Application Research of 5G Network in Coal Mine Communication Field

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Abstract. The mine-used 5G hybrid networking wireless system mainly uses 4G technology to provide voice calls, and 5G technology mainly provides high-definition video analysis, big data transmission and remote wireless control services. In this paper, the mine 5G mobile communication network is mainly composed of ground core network (CN), IP RAN ring network, baseband control unit (BBU), remote data convergence unit (RHUB), micro radio remote unit (pRRU) and other systems, and the application research scheme of 5G network in the field of coal mine communication is expounded, which can also be tailored according to the specific needs of professional users.

Keywords: 5G network, Seamless connection, Seamless roaming, Large bandwidth, Low delay.

1. Introduction

As users in the Internet age become more and more accustomed to enjoy broadband access services everywhere, mobile broadband has become a reality. By 2012, the total number of broadband users in the world is expected to reach 1.8 billion. About two-thirds of them will be mobile broadband users. At the same time, users also put forward higher and higher requirements for experience and tariff: higher peak rate and lower delay, so as to improve the user experience. Higher spectrum utilization and flexibility, higher system capacity, thus reducing network costs and benefiting end users. All of these form the main driving force to promote the development of wireless communication technology. 4G adopts many advanced wireless technologies, which can provide peak rate of users with downlink exceeding 100Mbps and uplink exceeding 50Mbps. Compared with HS PA release 6, the spectrum utilization rate is 2-4 times higher. The main success of 4G is to help human realize the rapid development and application of video.

5G technology has high speed (peak transmission rate reaches 10Gbit/s), low delay (end-to-end delay reaches ms level), energy saving, cost reduction, higher system capacity (connected equipment density increases by 10 ~ 100 times, traffic density increases by 1000 times), and provides connections for a large number of devices, and can provide users with stable user experience at a speed of about 500 km/h. High-speed, 5G has a very high transmission rate, which is about 10Gbit/s, which is converted to 1.25GB/s, which is hundreds of times higher than that of 4G network. Low latency: the latency of 5G
communication network is below millisecond level, while that of 4G communication network is about 50 milliseconds, which is about 50 times higher. The rapid decline of 5G communication network delay will provide powerful technical support for Internet of Vehicles, Internet of Things, telemedicine and intelligent network [1].

2. Overall design scheme of 5G network in coal mine communication field

2.1. Overall composition of mine 5G mobile communication network system

The 5G mobile communication network for mining is composed of ground core network (CN), IP RAN ring network, baseband control unit (BBU), remote data aggregation unit (RHUB), and miniature radio remote unit (pRRU). The function of core network (CN) is mainly to provide registration and control of underground wireless network, authentication of service, exchange of voice and data, etc.

The main function of IP RAN equipment is to form a high-speed and reliable 10 Gigabit industrial ring network, which can meet the needs of 5G wide bandwidth applications. IP RAN is connected to the core switching network on the ground and the baseband control unit (BBU) in the underground. The main function of the baseband control unit (BBU) is to complete the baseband processing of signals, provide transmission management and interfaces, and manage wireless resources. The base station consists of a baseband control unit (BBU), a remote data convergence unit (RHUB), and a miniature radio remote unit (pRRU). The main function and role are to provide underground 5G wireless signal coverage. The topological structure diagram of the system is shown in Figure 1.

![System Topology Diagram](image-url)  
*Figure 1. Schematic diagram of system topology*
2.2. Relationship between private network and public network of enterprise mobile communication network

Equipment such as core network (CN), IP RAN ring network, baseband control unit (BBU), remote data convergence unit (RHUB) and micro radio remote unit (pRRU) are deployed in coal mines. Seamless connection, the core network of the coal mine private network and the core network of the local operator's public network realize the complete docking of signaling, and then realize the seamless connection between the private network and the public network. Seamless roaming, 5G private network users in coal mines provide seamless roaming of voice communication and data communication services. Operators open "one card and double number" (public network mobile phone number and coal mine private network number) service for users who need roaming communication between the private network and the public network. There is no charge for communication in the underground private network, and the communication in the ground public network is charged according to preferential policies. For data communication, multiple access edge computing server (MEC) is deployed in the private network to realize the landing processing of underground data communication business in the ground core machine room of the coal mine, without transmitting to the public network and returning to the local [2].

2.3. Relationship with the original industrial ring network in underground mine

According to the requirements of the coal safety regulations and the national safety production informatization plan, coal mines should build an industrial ring network, including safety ring, control ring, video ring, etc., in the underground, so that various businesses can independently transmit communications to meet the needs of safe production and automated control. Due to its "large bandwidth, low latency, and wide connection" characteristics, 5G mobile communication technology provides a maximum bandwidth of 1G (1000M) for each mobile terminal. Therefore, 5G mobile communication requires a bearer ring network with low latency, high reliability, and high bandwidth. The total amount of underground sensors, controllers and other data equipment is calculated based on 10,000 points, and the amount of information transmitted in real time at each point will not be greater than 1K, and the total bandwidth will not be greater than 10,000K (10M=0.01G).

The underground mobile communication network mainly carries voice communication services and data communication services. The real-time bandwidth occupied by high-definition voice calls per user of mobile voice communication is not more than 72K, and the total bandwidth occupied by 500 users is not more than 360M (0.36G). The mobile data communication service volume will not exceed the data communication service volume of the industrial ring network (2.41G), and the total service volume will not exceed 2.77G. Since the IP RAN ring network can provide 10G (10000M) bandwidth, it can be smoothly upgraded to 50G and above in the future, and the bandwidth utilization rate can reach more than 70% of the total bandwidth, which can meet the needs of industrial ring networks and mobile ring networks [3].

2.4. Signal coverage design

The ground uses the operator's public network Hong Jizhan to realize the coverage of ground 5G signals, which reduces the investment of mining parties in the construction of ground base stations, and reduces the construction cost and later maintenance cost. Considering that the base station with 4G signal may be upgraded to 5G signal in the future, and the frequency point of 5G signal will be higher than 4G, resulting in the coverage radius of 5G signal will be smaller than 4G. In this scheme, the signal coverage radius of all base stations is 300 meters for alleys and straight alleys, and 200 meters for tunnels with poor conditions, which can meet the need of upgrading 4G signals to 5G signals.

2.5. Business integration design

Mining 5G wireless system can provide the following services: basic services and supplementary services.
Table 1. Mining 5G wireless system can provide the following service

| Category       | Name                          | Function brief description                                                                 |
|----------------|-------------------------------|------------------------------------------------------------------------------------------|
|                | HD voice call                 | Inoue-underground video call, underground-underground video call                           |
|                | short message                 | Support single and group sending of SMS                                                    |
|                | Data                          | Peak 4G provides data services with uplink > 20M and downlink > 50M. 5G provides data services with uplink > 100M and downlink > 700M M. |
|                | Low delay                     | Provide control plane with no more than 40ms delay                                         |
|                | Video analysis                | Realize the analysis and calculation of many high-definition videos underground            |
|                | Industrial remote control     | Wireless industrial control with long distance and low delay in underground is realized    |
|                | Application of robot inspection| Providing network makes it possible for downhole robot to patrol                          |
|                | Vehicle assisted driving      | In the early stage, the underground vehicles were responsible for driving and finally unmanned automatic driving was realized |

3. Research on 5G network service in coal mine communication field

3.1. Professional voice call
The mine 5G hybrid networking wireless system realizes high-definition voice call service based on volte, with independent protocol channels and no interference between data and voice. It not only improves the speech clarity, but also ensures the stability of the call.

3.2. SMS service
As a relatively independent interactive mode, SMS has become another way for people to obtain information. Support peer-to-peer SMS and SMS group sending.

3.3. Large bandwidth and high-speed data service
The mine 5G hybrid networking wireless system integrates the advantages of the 4th and 5th generation mobile communication technologies, and can provide the highest wireless access data rate, 1GHz data bandwidth, 500Mbps uplink data peak rate and 500Mbps downlink data peak rate. High speed data service can meet various business requirements of underground mobile Internet [5].

3.4. Low delay automatic industrial control
5G research organizations all put forward millisecond end-to-end delay requirements for 5G. Ideally, the end-to-end delay is 1ms, and the typical end-to-end delay is about 5 ~ 10 ms. The ideal end-to-end delay of the 4G network we currently use is about 10ms, and the typical end-to-end delay of LTE is 50 ~ 100 ms. This means that 5G shortens the end-to-end delay to one tenth of 4G. The delay requirement of downhole mobile control equipment is at ms level, and the reliability needs to reach 99.99%. The characteristics of 5G technology meet the use requirements of downhole automatic control.

4. Conclusions
Coal industry is the forefront of the development of energy industry, and the network technology system is the foundation of advancing coal mine communication field. The various technical standards of 5G are becoming more and more mature, which provides strong support for the field of coal mine communication, and is bound to have great potential in the field of coal mine communication. It can be said that leaving the field of 5G coal mine communication will greatly reduce the application effect and efficiency. This paper discusses the application and research technology of 5G network in the field of
coal mine communication. Combined with the advantages and characteristics of 5g network, it analyzes the application of 5g key technology in coal mine communication field in detail, so as to help the coal mine communication field to deploy and promote more effectively.

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