Key Technologies and Analysis of Computer-based 5G Mobile Communication Network

Guimin Yuan1,*

1Department of Electronics and Communication Technology, Tianjin electronic information College, China, 300350

*Corresponding author e-mail: yuanguimin@tjdz.net

Abstract. With the rapid increase in traffic in the Internet era, new services on 5G mobile communication networks are gradually facing many problems such as high return bandwidth and low latency. The use of computers can quickly solve the above problems. This article has sent a computer-based 5G mobile communication network architecture. According to the construction of the network architecture, it can be concluded that the 5G mobile communication network is a network of communication and multi-level computing. Virtualization technology can be used to achieve communication, computing, and storage. Efficient sharing of resources. Facing the collaboration of communication and computing, the main challenge of the 5G network that integrates computers in terms of basic theory is network capacity analysis.

Keywords: 5th Generation Mobile Communication Technology, Computer; Communication and Computing Integration, Centralized Architecture, Multi-Level Computing

1. Introduction
Looking at the development of mobile communication in the network era, the time span of its development stage is gradually shortening. Nowadays, in the era of 5G mobile communication, it will bring more radical performance requirements [1, 2], and it will also require huge changes and emerging technologies to meet the needs of 5G [3, 4]. In the era of 5G mobile communications, 5G network technology will continue to be combined with other related cutting-edge technologies, with people as the main service object, extending to a world where people and things are fully connected, and realizing the great vision of "Internet of Everything" [5, 6].

By sinking network-side functions and application deployment capabilities to the edge of the radio access network (RAN) closest to user equipment (UE), computers provide cloud for application developers and content providers. Computing power and IT service environment make application deployment more flexible, network capabilities can be orchestrated on demand, business processing closer to users, and better meet application requirements such as high return bandwidth and low latency. Among them, for high-definition, ultra-definition video, etc. For high-bandwidth services, by caching hot content at the edge of the network, it can effectively save backhaul bandwidth resources, while reducing user access delays and effectively improving the service experience; for low-latency...
services, operators can open the network edge to allow authorized third parties. The three parties can flexibly and quickly deploy applications and services for mobile users, enterprises, and vertical industries, effectively reducing end-to-end latency. At present, industry and academia have carried out in-depth and extensive research on computers. In 2015, ETSI was the first to launch in the world Computer standardization work, and then the mobile communication international standardization organization 3GPP also accepted computers as the key technology of 5G mobile network architecture. The coordinated development of 5G and edge computing has become an industry consensus.

2. Computer Network Architecture

The 5G network is a new network architecture model formed based on the continuous development and improvement of the 4G network. At present, the key technologies of 5G and its requirements for the network have been initially determined. In view of its development direction, the effective combination of the Internet and the Internet of Things will also be a major trend in the future. Of course, in addition to bringing about tremendous changes in the mobile Internet, 5G network technology can also provide strong support for wireless IoT requirements such as ultra-high traffic density and mobility. The 5G network itself has formed a certain basic model in its long-term development, and in-depth research and analysis can generally be conducted from the original cognitive model. Integrating the future development direction, the network architecture of 5G will be mainly developed around three modules, namely network deployment scenarios, access networks, and core networks.

The computer network frame structure is shown in Figure 1, which can be divided into two levels: system level and host level. The system level structure consists of computer system level management and users and third-party entities. Computer system level management is used to control the network. The deployed computer host, available resources, available computer services, and network topology are overall grasped; load user or third-party application packages, including checking the integrity and authenticity of the package, verifying the rules and requirements of the application. If necessary, adjust it to meet the operator's strategy; record the loaded data packets and prepare the virtual infrastructure manager for the further processing of the application, so that it can manage the virtual infrastructure according to the needs of application processing, such as Allocate, manage, and release the virtualized resources of the virtualized infrastructure; select or reselect the appropriate computer host for the application based on the delay and available resources.

![Computer network architecture](image-url)
3. Progress in 5G standardization of computers

At present, the standardization progress of computers in 3GPP5G is shown in Figure 2. The iconic work is the 3GPPSA2 working group (the SA direction is responsible for business and system work) R15 (3GPP mobile communication system standard version number) was officially accepted in April 2016. Computers have become a key issue in the 5G network architecture.

Figure 2. Computer standardization progress in 3GPP.

In addition, the SA2 working group is mainly engaged in the evolution of the 5G core network architecture of the control plane (CP) and the user plane (user plane, UP) (user and control plane separation, CUPS) in the R14 direction. The stage has been frozen. Among them, the 5G core network will separate the different functions of the same network element solidified in the 4G core network and regroup into different modules, which focus on specific functions. The 4G core network is mainly composed of a mobility management entity (mobility management entity). MME), serving gateway (S-GW) and packet data network gateway (P-GW) and other solidified network elements and gateways. The 5G core network will integrate the functions of the MME in the 4G core network. Decomposed into session management function (SMF), access and mobility management function (AMF), etc.; the routing functions of the 4G core network S-GW and P-GW are reorganized, and 5G The user plane function (UPF) in the core network is implemented. At the same time, the 5G core network will increase the network exposure function (NEF) to open the network capabilities such as monitoring, configuration, policy and charging to third parties, To support the deployment of computers in 5G networks. The C/U separated architecture supports user plane function UPF and some control plane function modules, such as session management function SMF, policy control function (PCF), network opening function NEF And so on, with the computer server for flexible deployment on demand. In addition, by adding a local data network (L-DN), content access is realized on the computer.

Other working groups have also carried out corresponding standardization work on computers. The 3GPPRAN3 working group is responsible for the overall structure of the mobile communication system network and the interface technologies such as S1 (the interface between the base station and the mobility management entity) and X2 (the interface between the base stations). Standardization. In 2016, wireless sensing and intelligent distribution (context aware service delivery, CASD), that is, the research of computer applications, is currently in the technical feasibility study phase (study item, SI). At the same time, the RAN2 working group is responsible for the mobile communication system protocol architecture. The work of layer 2 and layer 3 has been researching video enhancements (enhancements on video, eVideo) since 2017, and is currently in the stage of writing specific technical specifications (work item, WI).

4. 5G network architecture integrating computers

4.1. Computer deployment in the network

In mobile communication networks, there are two main ways to deploy computers: 1) Integrate
computer functions into the base station, and use the computer as an enhanced function of the base station through software upgrades or additions; 2) Deploy the computer as an independent network element, and realize collaboration and unified management with the core network at the same time.

In addition, the deployment location of the computer can be based on factors such as performance, cost, existing network deployment, and combined with the delay requirements of the business, adopting different levels of network deployment strategies. One strategy is that the computer can be deployed at the wireless access point because it is close to the baseband unit (BBU) of the base station and has no transmission delay and is suitable for services and applications with high delay requirements. However, due to the small coverage area, it can only provide small-scale and localized services, and the use of nodes is inefficient. One strategy is that the computer can be deployed at the convergence point to provide a large-scale, relatively short-distance service and cloud service support. However, due to the transmission delay from the base station BBU to the computer, it is suitable for lower-latency services and applications.

It is worth noting that when the computer is deployed at the wireless access point, the entire network element of the traditional core network? The gateway function needs to be deployed along the computer at the edge of the network, which will lead to a large number of interface configurations, signaling interaction design, etc. The network architecture has changed a lot. However, if the core network adopts an architecture that separates the control plane and the user plane, only part of the modular network element? Gateway functions, such as access and mobility management functions, network opening functions, etc. The plane is deployed to the computer together to realize flexible deployment with the computer on demand, making business processing faster and effectively reducing delay; at the same time, other control plane network elements and gateway functions are still deployed in a centralized manner, reducing the burden of interface configuration.

4.2. The deployment of computers in 5G networks

The architecture of the future 5G network is different from that of the traditional mobile communication network, so the deployment of computers in 5G has its uniqueness. 5G will use the technology of ultra-dense cells to increase network capacity, that is, to further reduce the cell coverage radius and use more The cell realizes the coverage of a certain area in order to further improve the efficiency of spectrum utilization. The mobile communication system has developed from 1G to 5G, and has been using this network expansion technology to reduce the radius and increase the number of cells. So far, this technology has been used for mobile The communication network has brought a 1,000-fold increase in capacity, and 5G will continue to use ultra-dense cell technology to improve network capacity.

Figure 3 shows the functional block diagram of the super base station of the Institute of Computing Technology of the Chinese Academy of Sciences, which is mainly composed of a hardware resource layer, a resource management layer, and a virtual base station layer. Among them, hardware resources are the basis of the hardware architecture, including multi-mode baseband processing DSP pool, protocol processing CPU pool, etc., support large-scale mobile communication baseband computing and protocol processing; resource management layer is the key to logic function innovation, including baseband processing management and protocol processing management software, mainly using virtualization technology to allocate and manage hardware resources, and virtual The base station function is generated to form a virtual base station layer. Since the super base station adopts resource pooling and virtualization technology, different modes of communication systems can be realized by customizing different modes of baseband and protocol processing software, and the efficient multiplexing of hardware resources is realized. It is conducive to the rapid upgrade of the network and cost savings. In addition, the super base station adopts resource level sharing and centralized management and control, which can perform real-time dynamic scheduling of hardware resources from a global perspective, effectively improving the utilization of communication, computing, and storage resources, and achieve Load balancing solves the problem of resource waste caused by tidal effects. In addition, because the super base station adopts a physically centralized and logically
distributed networking method, the radio frequency unit and the baseband processing unit are decoupled, which is conducive to the flexible deployment of the remote terminal according to actual needs. Radio frequency unit.

Figure 3. Basic functional block diagram of super base station.

Comparing the super base station with the computer host in Figure 1, it can be seen that the structure and core functions of the two are similar. Therefore, under the 5G centralized network architecture, the central control unit of the architecture, such as the super base station, is fully capable of using its computing and storage resource pools. Virtualize the functions required by the computer, seamlessly integrate the computer into the mobile communication network architecture, provide edge computing and storage capabilities, and meet the needs of low-latency and intensive computing. However, compared with traditional distributed base stations, super base stations are due to The coverage area is large, and the longest distance to the user is between 20-40km. According to the transmission speed in the optical fiber of $2 \times 10^8 \text{m/s}$, it will produce a delay of $100 \mu \text{s}~200 \mu \text{s}$. Therefore, for small-scale, ultra-low-latency services and For application scenarios, you can choose to deploy computers on the side of traditional distributed base stations; for other large-scale, low-latency services and application scenarios, you can choose to embed computers in centralized super base stations.

Based on the above analysis, as shown in Figure 4, the 5G mobile communication network will be a heterogeneous communication network that combines a centralized architecture and a traditional distributed base station architecture. At the same time, it will also be able to communicate from mobile terminals, traditional base stations, and central control units. A multi-level computing network that provides edge computing or cloud computing functions at different levels such as the core network is a network of communication and computing collaboration.

5. The basic theory and key technology of 5G network with integrated computer

It can be seen from Figure 4 that the computer-integrated 5G network has a multi-level computing and communication collaboration architecture. The introduction of multi-level computing collaboration in
the traditional mobile communication network may use computing and storage resources to reduce the demand for communication resources and improve overall network performance. Facing the collaboration of communication and computing, the 5G network that integrates computers still faces many challenges in terms of basic theory and key technology research.

In terms of basic theory, how to obtain the 5G network capacity of the integration of communication and computing is a core issue. Only communication resources, such as frequency band and transmission power, are considered. The capacity of wireless communication has been given by Shannon; but considering the computing and storage resources introduced by computers, etc. Later, Shannon's theory of the relationship between capacity and communication resources cannot be directly extended to computing and storage resources; the research in literature shows that the gains brought by communication resources are logarithmic, and the capacity gains brought by computing dimensions are in a logarithmic relationship. The ability to calculate and store dimensions is approximately linear. Therefore, if computing and communication can be effectively integrated, it is expected to promote the sustainable development of future communication networks; the basic theoretical research direction of the integration of communication and computing is summarized, that is, how to define and model Network utility capacity, how to convert between network utility capacity and computing power, and how to use virtualization and network technology to realize the effective allocation of resources; researched the coordination of communication, computing, and storage three-dimensional resources, and used computing power as "calculation degree" "To measure and characterize the number of information flows involved in the operation. However, how to standardize the definition of communication, computing and storage resources, and to provide a unified capacity analysis for the future 5G network of the integration of communication and computing, is still one that needs to be resolved. Big challenge.

Figure 4. 5G mobile communication network architecture with integrated computers.

In terms of key technologies, for a 5G network that integrates computers, the collaborative optimization of communication and computing resources is one of the focuses. For example, after the introduction of computers, the 5G network has the capability of multi-level computing, so for each business, How to allocate computing tasks to nodes with different computing capabilities, that is, computing task offloading, is an important problem that needs to be solved. Unlike traditional computing task offloading, which mainly considers computing resources, the computer-assisted 5G mobile network is a wireless transmission network, Wireless resources such as bandwidth and transmission power are strictly limited, and must be taken into account when designing the computing task offloading mechanism and joint optimization.
6. Conclusion
The 5G mobile communication network integrated with computers is expected to meet the high return bandwidth and low latency requirements brought by video services and new services. This article introduces the computer framework and its standardization progress in 5G, and summarizes the deployment methods and methods of computers. Strategy. Then combined with the development of 5G mobile communication network architecture, a 5G mobile communication network architecture that integrates computers, communication and computing collaboration is proposed. Finally, it introduces the basic theory and key technology research of 5G networks oriented to communication and computing collaboration and integrated computers. Challenges and current research progress.

References
[1] Popovski, P., Trillingsgaard, K. F., Simeone, O., & Durisi, G. (2018). 5g wireless network slicing for embb, urllc, and mmtc: a communication-theoretic view. IEEE Access, PP, 1-1.

[2] Shah, S. T., Kim, J. S., Bae, E. S., Bae, J. S., & Chung, M. Y. (2016). Radio resource management for 5g mobile communication systems with massive antenna structure. Transactions on Emerging Telecommunications Technologies, 27(4), 504-518.

[3] Katti, R., & Prince, S. (2019). A survey on role of photonic technologies in 5g communication systems. Photonic Network Communications, 38(2), 185-205.

[4] Chen, T., Matinmikko, M., Chen, X., Zhou, X., & Ahokangas, P. (2015). Software defined mobile networks: concept, survey, and research directions. IEEE Communications Magazine, 53(11), 126-133.

[5] Kun, Zhu, Ekram, & Hossain. (2016). Virtualization of 5g cellular networks as a hierarchical combinatorial auction. IEEE Transactions on Mobile Computing, 15(10), 2640-2654.

[6] Chi, K., Huang, L., Li, Y., Zhu, Y. H., Tian, X. Z., & Xia, M. (2017). Efficient and reliable multicast using device-to-device communication and network coding for a 5g network. IEEE Network, 31(4), 78-84.