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Future Generation 5G Wireless Networks for Smart Grid: A Comprehensive Review

Abstract

Wireless cellular networks are emerging to make a strong breakthrough in mass acquisition, communication and processing due to the evolution of 5G networks. Now a day's cellular technologies and emerging 5G are both considered to be beneficial for the smart grid. Many services for many important and timely applications of smart grid are offered by 5G Network. In the current power sector, 5G is providing a new business model to energy providers and improves communication. In this article, 5G network analysis and its vision for smart grid are reviewed. In addition to understanding user-driven analytics in Smart Grid, a detailed analysis of 5G architecture is presented along with gridviews. The current situation of 5G networks in Smart Grid is clearly illustrated in this work with a different analysis for energy efficiency. In addition, the future course and the challenges they face are carefully studied. The entire work of 5G Networks is studied in-depth as they relate to the future smart grid as a comprehensive analysis.

Keywords: 5G; smart grid; smart meters; wireless communication; energy efficiency

1. Introduction

Permanent supply of electricity is an important issue in the current era of smart grid. New technologies of wireless technologies have to be integrated with the grid to achieve more distributed generation and power storage. Smart grids deal with smaller distributed sources unlike traditional grids, which rely on large central sources. The main purpose of the conventional power grid is to change the power output so that it can meet the demand for electricity. While the smart grid adjusts demand according to the available sources [1–4]. Although a smart meter consists of sensors, proper monitoring and data management system. Smart grid and smart metering technology [5-10] need to be implemented to further consolidate power utilities. One of the biggest challenges for this is managing remote communication between different headsets and systems where smart meters are connected. An information system network is required that covers the user's facilities and all associated stations. It provides the required analysis of the system, along with the required reliable communication system, which is one of the major smart grid buildings. According to the standards of communication, late communication technologies [11,12] can be categorized on the basis of wired or wireless communication. Currently wireless communication is preferred for a variety of reasons and with low cost reliability compared to different applications. There are a number of factors, such as operational costs, environmental concerns, and resource availability, which should be considered when choosing a suitable, stable communication system so that it can upgrade new wireless communication technologies for smart grid communications systems in the future [14–19]. Will be graded. There are some parameters that need to be addressed to address the key issues for developing a new generation of cellular communications. These include increased capacity data with fewer delays and consequently better service quality.

5G networks are also found to be more efficient and more flexible, as reported by Navigant Research [20]. Moving to a new wireless communication network can bring Internet of Things (IoT) to power markets in the future, delivering maximum benefits to consumers. Historically, 5G energy consumption has been found between wireless networking in wireless modes. Bringing 5G networks to the smart grid can set new business models toward utilities with automation and intelligent control [21-24], as well as edge and fog computing. 5G technology relies on small-cell functions for its slicing network, which provides long-lasting assets for distribution and distribution parties to operate everywhere. This work has identified the need for smart grid and 5G technology in areas where new power grid cannot benefit from data access. The main purpose of this work is to showcase generally 5G architecture in the smart grid as compared to other wireless technologies and new networks, thus bringing energy to the Internet in the future.

2. Overview of Wireless Communications Technologies

In the last few decades, there has been a gradual and steady growth in the communication network from first generation to fourth generation. Currently, there are many advances in wireless technologies such as orthogonal frequency division multiplexing [23,24] with environmental frequency. With this growth, the rise of smart devices in everyday life has increased drastically. With 5G, new applications and new business market providers are also growing.

3. 5G Networks—Outlook

Fifth Generation (5G) network is the best in the best wireless communication technology because it offers different capabilities and encourages networking across countries [32–35]. Various new technologies have been proposed to provide entertainment for 5G services [36,37], namely millimeter wave communication, heatnets, large-scale multi-input multiple outputs for the new generation of communication systems. Are. Input (MIMO), and Visual Light Communication [38].

Millimeter Wave Communication [37] represents the low latency network obtained by using the less used mm wave spectra as a carrier frequency from 3 GHz to 300 GHz. In terms of heat net technology [38,39], these are the paths of 5G networks. This network has identified the need for data because there is a large number of small cells living in and out, and the deployment of small base stations can greatly improve the coverage and network capacity. New technology for 5G networks is visual light communication, which began as an alternative communication technique to overcome the limitations of existing radio frequency [40]. This technology is also called Li-Fi, and optical wireless communication has the advantages of less power, less interference, and greater local use. These benefits make Li-Fi the best choice for indoor communication in 5G networks in the future. About the need for 5G networks in various applications, key core technologies include IoT and software-defined networks (SDNs). There is a special need for services that can be used significantly with cloud-based services, but the cost of investing in these technologies is high. Software-defined networks [41,42] use decoupling controls and data planes to enable advanced programming, adaptation and flexibility in relation to network architecture.

To achieve superior productivity with efficiency, IoT is considered in conjunction with cloud computing services for existing technologies developed over 5G [41,42] networks. The combination of cellular infrastructure with binary coding can be extended to 5G networks, which can be used exclusively for smart grid communication in wide coverage areas [43].

3.1. Architecture of 5G Networks

For future applications, 5G networks provide the possibility of a fully integrated society across all domains. In order to meet the current telecommunication paradigm, appropriate architecture with slicing networks needs to be developed. A large amount of data was transmitted to monitor and control smart grid communications. This work highlights the need for multimedia communication and knowledge-based communication for data transfer. Long-Term Evolution (LTE) defines different architecture for modern networks, including understanding different domains and providing different architecture for energy efficient needs, with its advantages [52–54] that provide the architecture required for 5G cellular networks.

The need for the proposed 5G architecture depends on different techniques. Cell scheduling [56,57] is essential for achieving high performance where there are more overloaded cells in the network. It provides the most profitable channel over time, requiring allocated resources in areas with active mobile networks.

3.2. Applications of 5G Networks in General

There are many applications where 5G networks provide many benefits, such as IoT, healthcare systems, energy sector, financial technology and more. Extensive area coverage between these distributed and diverse devices can be achieved through 5G networks with high throughput and low latency.

Intelligent and smart vehicle communications can be applied everywhere [60–65]. For the 5G networks requires large bandwidth and low latency. The advent of usable technology has strengthened the healthcare sector. The 5G network has extensive bandwidth, low latency and security improvements, which helps with real-time precision monitoring.

4. Smart Grid and 5G

Smart Grid integrates information, communication and networking with automation in Lumi's Power Management, changing the way energy is stored and distributed to utilities and users. Nowadays, in many developing countries, the smart grid is considered the most important framework of various international energy strategies. They work on all Smart Grid connected components and monitor and control their functions.

A lot of data is used here, and the links between networks are very broad and the central information is shared centrally. Therefore, in the future, the smart grid needs a suitable communication system that combines all the transfer and distribution power with the overall management system. Wireless communication is important as a reliable, efficient and intelligent way to extend the traditional power grid to the smart grid.

The role of data traffic distribution in the smart grid network [66-70] can be categorized into two parts. The first of these is the Home Area Network (HAN), which involves interaction between utilities and users, such as sensors such as smart contacts and basic contacts. Over the past decade, power line communication has been considered one of the best communication between these segments. Communication systems in the future. Accuracy will be improved to allow power line communication [1] for the integration of information and communication. This is achieved by activating digital communication in power lines in addition to power transmission.

5G architecture and the smart grid [73, 74] pave the way for both the distribution and distribution of assets. The diversity of services brings new energy and customers, and includes the difficult aspects of balancing load. Another important feature of the under construction architecture is the deployment of demand where network functions are evaluated based on service needs. In addition, 5G network slicing guarantees a low-end assurance in the end-to-end network.

The End-to-End (E2E) Service Level Agreement [75–81] with the proposed design provides various key components, such as communication service management and network slice management. They are widely involved in reducing network costs and deploying on-demand users. The 5G grid provides logically separate networks that are isolated and widely shared with telecom networks [2]. Flexible network capability is an important step that provides secure capabilities. From a technical standpoint the service provides many slicing layers with 5G networks. This scenario involves deliberately distributed feeder automation with communication delays at high levels and low bandwidth [79–81]. The information obtained in low voltage distributed systems shows that the new architecture produces less communication delays and lower bandwidth requirements. It also shows the need for low service isolation and the preference for middle service [85]. In a distributed power supply scenario, medium or high communication delays meet high reliability requirements. The grid has a multi-slice architecture developed that considers various scenarios of low-voltage distribution systems with intelligent feeder automation [76] SmartGrid 5G slice deployment includes virtualized infrastructure layers.

Synchronous connectivity between wireless transfers with simultaneous power allows the development of wireless communication. The cognitive radio network smart serves as a promising technology to provide lockers with all the spectrum resources available to timely smart grid wireless communications.

The smart grid is a boom in the new Internet of Energy, where the boom for productive and stable communication is constantly on the rise. Therefore, bringing 5G to the Smart Grid creates even more expectations for meeting the growing energy needs. According to recent reports [89], by recognizing the various power interconnects connected to the power grid, 5G networks could pave the way for connecting these connected devices more quickly to monitor these energy forecasts.

Therefore, interconnecting these devices with these 5G networks helps in managing the energy balance. This helps reduce energy costs. Figure 4 shows the various domains of communication networks in the smart grid where 5G can play an important role. These networks together with the domain power infrastructure form the smart grid [90].

Different access networks combine elements in a smart grid, such as smart meters and secondary substations, while backhole networks combine elements in medium-voltage areas, such as secondary substations. The backbone network deals with integrating elements into the domain high voltage and additional high voltage power grid, such as the primary substations, which are desperately needed. Table 3 shows the specific needs of each communication network domain for a smooth process without a smart grid.

4.1. Advantages of 5G Networks in Smart Grid

There are many benefits to using the 5G network in the smart grid, which brings high quality service with interconnectedness. The traditional state-of-the-art estimates show high computational complexity and communication delays, caused by dynamic and distributed power grids. This can be easily ignored by implementing a 5G network, as it enables state-of-the-art estimation schemes [91]. Figure 5 represents the major advantages of using 5G in the smart grid.

Similarly, circuit breakers used in system security measures detect system defects that work overtime. Circuit breaker interference speed in fault detection is better in network management distributed in 5G [92] than in centralized network management in LTE. Communication malfunction can negatively impact demand response. This requires advanced communication technology to enable a controlled eruptive loop between the consumer and the energy provider. 5G and Smart Grid require interconnected structures, which have different features and this is due to the superiority of 5G cellular networks [95]. There are many benefits to these frameworks, including bilateral energy trading between grid and networks, dynamic energy pricing, and active wireless transmission spectra.

4.2. Security in 5G Based Smart Grid Networks

Security concerns involved in creating an efficient communication system in the smart grid are an important issue to resolve before the deployment of efficient energy systems in the future [7, 77] Furthermore, establishing a reliable one. Increasing security risks must be addressed for, in the smart grid, modern measurement infrastructure [98]. In any communication system security attacks can be classified as active or passive attacks. Managing and distributing balance keys is needed to handle security attacks using encryption analysis. The existence of conflicting network architecture in 5G imposes challenges to the management of balance keys, which calls for better security mechanisms. Another security strategy that can be implemented in the smart grid is the method of protecting the physical layer. In addition to traditional cryptographic methods and physical layer approaches, secure communication using 5G in Smart Grid can be ensured using an interference detection system [80]. The game's theoretical point of view can bring new insights into network consolidation and cyber security [100–102]. Key keys are effective security technologies for public key infrastructure, hashing schemes, and reliable computing smart grids [104,105]. Therefore, in order to achieve an effective and secure communication system, an appropriate security-based strategy [106] must be implemented.

4.3. Challenges of 5G Based Smart Grid Networks

Although smart grid has the potential to use 5G network as a communication technology, the system has not been fully implemented due to the following challenges. The real challenge in front of the smart grid network is the unexpectedly large number of small generation stations and user-level fluctuating energy consumption. Furthermore, the demand and supply side of traditional grid demand are mutually exclusive. With regard to the smart grid, the end user also becomes the producer. The smart grid must be able to control the communication technology up to the end of the user. The 5G network is expected to be standardized by 2020. A new technology should have mutual communication and backward compatibility with existing technologies. The basic requirement of any wireless network is not only its performance but also its effect on energy parameters. The number of devices connected to the appearance of the 5G network will increase manifold. This will significantly increase the power consumption through the network. In this way, a sustainable network with renewable energy sources, maximum power consumption and minimal power outages must be implemented. Verification of network devices is required in any network and the current system requires hundreds of milliseconds delay. The threat of cyber-attack is a huge challenge that the network must address. This requires 5G technological solutions that enable switching between different communication technologies, thus guaranteeing synchronization and real-time information delivery.

In smart grids that provide reliable, reliable infrastructure for security concerns (which leads to the promotion of smart grid architecture), Supervisory Control and Data Acquisition (SCADA) provide the necessary adaptation.

SCADA provides increased security [49], this process involves three key units - the human machine interface, the remote and the master terminal unit [2]. In the smart grid, the Skoda system brings more secure communication modules that optimize transmission sources.

The group also provides a number of security-aware mechanisms for setting up key security management with communication. With SCADA, the required entities in the smart grid provide high reliability [49] wireless networks such as 5G to provide advanced levels of communication channels.

The basic requirement for achieving scalability is the network's proper planning so that it can find and utilize the appropriate capacity needed to meet future needs [98]. An essential component of a smart grid using 5G is the information exchange between electronic devices that are located in the system's distribution mode. The design of a reliable network [109] requires analysis of delayed communication.

It includes a pool of tools managed by the IoT Cloud Provider. The need for energy efficient communication models has received considerable attention in recent years by researchers. It provides great support for future smart grid to improve control and monitoring distress between large networks in a successful brand. This review discusses the requirements of the smart grid with 5G and discusses the areas where the network can be analyzed. This work marks the beginning of a new era of 5G networks with smart grid and a way for emerging researchers to work on new technologies with smart grid and to provide trending transceivers to new energy domains around the world.

5. Conclusions

In this work, a complete overview of the upcoming 5G technology for the development of smart grid as an energy field is presented, and analyzed. 5G services at Smart Grid Junction will carry out extensive and decisive acquisition of information on system-timed scales, in addition to large-scale storage backups and new computing techniques.

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Time limit: 00:23:08

1. What is the frequency range of the IEEE 802.11a standard?

- A) 2.4Gbps
- B) 5Gbps
- C) 2.4GHz
- D) 5GHz

2. What device separates a single network into two segments but lets the two segments appear as one to higher protocols?

- A) Switch
- B) Bridge
- C) Gateway
- D) Router

3. The slowest transmission speeds are those of

- A) Twisted-pair wire
- B) Coaxial cable
- C) Fiber-optic cable
- D) Microwaves

4. Which of the following does not allow multiple users or devices to share one communications line?

- A) Doubleplexer
- B) Multipplexer
- C) Concentrator
- D) Controller

5. In CRC there is no error if the remainder at the receiver is _____.

- A) Equal to the remainder at the sender
- B) Zero
- C) Nonzero
- D) The quotient at the sender

6. Frames from one LAN can be transmitted to another LAN via the device

- A) Router
- B) Bridge
- C) Repeater
- D) Modem

7. What is the maximum distance with maximum data rate for 802.11g?

- A) About 65-75 feet
- B) About 90-100 feet
- C) About 150 feet
- D) Over 200 feet

8. Which of the following is used for modulation and demodulation?

- A) Modem
- B) Protocols
- C) Gateway
- D) Multiplexer

9. What is the frequency range of the IEEE 802.11b standard?

- A) 2.4Gbps
- B) 5Gbps
- C) 2.4GHz
- D) 5GHz

10. To connect a computer with a device in the same room, you might be likely to use

- A) A coaxial cable
- B) A dedicated line
- C) A ground station
- D) All of the above

11. Internet-like networks within an enterprise.

- A) Intranets
- B) Switching alternating
- C) Inter organizational networks
- D) Extranets

12. The packets switching concept was first proposed

- A) In the late 1980s for the Defense Ministry of US
- B) In the early 1960s for military communication systems, mainly to handle speech
- C) In the late 1950s for Defense Ministry of US
- D) None of the above

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13. How many non-overlapping channels are available with 802.11b?

- (selected) A) 3
- B) 12
- C) 23
- D) 40

14. Which of the following device is used to connect two systems, especially if the systems use different protocols?

- A) Hub
- B) Bridge
- (selected) C) Gateway
- D) Repeater

15. How many non-overlapping channels are available with 802.11a?

- A) 3
- B) 12
- (selected) C) 23
- D) 40

16. How many non-overlapping channels are available with 802.11h?

- A) 3
- B) 12
- (selected) C) 23
- D) 40

17. How many hosts are attached to each of the local area networks at your site?

- A) 128
- (selected) B) 254
- C) 256
- D) 64

18. A distributed network configuration in which all data/information pass through a central computer is

- A) Bus network
- (selected) B) Star network
- C) Ring network
- D) Point-to-point network

19. What is the maximum data rate for the 802.11a standard?

- A) 6Mbps
- B) 11Mbps
- C) 22Mbps
- D) 54Mbps

20. What is the maximum distance with maximum data rate for 802.11b?

- A) About 65-75 feet
- B) About 90-100 feet
- C) About 150 feet
- D) Over 200 feet

Question #	Answer Selected
1.	D. 50Hz
2.	B. Bridge
3.	A. Twisted Pair Wire
4.	A. Doubleplexer
5.	C. Nonzero
6.	B. Bridge
7.	B. About 90-100 feet
8.	A. Modem
9.	C. 2.4GHz
10.	A. Coaxial Cable
11.	A. Intranet
12.	B. In early 1960's for military communication system, mainly to handle speech
13.	A. 3
14.	C. Gateway
15.	C. 23
16.	C. 23
17.	B. 254
18.	B. Star Network
19.	D. 54Mbps
20.	C. About 150 Feet