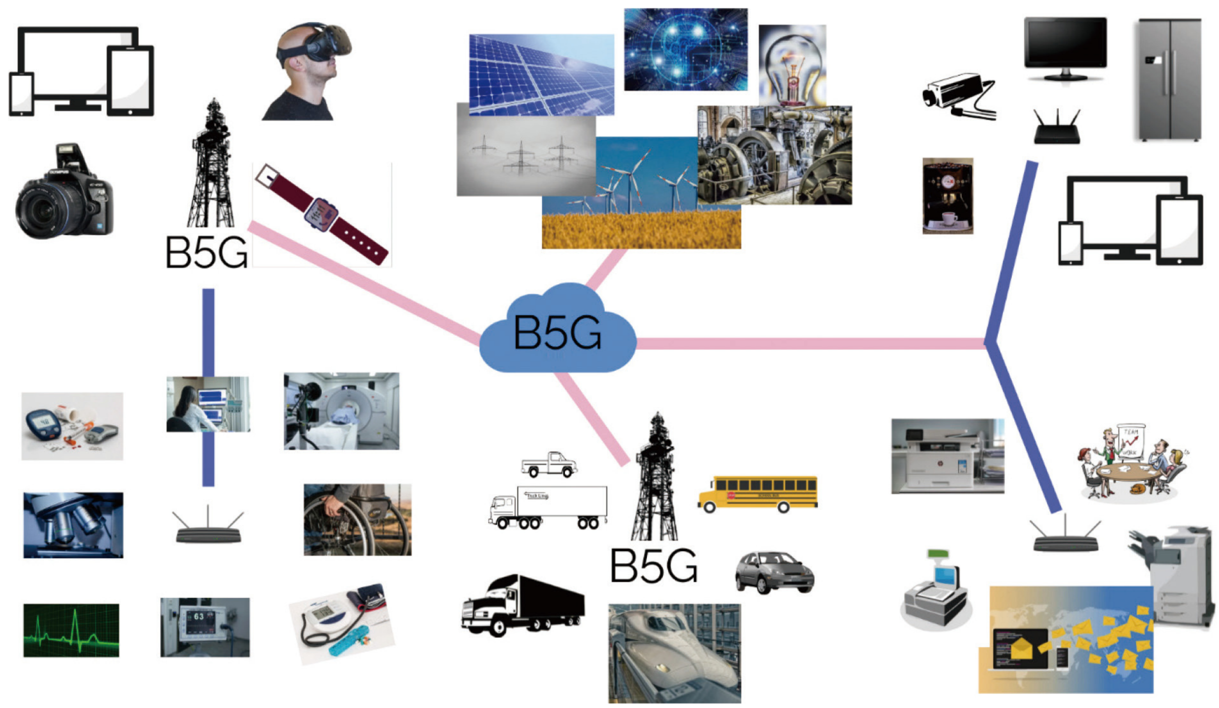

Fig. 4 B5G and IoT.

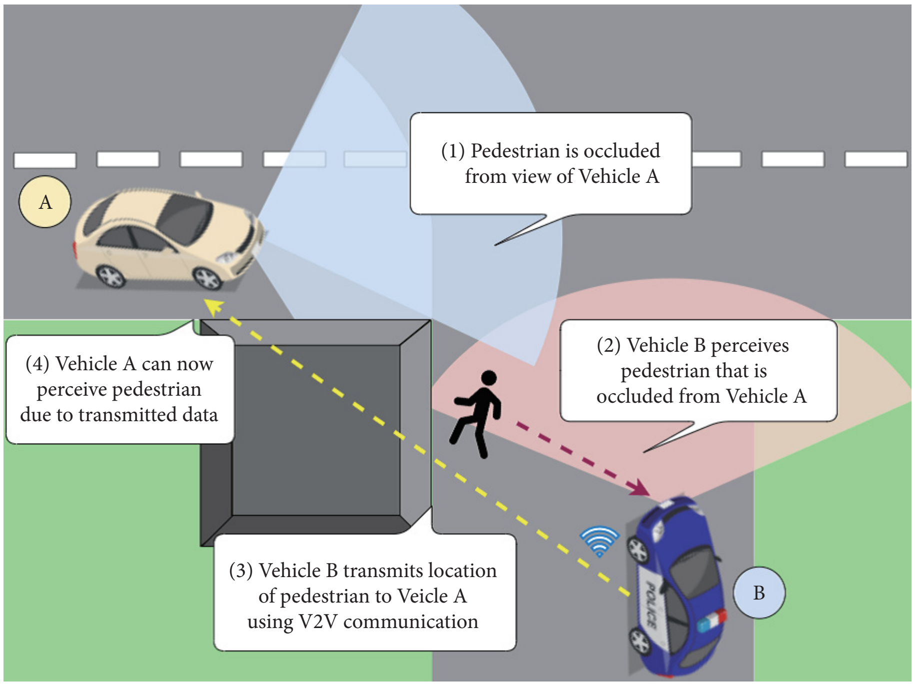

Fig. 5 Occlusion depicted. The building blocks the pedestrian from being seen by the top left vehicle, but the bottom vehicle can spot the pedestrian and relay this data to the ultimate vehicle.

collaboration and communication between vehicles, recognized as a critical enabler of cooperative perception, enhanced situational awareness, and coordinated decision-making among autonomous vehicles, leading to safer and more efficient transportation systems.

2.4 Vehicular communication

Vehicles are considered an essential part of the modern telecommunications era, capable of providing ubiquitous connectivity and reliable, low-latency transmission. Even if the idea seems tremendous, efforts are made to achieve this goal through the B5G communication architecture[51]. Some significant concerns about current vehicle communication standards (i.e., IEEE 802.11p)[52] are low latency, lack of spectrum, and reliable transmission of periodic communication. Furthermore, the current standard exhibits inadequate scalability in large-scale network installations and lacks reliable service delivery. Although research on LTE-based vehicular communications has been conducted, the possibility of LTE's successor, B5G, has stimulated additional studies on B5G-enabled vehicular communications. Recent initiatives have included the collection of diverse application needs as well as some preliminary standard specifications for B5G deployment till 2020[53].

2.5 D2D communication

The D2D communication shown in Fig. 6 is new to mobile networks[54], allowing nearby UEs to communicate over a direct connection instead of sending the radio signal to the BS or the entire CN. The short signal traversal path is the main advantage in D2D communication, so the communication delay is very short. D2D communication is facilitated by various short-range wireless technologies, including Bluetooth, Direct LTE, and Direct Wi-Fi (as specified by 3GPP).

The main differences between the technologies mentioned above are the distance between 1-hop devices, the device identification algorithms, the data rates, and the typical applications. Direct Wi-Fi offers a maximum data rate of 250 Mbit/s and a range of 200 m, while Bluetooth 5 has a maximum data rate of 50 Mbit/s and a range of up to 240 m, where direct LTE, on the other hand, has a range of 500 m and speeds of up to 13.5 Mbit/s[55].

D2D connectivity allows operators to offload traffic off the leading network with greater flexibility, enhancing spectral efficiency, cost per bit, and lowering energy. Moreover, D2D connectivity offers operators extra flexibility in offloading visitors from the middle community, growing spectral performance, and decreasing the strength and fee consistency. In addition, D2D is a singular cell-era idea that permits direct communication among devices that do not contain routing. Enabling the D2D communique gives connectivity to customers who cannot talk because of broken infrastructure[56]. Nevertheless, enforcing the D2D era needs complicated transmission protocols. D2D communications had been suggested to enhance spectral performance, first of all, produce multi-hop relays among devices in mobile networks, and then each certified and unlicensed mobile band and a few D2D communications were tested as a part of the LTE-Advanced (LTE-A) networks. The D2D communication type was provided in Refs. [57, 58], where B5G networks might stay to offer aid to packages that want devices to shape D2D communication hyperlinks with their peers. The benefits of allowing devices to communicate directly without the use of an access point or base station infrastructure are as follows[59]:

- Increasing community potential.
- Extending insurance and evolved NodeBs (eNB).
- Offloading of facts.
- Improving strength performance.
- Creating new packages.

2.6 M2M communication

M2M communication is the essential basic technology of IoT[60], where M2M represents a technology that allows machines to exchange data and perform actions without human intervention. That impacts autonomous networking and communication between devices, ranging from low-power embedded computing

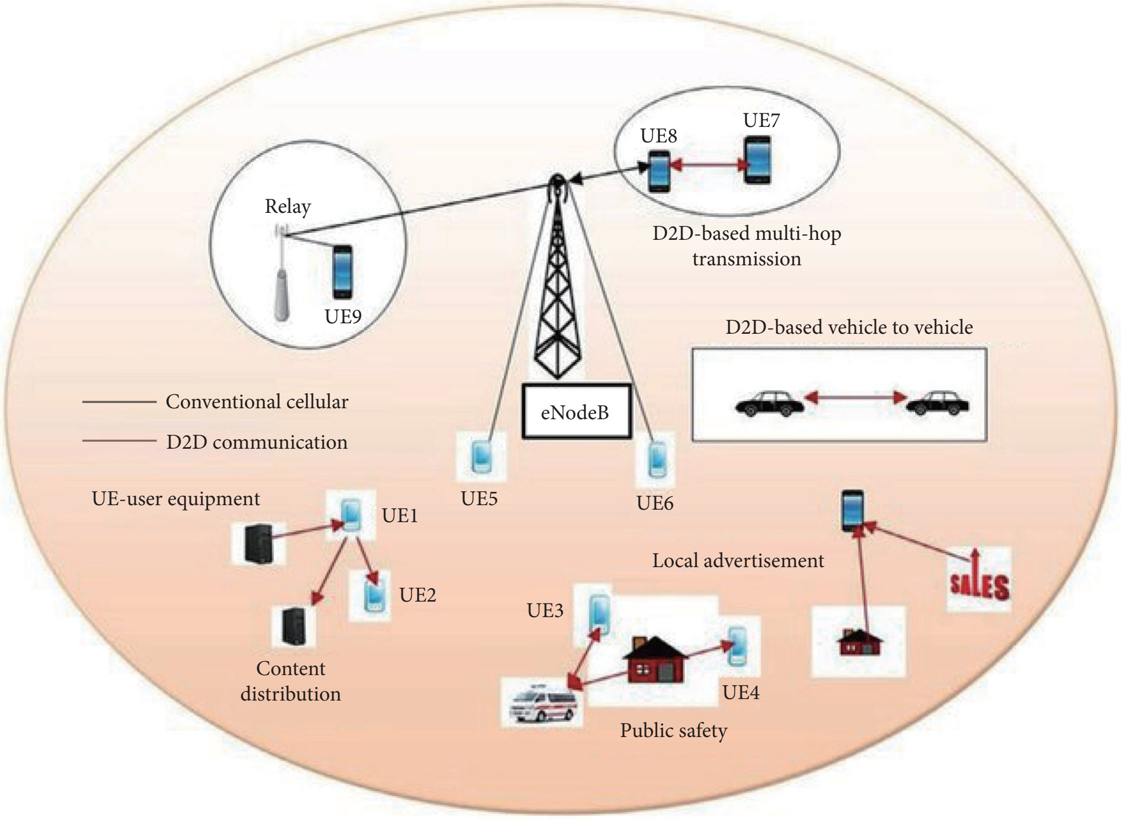

Fig. 6 D2D communication and cellular communication function[54].

to high-performance computing. The low latency and real-time response enable D2D connections to build M2M communications in the IoT[61]. One application is V2V communication, which allows D2D connections to exchange information between nearby vehicles and quickly mitigate traffic. V2I and V2P communication are also possible.

3 5G Emerging Service

5G opens up many possibilities for offloading the application code to edge devices, which has traditionally been an untapped computing capability. Unfortunately, B5G networking and apps face several challenges.

3.1 Challenge in B5G services

3.1.1 Diversity of mobile devices

The first significant characteristic of upcoming IoT networks would be how to enable devices with vastly different capacities to collaborate and receive all necessary information to ensure optimal operation. The increasing number of IoT devices is exerting pressure on communication routes, hence making connection a crucial consideration for interoperability. The IoT devices encompass a diverse range of processing capabilities, communication protocols, and application scenarios. The current state of mobile networks restricts the customization of control functions to a single set of logical functions for all services, without the ability to customize them for individual services.

The integration of control functions and complex interfaces poses challenges in service rollout, network operation, and administration. The logical control functions are segregated into distinct functional components that are linked to the service requirements in a service-oriented B5G network design.

3.1.2 Efficient use of computational resources

IoT devices have limited processing resources. Accordingly, it is a standard procedure to divest duties of several applications to computing systems with adequate computational abilities, such as cloud DCs. However, the offloading strategy in IoT infrastructures has limitations such as high latency and network congestion. In light of this problem, the edge computing paradigm enables devices to bring the cloud closer to the network’s edge, which appears to be an exciting option.

3.1.3 Demand for low latency computing

Low-latency computing is in high demand nowadays, with such devices being able to be deployed in moving vehicles or mobile. The restricted availability of low latency computing is app developers’ most significant issue today. Connection time is crucial for mission-critical apps. Despite this, numerous apps still have unsatisfactory latency time for end-users without employing the edge. In addition to latency standards, another essential feature of a legacy system or a typical cloud platform is security.

3.1.4 Mobility and dynamic changes in the network

The term “things” has a broad definition that includes intelligent cars and smartphones. It is worth mentioning that some items, such as cell phones and health-monitoring equipment, can move.

Furthermore, the network’s edge configuration is subject to frequent dynamic modifications. Accordingly, the network may need to optimize or reallocate resources as connected devices physically move. An offloading framework is still necessary for an IoT network to function effectively on a fault-tolerance scale.

3.2 Health care service

Diagnosis and treatments for chronic conditions that can be done remotely and long-term monitoring are among the most popular health care services in B5G. Remote patient care with the help of robots, AR-enabled care services, hospital logistics automation and optimization, and remote surgery are just a few of the new uses, as shown in Fig. 7. The following are the chances and challenges:

• B5G will enable increased interconnectivity between a wider range of devices using various protocols. An evident benefit of B5G is its capacity to efficiently transport substantial datasets with little latency[62]. This is particularly advantageous for applications that depend on superior picture quality, such as remote operation imaging or robot support for patients with disabilities. Many apps might escape the CN utilizing B5G device-to-device communication, perhaps posing control and payment concerns.

• Real-time AI data analysis and interpretation need significant computational resources. Hence, The importance of processing power at the local node level cannot be overstated. Robots in home care often require quick judgment and task execution based on their acquired knowledge and observations of their surroundings. On the other side, this automation is frequently costly. Moreover, MEC is a B5G system architecture component that seeks to change how robots are programmed and operated. It moves system intelligence to the cloud and makes robots easier to use on the ground. Using less infrastructure adaptation and cabling, MEC saves money on infrastructure and updates.

• Processing operations are moved from local nodes to edge nodes via MEC, enabling the implementation of a minimal terminal set and cloud-based data storage and processing. However, it is anticipated that different abilities of local nodes will be the case.

• E2E network slicing is a high priority, according to the International Telecommunication Union (ITU). Negotiating and selecting the transmission slice and orchestrating the transferred data in the cloud is a challenge that varies depending on the application.

• While moving, M2M connections and sensors can communicate with others. Thus, B5G networks will transmit a great deal of personal information. Managing user identities, device identities, location identities, and data identities becomes challenging[11].

• 5G indorses the concept of "always available", in which consumers can access services anytime and from any location. This constant communication with other devices may facilitate Denial-of-Services (DoS), impersonation, and replay attacks.

• Intervention and remote diagnosis, as well as monitoring for long-term, eHealth system, homecare using a robot, and surgery for chronic conditions, are among the healthcare services that can be performed efficiently using B5G. Monitoring systems, devices, robots, AR/VR, AI technology, and data analysis are the driving technologies for these B5G health services.

3.3 Smart grid service

The never-ending need for electricity has been a significant problem that must be addressed. Modern wireless communication devices are integrated into the grid to enable greater dispersed generating and storage. Experts suggest that highly secure communications are required for sensing and controlling transmission and distribution exchanges[63].

An intelligent grid comprises smart meters, sensors, sufficient monitoring, and data management systems. While managing remote connectivity across different head-end systems is one of the most challenging tasks. A network of information systems covering all substations connected to the user facilities is required. B5G communication networks are more multifunctional and flexible than previous generations. B5G is following a trend of increasing demand throughout the energy sector. Integrating B5G networks into the smart grid can lead to new utility business models[64].

Intelligent grids integrate communication, networking, and information, as well as automation, into conventional power systems, transforming how energy is supplied and stored between utilities and users. A robust communication system is essential for the future smart grid since it connects all electricity distributed and transferred with overall management systems. Smart grids are based on closely monitoring and managing all grid-connected components. The future validity of the communication system will be improved by allowing power line communication.

A smart grid network may divide data traffic distribution into two categories. The first is the utility's interaction with its consumers, which is made possible through underlying linkages like smart meters and sensors. The second is the direct connection between generating sides and the utility. The smart grid is a booming part of the new Internet of energy, where the demand for effective and stable connectivity is constantly growing. As a

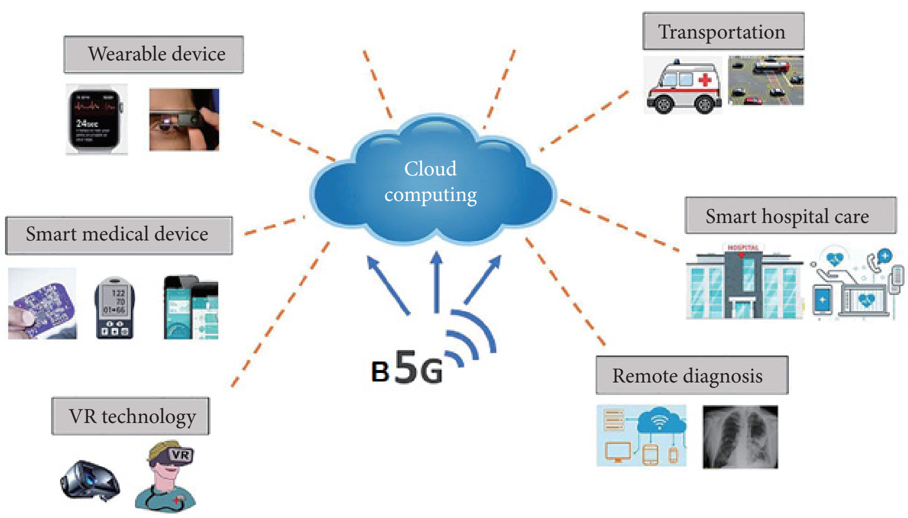

Fig. 7 Applications of B5G technology in healthcare.

result, integrating B5G into the smart grid raises even more expectations for meeting escalating energy demands.

According to recent reports[63], by enabling multiple networked energy devices into the energy grid, B5G networks allow linked energy devices to be included swiftly to monitor energy predictions, as demonstrated in Fig. 8.

As a result, efficiently connecting these devices to these B5G networks aids energy balance management. This contributes to lower energy costs. B5G networks can facilitate efficient data analysis, allowing communities to implement energy plans that are more cost-effective in light of changing demographics. Furthermore, B5G networks greatly assist distribution operators in achieving substation-level observability, which ensures that the grid's operations are significant and balanced.

There are numerous benefits to deploying B5G networks in smart grids, including enhanced scalability and high-quality service to interconnections. The state estimation provides a complete system estimation that comprises the state variables of the network nodes from an utterly remote setup situation. Traditional state estimation is constrained by the computational complexity and communication latency created by dynamic and dispersed power grids. It is easy to overlook the B5G network, which enables sophisticated and distributed state estimation techniques.

Similarly, circuit breakers utilized in the system's protective measures detect system problems with high time criticality. Compared to centralized network management in LTE[65], the speed of circuit breakers intervention in fault detection in distributed network management in B5G has been proven to be faster[66]. Demand response allows users to shift their power usage during peak hours due to time-dependent pricing. Communication issues might hamper on-demand response management. Modern communication technology is necessary to offer a control feedback loop between the energy providers and the user. Effective B5G small cell planning makes this achievable.

3.4 5G and tourism service

The widespread use of the IoT and B5G and the possibility to apply them individually are the reasons to make them good candidates for tourism. Figure 9 shows the application of the IoT in smart tourism.

The Internet of Things will significantly influence all aspects of human existence. Companies, particularly those in the tourism sector, will simultaneously focus on developing the Internet of Things (IoT) to facilitate quick growth. IoT-based intelligent tourism has gained popularity among travelers because of its intelligent scene space and real-time online experience. Smart tourism can help tourists comprehend attractions more effectively and acquiring all the necessary information. However, it is possible to ignore the possible impact of deceptive scams and other adverse incidents at several tourist locations.

The present system seeks to provide diverse tourist groups with more accurate scientific information and services to change the paradigm of tourism development. The advent of cloud services has significantly improved our capacity to access data. Thanks to the emergence of B5G networks, the integration of GPS technology and cellphones, individuals may now experience innovative and distinct mobile travel patterns. As the B5G system matures and becomes more integrated into people's daily lives, the concept of intelligent tourism is becoming more appealing. The tourist industry can benefit from the widespread adoption of B5G since transmission speeds are quicker and accuracy is excellent. Tourism development is aided by integrating B5G technology with artificial intelligence, augmented reality, and other technologies, as well as creating corresponding applications[67], which will help a more significant number of businesses and individuals.

Sustainable tourism investment is also on the rise[68]. The IoT is a comparatively new communication technology that has grown attractive in tourism in recent years because it allows users and services to connect seamlessly. Precision services can be provided by intelligent processes and rapid demands storage for diverse users with diverse requirements[69]. Radio Frequency Identification (RFID) and shopping systems can assist blind individuals shop by providing more precise information about local shopping centers or directing individuals to where they need to go using this

Fig. 8 B5G and smart grid concept.

Fig. 9 B5G and the IoT in the smart tourism field.

information. The expected released software will make it easier to provide intelligent tourism services. Park administrators can also use the IoT and B5G communication to give extraordinary intelligent services to their parks. Recovering memories with smart gadgets leads to new interpretations and exploits buried cultural heritage values to connect personal memories with historical events[70]. Managers can use evaluation to equip smart services, improve management efficiency, and boost tourist satisfaction and attractiveness. The rapid expansion and advanced technology of such communication and information technologies, IoT, and Big Data (BD) applications have increasingly grown, with geographical data becoming more widely available[62,71].

Wildlife surveillance, hotel services, tourist information services, mountaineering, tourism marketing, ocean surveillance, all-weather surveillance monitoring, tracking, and plant and bird species surveillance are just a few of the tourism IoT and B5G applications. The IoT can monitor wildlife using B5G, including personnel visiting, transferring data to servers, and tracking animal movements thanks to animal sensors. Trip management, ticket administration, passenger flow management, data collecting, security monitoring, and environmental monitoring are features that smart IoT travel apps can cheval. Statistical analysis makes IoT adoption easier by giving statistical information and careful management.

3.5 Impact of the B5G system on agriculture

Over the coming years, the ultra-fast B5G network will have a significant influence on the agriculture industry, enabling higher crop yields and improved quality while reducing the amount of human labor required[54]. The utilization of precision techniques and intelligent agricultural methods holds the capacity to enhance farmers' understanding and productivity. The introduction of B5G will bring about significant changes to the agricultural workforce and farming techniques. The B5G network and an Internet of Things (IoT) cloud computing service offer intelligent and effective agricultural solutions. Smart farming facilitates the automated operation of unmanned agricultural equipment for planting, plowing, and managing crops, with the aim of creating farms that are safe, reliable, environmentally friendly, and energy efficient. This article examines the various possible uses of 5G technology in the field of agriculture, such as unmanned aerial vehicles, live monitoring, virtual consultations, proactive maintenance, augmented reality/virtual reality, artificially intelligent robots, cloud storage, data analysis, and cloud databases. The implementation, supervision, and functioning of IoT devices and farms are made easier with the utilization of B5G technology, as shown in Fig. 10[72].

B5G can be involved in the agriculture industry in several ways, such as the following.

3.5.1 Unmanned aerial vehicle

Drones have recently become popular in the agriculture industry. These drones can perform jobs in the air and on the ground, where farmers can send real-time data from drones across vast swaths of land using B5G connectivity. Drones and humans may share high-definition video feeds, telemetry, and other vital sensory information. Drones can communicate, allowing for an autonomous flight across a large area.

3.5.2 Real-time analysis

Wireless sensors may be connected to the internet to continuously monitor temperature, humidity, soil moisture, and light intensity. In order to maintain optimal conditions for plant growth, automatic reactions can be initiated in the event of any alterations in these variables[73]. Pycno is utilized for weather monitoring. We employ Smart Element, Power BI, and Tableau for data analytics.

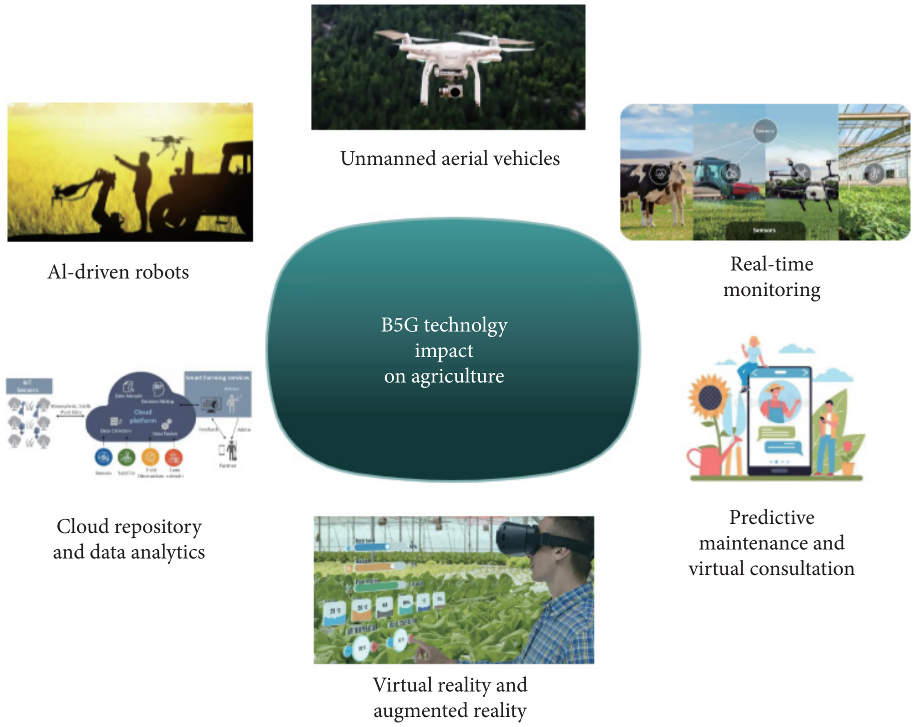

Fig. 10 B5G services in the agricultural sector.

LPWA technology provides fast data rates, energy efficiency, low power usage, and extensive coverage in B5G mobile networks. Using a B5G cellular network, farmers have the capability to connect several sensors—up to one million per square kilometer—to a single cell tower. The implementation of B5G technology will enhance the installation and operation of more Internet of Things (IoT) sensors, enabling more efficient performance through its low-power transmission and high dependability.

3.5.3 Predictive maintenance and virtual consultation

Virtual consultations employing High-Definition (HD) streaming allow agricultural domain experts to reach out to farmers. The utilization of B5G technology enables the simultaneous measurement of diverse parameters in real time through many sensors connected to various apparatus, owing to its low latency and high data transmission rates. By utilizing data gathered from B5G-enabled sensors, farmers received early notifications on potential issues and malfunctioning parts, enabling them to promptly and effortlessly address them.

The proliferation of readily accessible virtual reality and augmented reality kits has created new opportunities for farmers to harness the advantages of technology progress. Information such as insect identification, soil and weather updates, water conditions, crop and machinery data, drone telemetry and live feed, soil and plant disease diagnostics, land evaluation, and wearable glasses and telephones may all provide valuable insights. According to Fig. 11, augmented reality glasses can provide farmers with vital information such as the health status of crops and the optimal time for harvesting[54]. Virtual reality[74] enables the provision of comprehensive and engaging education and training in agriculture.

For a satisfactory cloud VR experience, prerendered 4K 360 films require a minimum bandwidth of 20–60 Mbit/s and a

Fig. 11 AR glasses for agriculture applications[54].

latency of less than 50 ms. However, 12K 360 movies necessitate a bandwidth of 440 Mbit/s or more and a latency of less than 10 ms. B5G addresses the increased connection demands of cloud streaming for virtual reality and augmented reality, which have significantly elevated the bandwidth requirements for an authentic VR experience.

The utilization of 5G cloud VR enables immersive prerendered video experiences and highly interactive virtual reality services, which have the potential to enhance agricultural education, training, and practice. B5G will revolutionize online learning by utilizing cloud-based virtual reality and augmented reality, creating a highly interactive and immersive educational experience that surpasses the limitations of traditional classroom settings.

3.5.4 AI-driven robot

Integrating AI and B5G technology results in new advancements in live video surveillance, on-site prescription, and remote diagnostics to support smart farming and stabilize drones and robots through precise parameter control.

The projected Compound Annual Growth Rate (CAGR) for AI in agriculture from 2020 to 2026 is expected to be 25.5%. After doing a thorough examination of certain crops, the robot will identify any pests or diseases, mark the affected areas, and document the specifics of the infestation. Certain robots are capable of collecting and preparing objects for shipment. We employ AI-driven facial recognition technology to oversee the emotional conditions of pigs and promptly notify us of any deviations from the norm. The regulated environment of a greenhouse, characterized by its enclosed structure, provides an ideal habitat for a multitude of robots to thrive. In order to ensure reliable and fast completion of these activities across a wide expanse, it is necessary to employ many robots in close proximity to each other.

- Seeding and plowing robots.
- Harvesting robots.
- Packaging robots.
- Greenhouse management robots.
- Animal monitoring bots.
- Watering robots.
- Spraying/weed-eliminating robots.

By using the extensive device capacity of the B5G network, it is possible to outfit a greenhouse with many robotic arms capable of spacing, hydrating, seeding, and harvesting plants[75].

3.5.5 Cloud repository and data analytics

Data plays a crucial role in propelling the advancements in the smart agricultural business. In order to facilitate future study, a cloud data repository is utilized to store data obtained from diverse sources across several farms, such as drones, Internet of Things (IoT) sensors, and robots[73].

The introduction of 5G and edge computing enables rapid transmission of data to the cloud, therefore allowing real-time analysis and machine-to-machine connections. This, in turn, has the potential to automate and streamline farming processes. Essential data science applications encompass the subsequent:

- Disease identification at an early stage.
- Forecasting the weather and dealing with changing climate.
- Mapping of soil and crop in digital format.
- Suggestions for fertilizer.
- Recommending pesticides.
- Irrigation system that operates independently.
- Predictions and trends in yield.
- Generating insights.

Cloud-based edge computing enables smart robots to reduce complexity. Additionally, it maximizes the utilization of B5G technology, enabling faster processing of cloud data and minimal delay in communication between many B5G-connected devices, resulting in the maximum productivity in smart farming.

Figure 10 illustrates the many applications of 5G networks in smart farming, including the utilization of sensors, drones, robots, smart devices, cloud computing, and data analytics.

These applications utilize the fundamental components of 5G, which include security, high dependability, minimal delay, and increased device capacity.

Several sophisticated agricultural equipment, including drones, Internet of Things (IoT) sensors, and robots, can work together to enhance productivity while reducing costs.

Future study aims to produce a comprehensive paper that compiles data on the planned B5G medical uses. Moreover, it is important to describe the required characteristics for the recent published techniques in medical field based on B5G. On the other hand, the optical communication systems in 5G network can be another direction to our future work, based on the work published in Refs. [76–78], where authors could include the optical communications in medical fields.

4 Conclusion

This study provides a thorough examination of the overall structure and essential criteria of the B5G network, following an extensive analysis of B5G technology. Furthermore, the research conducted a comprehensive assessment of the primary uses of B5G communication, encompassing eMBB, IoT, V2X, D2D, and M2M communications. 5G technology has the ability to significantly impact all aspects of human life and influence the trajectory of human civilization. Hence, traditional industries such as agriculture require technology innovations that enable swift and extensive crop harvesting while minimizing human effort. New 5G services can expedite the rapid expansion of the tourism sector, smart grid, and healthcare systems. The introduction of B5G enables the fulfillment of current norms and requirements, resulting in increased productivity with less human labor. The impact of B5G will become evident when future technologies and their applications are defined in the forthcoming years. This research report provides a comprehensive overview and analysis of B5G wireless networks and their applications. We examined the latest state-of-the-art research and analyzed the unique qualities that set them apart. This article comprehensively encompasses all aspects of B5G research, therefore consolidating the fundamental technologies and regions associated with B5G into a unified framework. This approach facilitates the examination of B5G as a cohesive and integrated system, rather than a disparate collection of individual systems. Based on the taxonomy presented in this paper, more investigation into B5G will arise from this thorough analysis of the network, perceiving it as a whole entity composed of several intricate systems.

Dates

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