ISSN: 1813-4890

Current status and trends in meta-universe underpinning networks

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Abstract

In the information age, the Internet has been integrated into our daily lives, and technologies such as virtual reality, mixed reality, augmented reality, and artificial intelligence have been applied to daily teaching and entertainment activities. However, with a new wave of popularity, the rise of the metaverse has attracted attention, coupled with the emergence of the New Crown Virus. However, none of this can be done without the support of technology, which has continued to evolve and develop, laying a solid foundation for the realization and application of meta-universes. With the rapid development of 5G, big data, VR/AR, and other information technologies, the metaverse presents a transition from the real world to the virtual world, and at the same time, it is also expanding the imagination of human beings. At the same time, the demand for 5G, cloud computing, the Internet, and other basic technologies for these devices is growing. In the context of the metaverse empowering the information society, the article analyzes the development and current status of its underlying network by reviewing several literatures.

Keywords

Meta-universe, underlying network,5G.

1. The concept of meta-universe

American science fiction writer Neal Stephenson first introduced the concept of "metaverse" in his 1992 book Snow Crash: "Human beings, through a variety of high-tech means, project the real world into another virtual world, where people can set their own identities and socialize as they wish"[9].Peking University Professor Chen Gang and Dr. Dong Haoyu of Peking University define the metaverse in this way: "The metaverse is a virtual world mapped and interacted with the real world using technological means for linking and creation, and a digital living space with a new type of social system." The new visual effects brought by the metaverse will make more people addicted to the virtual world and unable to extricate themselves.

Simply put, "metaverse" is not a new concept; it's a synonym for its reinterpretation in the information age. "It's still a growing and evolving concept, and everyone is expressing themselves in their own way." A metaverse is a virtual digital world where people socialize using virtual identities and currencies. People can live virtually outside of the real world, as well as engage in practical activities related to reality. For example, it is possible to socialize and play games in the virtual world, as well as conduct real-world transactions.

In the definition, we also mentioned that the metaverse is an integrated technology that combines various high technologies, and its development also reflects the development of the metaverse in a sense.

ISSN: 1813-4890

2. The network layer of the metaverse

The metaverse infrastructure includes communication networks, cloud computing, and edge computing, among others, and the communication network is still pending the continued rapid advancement of 5G construction.

2.1. Communication networks: evolving towards a meta-universe

Generally speaking, there are three typical usage scenarios for 5G: enhanced mobile broadband (eMBB), massive machine-type communications (mMTC), and ultra-reliable low-latency communications (URLLC)[1].Specifically, the metaverse will have many different dimensions, including the integration of virtual reality, the need for access, safety, and reliability, and the integration of near and far. Based on these four characteristics, we can see that the new generation of 5G will be the "key" to unlock the virtual world, connecting the two real worlds.

Xu Hao believes that: 5G, as a representative of the new generation of mobile communication technology, with the characteristics of large bandwidth, low latency, high reliability, and wide connectivity, will play a great role in the promotion and development of the metaverse and open the door for people to enter the metaverse. Of course, 6G in10 years may be able to better meet the communication needs of themetaverse[2].Deng Tingjun and Li Benqian pointed out that: in terms of the network environment, it mainly relies on 5G and 6G technology,which solves the problem of connecting the virtual world and the realworld, which is the core of the metaverse. The fifth-generationmobile communication technology (5th-Generation, or 5G) is not only animportant mobile communication technology but also the root of the development of all intelligent technologies[3].

Hua Zixun and Huang Muxiong said: the metaverse, as an emerging concept, is built on the basis of 5G, virtual reality, and other technologies and gradually takes shape[4].

2.2. Internet technology and cloud computing

Many experts and scholars predict that in the near future, the web will usher in a new era, and the metaverse will open a brand new era.

Scholars Zheng Shilin, Chen Zhihui, and Wang Xiangshu pointed out that with the deep integration of the Internet into people's daily life, the high-speed development of metaverse underlying technologies such as VR, MR, 5G, cloud computing, blockchain, and so on, coupled with the impact of the New Crown Epidemic, people have put forward new requirements for the Internet industry models such as games, telecommuting, and e-commerce. Therefore, some scholars believe that the metaverse world stage is the general trend of the high-speed development of the Internet and the ultimate stage of Internet development[5].

Cao Yafei proposed that in the era of the metaverse, cloud computing will be the key to unlock the door to the future. Whether it's a large-scale gaming scenario or an immersive user experience, cloud computing as a computing powerbase is indispensable[6].

2.3. Internet of Things (IoT) technology

The development of digital technologies such as the Internet, artificial intelligence, big data, the Internet of Things, blockchain, and others has greatly improved the ability of humans to produce and utilize information and data[7].IoT will play a very important role in the development and implementation of meta-space network architecture. The interconnection between the virtual and the real requires a large number of sensors, smart terminals, and other IoT devices for real-time data collection and processing, so the IoT can provide real, long-lasting, and smooth interactions and is the link and bridge between the virtual and the real. The sensing layer, the network layer, and the application layer are the three-layer architecture of IoT, which are closely related to the construction of the metaverse[8].

ISSN: 1813-4890

The Internet of Things (IoT) provides a technological guarantee for the connection and virtual coexistence of everything in the metaverse. On the basis of game engines, 3D modeling, and real-time rendering, video game technology builds a high-quality networked social environment and enriches the expression of "meta". Developed communication networks and powerful data processing capabilities have enabled the development of network and computing technology, which is an emerging field based on massive data. It provides a high-speed, low-latency information transmission channel for the metaverse, allowing users to be more fluent and efficient in their social activities.

3. Developments at the network layer

3.1. Communication technologies: 5G evolves towards the meta-universe, 6G for the meta-universe

In the industrial metaverse, wireless communication technology is an indispensable technology. 5G technology will undoubtedly become part of the metaverse of technologies, and the development of 5G technology provides a solid foundation for the integration of virtual reality, AR, MR, and digital twins. By 2030 and beyond, 5G will not be able to meet all the demands of the future. Researchers are now beginning to focus on sixth-generation (6G) wireless communication networks[9]. Currently, 5G technology is not ready for metaspace support; it changes as different application scenarios require it. It can be said that 5G is meta-world-oriented evolution, and 6G is meta-world-oriented.

In the network environment, the connection between the virtual and the real is solved based on 5G and 6G. The 5G network has the characteristics of fast, high reliability, low latency, multi-connection, and multi-signal, which lays a solid foundation for the application of various new technologies in the metaverse. Shanghai formally issued the "14th Five-Year Plan for the Development of Shanghai's Electronic Information Industry" on December 30th, 2021, in which it is clearly stated that in the future, Shanghai will focus on the development of basic technologies and the enhancement of independent innovation capacity. Among these cutting-edge technologies, there are 6G communication, the metaverse, and so on. Peng Bo and Zhong Xiangming believe that with the commercialization of 5G, China has stepped into the digital technology era of "A, B, C, D, E + 5G"[2]. In the future, the immersive, intelligent, and omnidirectional characteristics of 6G will make various new technologies combine more deeply, so as to maximize the potential of the metaverse, thus realizing the qualitative change and development of the metaverse technology system.

On March 1, 2022, in Figure 1, people experience the "4D metaverse" through virtual reality technology at the Mobile World Congress 2022 in Barcelona, Spain.

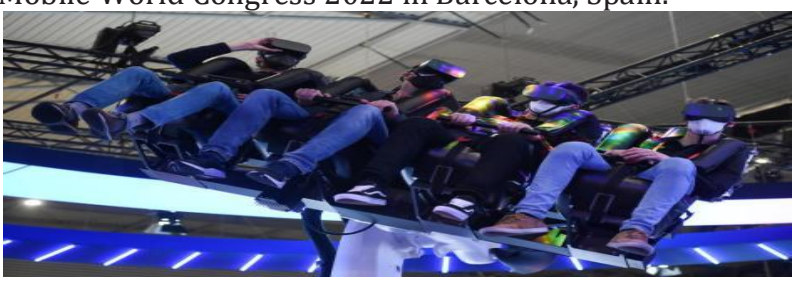

Figure 1 AFP (Photo by Gustavo Baliente)

Meta-space requires high synchronization and low latency; therefore, synchronization between real and virtual worlds is achieved through communication networks, which is a key feature of 5G. The uRLLC solution has 5G highly reliable low-latency communication with microseconds latency requirements for the air interface, while the low-latency requirement for meta-space is basically met in the air interface. Whenever and wherever possible, it is necessary for human beings to be able to transcend the limitations of time and space and have access to the

ISSN: 1813-4890

metaverse at any time and any place. To achieve this goal, not only the function of various metaverse terminals but also the ability to connect to the Internet at any time and any place, which is in line with the development of wireless communication in the direction of "air" and "sky", facilitating the various applications of the metaverse.

The development of 5G technology will improve its performance in many fields and also be able to adapt to more industrial applications. The broad prospect of the metaverse and the combination of multiple technologies have made most of the evolution of 5G standards to be metaverse-supportive, with large bandwidth, low latency, high reliability, low power consumption, and large connectivity, all of which are necessary for the metaverse. In particular, the evolution of the 5G standard has been deeply researched and standardized in many aspects, in a sense solving some specific problems in the metaverse, and XR of the 5G standard is the most typical, which is directly related to many problems between the virtual and real.

3.2. Three stages of Internet development:

China's network development can be broadly divided into three periods, each of which has seen profound innovation and development. The first period was the start of the Chinese web, the latter being the first decade of the 21st century. The third period of development, the era of the mobile web as we know it, began in 2011 with the launch of mobile applications such as Xiaomi MIUI and WeChat and continues to the present day. During this period, the development of the Internet benefited from the popularity of smartphones and high-speed network communication technology. The combination of the three major technologies has led to the development of the mobile Internet at an increasingly fast pace, with more and more smartphones and high-speed network communication technology[8].

3.2.1. The development of the metaverse from the history of the Internet in China

The development of the metaverse cannot be separated from the Internet, as the metaverse is essentially a brand new form of Internet application. Its development is built upon the foundation of the original Internet, and its course of development will also be subconsciously influenced by the Internet. Therefore, from the perspective of China's history of Internet development, the development of the metaverse may go through similar three stages.

In the first stage, the concept of the metaverse gains traction, and forward-looking enterprises must align themselves and lay out strategies for the metaverse. They delve into underlying technologies and explore metaverse applications, much like the early days of Internet development when domestic Internet companies emerged one after another, exploring Internet applications.In the second stage, more enterprises enter the metaverse, focusing on social interaction, gaming, and convenience as entry points for technological breakthroughs and metaverse construction. This attracts and accumulates a large number of user experiences and production content in the early stages, leading to continuous improvement and perfection of services. As user experience and user base grow, this will also lead to more comprehensive and systematic metaverse construction and further breakthroughs in underlying technology. Eventually, the formation of a mature social ecology and the development of game-centric metaverse are closely linked to the Internet. It can be said that the metaverse is a brand new form of network application, and its development process is rooted in the network, influenced by the network in subtle ways. Therefore, from the perspective of China's Internet development history, the metaverse is likely to go through three stages as well.

The first stage sees the concept of the metaverse making waves, with major companies choosing sides and entering the metaverse, leveraging new technologies and starting new business models. In the second stage, more companies enter the metaverse to make technological breakthroughs and construct metaverse spaces with social, gaming, and convenience as core elements. This attracts a large number of user experiences and products, leading to continuous improvement and perfection of services. As user experience improves and the user base grows,

ISSN: 1813-4890

this will also lead to more comprehensive and systematic construction of metaverse spaces and further breakthroughs in underlying technology. Eventually, a mature social and gaming ecology is formed in the metaverse, along with a variety of rich metaverse applications. The third stage marks the emergence of mobile terminals, signifying a new era in metaverse development. With the popularity of mobile devices, metaverse applications will become more widespread, eventually covering the entire society and becoming a mature application system. All aspects of the metaverse will become "software-ized," allowing users to experience them with a simple click on their devices[8].

In general, the development of the metaverse is characterized by an easy early stage and a challenging middle stage compared to the Chinese Internet. In the early stage, the development of the metaverse garners increasing attention due to the significant influence of the Internet, leading to increased investment from companies and capital, pushing metaverse development forward. However, from the second stage onwards, metaverse development encounters numerous challenges. The need for basic technology and infrastructure makes metaverse development more difficult, and in the third stage, the requirement for mobile terminals poses a significant obstacle to metaverse development.

3.2.2. Data processing in the metaverse: cloud computing

Cloud Technology. The operation of the metaverse requires a large number of users, but also requires a large number of virtual activities, which requires strong computing power, and cloud technology can solve the high cost problem of all people in the metaverse, while cloud technology can solve the high cost problem of all people in the metaverse, providing the infrastructure and software and hardware platform responsible for building the metaverse, and enterprises only need to pay on demand. For users, the use of cloud technology can allow them to directly access the metaverse without the need to purchase highly configured equipment. Whether it's in large gaming scenarios or in providing a better experience for users, the computing power of the cloud is inseparable from cloud computing. Cloud computing, cloud storage, cloud rendering, and other technologies are developing rapidly, which is an important foundation for the metaverse, but the development of cloud computing is a crucial aspect of cloud technology.

In today's rapid development of big data, cloud computing, and other technologies, the cloud computing industry's ability to better provide more arithmetic support for the metaverse and reduce latency for immersive experiences has become an important issue that current cloud computing companies must consider. No one doubts the importance of the cloud to the metaverse anymore; cloud computing is the key to opening the door to the metaverse era. Whether it's large-scale gaming scenarios or immersive user experiences, the cloud provides powerful computing power that is indispensable.

4. Future trends in the network layer

4.1. 5g future: '5G+' will drive meta-universe technologies

China's IMT2030 Promotion Group published a White Paper on 6 G Overall Vision and Potential Key Technologies in June 2021, which details the application scenarios of 6 G and points out the business scenarios in which 6 G will realize omni-directional immersive interactions, multi-dimensional sensory and pervasive intelligence convergence and symbiosis, and the deep fusion of virtual and reality in the years 2030 and 2030[1] . The business scenarios include: holographic cloud XR, holographic communication, sensory interconnection, intelligent interaction, communication perception, pervasive intelligence, digital twin, and full coverage.

It can be seen here that most of the scenarios fulfilled by 6G are future scenarios in the metaverse plan. We can say that 6G is for the metaverse. The metaverse will be a new world

ISSN: 1813-4890

and a new era, and the new generation of mobile communication technology, represented by 5G, will become a new architecture of the new cloud space. 5G will also open the door to the "metaverse". The immersive, intelligent, and omni-directional characteristics of future 6G will integrate various new technologies more deeply, maximizing the potential of the metaverse and realizing qualitative changes and developments in the metaverse technology system.

4.2. Metaverse Leads Cloud Computing Trends

Arithmetic power is a fundamental structure of the metaverse, which itself is a virtual world as complex as the real world and has very high requirements for computing power. Various functions and scenarios of the metaverse, such as architectural modeling, scene rendering, information feedback, physical computation, data coordination and synchronization, artificial intelligence, motion capture, blockchain, and so on, cannot be separated from powerful computing power. Cloud computing and edge computing technology are excellent ways to promote the development of arithmetic power, allowing the hardware's performance to be fully utilized and thus safeguarding the metaverse supported by arithmetic power. It can be said that the metaverse will develop in the direction of cloud, edge, and terminal synergy in the future, and the computing power of the cloud edge determines its scale and integrity.

At present, the concept of the metaverse is still in its infancy, and the technological foundations of the five levels have not yet been fully implemented. From the current development of the metaverse, the future metaverse will have five major development trends, two of which are the increase in computing power. The development of the metaverse has grown to produce huge computing power. The second is the enhancement of experience. With the development of information technology, we will transition from real interaction to a natural metaverse. We can also have touch, taste, feel, and so on in the metaverse.

4.3. Metaverse Future

4.3.1. Metaverse Basic Technology Industry May See a Boom

Meta-universe provides new investment direction for capital and forms a positive promotion mechanism that the higher the heat of the meta-universe, the more capital influx, which is conducive to promoting the prosperous development of meta-universe related basic science and technology industry.6G is built on the basis of 5G, which focuses on solving the problem of network latency, and is able to bring a more realistic and immersive experience for the users; with the development of the world of the meta-universe, a huge amount of data will be generated, which will rely on powerful cloud computing capabilities for data storage and analysis. Many policies introduced by the state will benefit a series of meta-universe underlying technologies, which will in turn promote the rapid development of meta-universe underlying technology-related industries. China's Ministry of Industry and Information Technology (MIIT) and Net Information Office (NIO) issued the "Guiding Opinions on Accelerating the Promotion of Blockchain Technology Application and Industrial Development", which puts forward a grand vision that the comprehensive strength of the blockchain industry will reach the world's advanced level and the industry will begin to take shape in 2025, and that the comprehensive strength of the blockchain industry will continue to be improved and the scale of the industry will be further enlarged by 2030. The "new infrastructure" represented by 5G, big data, cloud computing and blockchain is precisely the underlying science and technology that constitutes the technological architecture of Yuan Universe, and it can be said that the underlying science and technology represented by Yuan Universe is in line with China's development objectives and direction, and the national strategic arrangement provides good development opportunities for the real landing of Yuan Universe.

ISSN: 1813-4890

5. Metaverse Network Technology Situation

This is the literature about the metaverse network layer that I downloaded from the Knowled ge Network. As shown in Fig. 2 bar graph, it is not difficult

to see that the rise of the metaverse has attracted attention since the year 2021with the new round of fads. Coupled with the emergence of the New Crown Virus, the metaverse has become increasingly heated. People from all walks of life are also paying more and more attention to the technological requirements.

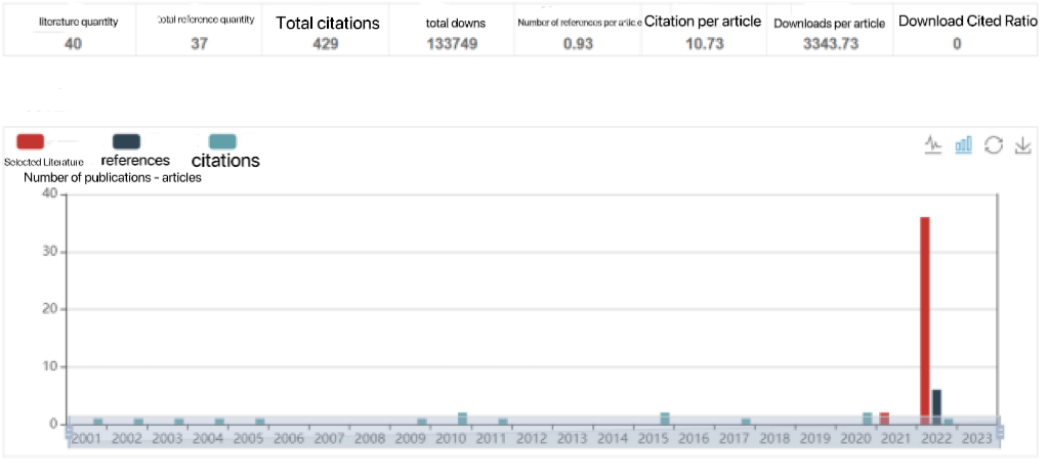

Fig. 2 Volume of relevant postings in the network layer of the meta-universe

Figure 3 depicts the time partition of the metaverse. From 2021 onwards, technologies related to media convergence, digital communication, virtual reality, blockchain, and other metaverse-related technologies have gradually been utilized for research. China's digital underlying technology has achieved certain results in recent years, especially in the new generation of network communication technology represented by 5G, which is leading the world. The realization of the metaverse depends on the development of a series of cutting-edge technologies such as 5G/6G, cloud computing, blockchain, virtual reality, augmented reality, etc., giving our country a certain first mover's advantage in the construction of the metaverse. However, the current technological level is still far from realizing the metaverse.

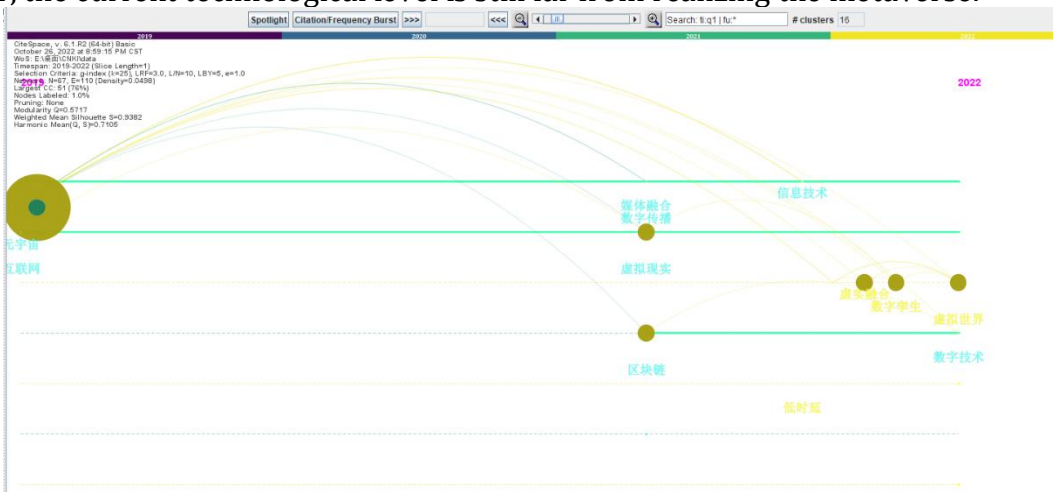

Figure 3 Time partitioning

As shown in Table 1, the table presents a search analysis about the distribution of the metaverse network layer industry. It can be seen that in recent years, Amazon, Microsoft, Tencent, and Huawei, these cloud giants, are actively exploring the metaverse. In the next three to five years, the metaverse will usher in a preliminary exploration phase. Metaverse network technology

ISSN: 1813-4890

will continue to evolve, and the combination with other technology areas will form a more powerful "chemical reaction."

Table 1 Distribution of Metaverse Network Technology Industry

network layer	Industry representative	Technology role
5G	China Telecom, China Mobile, China Unicom, Huawei, Fiberhome Communications, ZTE, Nokia, Ericsson	Provide technical support for the signal transmission of the meta-universe to perceive everything in the physical world and provide a high-speed, low-latency, scale transmission channel for the meta-universe, so that users can have a more real-time, smoother experience.
cloud computing	Microsoft, Amazon, Aliyun, ZTE, China Unicom, UFIDA, SZXS, Quanta, Ziguang, Lansin Technology	Provide meta-universe users with terminal equipment that is more powerful and larger in function and lighter in weight. Enhance the computing power of servers to further upgrade the low-latency, high-immersion experience of metaverse users, while also reducing the performance requirements for terminal equipment, which is an indispensable infrastructure for metaverse construction
edge computing	Ali, Huawei, Tencent, and CSC, Wave Information, Cambrian-U, NetCast Technology Megger Intelligence, Danghong Technology	Solving the problem of cost and network congestion to provide a more delayed, smoother experience for meta-universe users.
the Internet	Jingdong, NetEase, ByteDance, BeiliBeili, Google, Microsoft, Tencent	The meta-universe was developed based on the integration of existing Internet technology, which is more closely linked to reality, creating a new type of symbiosis between reality and reality.

6. Conclusion

During the development of the metaverse, advancements in network technology have brought significant benefits, attracting more funds into the metaverse and facilitating its rapid development. However, in the middle and later stages, issues related to funds, technology, techniques, and infrastructure all require further research. Firstly, significant efforts should be made to construct a new type of infrastructure at the base of the metaverse. The metaverse itself embodies the integrated innovation and fusion application of cloud computing, distributed storage, the Internet of Things, 5G, blockchain, and other cutting-edge digital technologies. Therefore, promoting the rapid development of the metaverse imposes higher requirements on the construction of underlying new infrastructure. Fifth-generation mobile communication technology is not only crucial for mobile communication but also forms the basis for the development of all intelligent technologies. The new generation of digital underlying technology networks represented by 5G/6G, cloud computing, and blockchain serve as the cornerstone for the construction of the metaverse world.

ISSN: 1813-4890

It is suggested that China should increase investment to promote the construction of new infrastructure represented by 5G, blockchain, cloud computing, artificial intelligence, AR, and other technologies. The central government should establish guidance funds, attract local government supporting funds, and drive private capital to invest in the underlying new infrastructure of the metaverse. The communications industry is undergoing significant changes due to digital transformation driven by technological and innovative advancements. As a leader in the communications industry, especially in the context of emerging technologies such as 5G, big data, cloud computing, and artificial intelligence, the industry should proactively consider how to leverage the momentum and benefit from the metaverse world through innovative initiatives.

By utilizing advanced meta-universe-related technology, industrial fields, servicebusinesses, etc., and closely integrating with traditional industries, the communications industry may become a development highlight in the process of digital transformation.

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