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**Requirements for the architecture of intelligent coal mine  
systems**

煤矿智能化体系架构要求

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### 6.1 Basic Requirements

6.1.1 The intelligent network architecture for coal mines, as shown in Figure 3, should comply with the relevant technical requirements of GB 50215 and GB/T 51272, and is divided into external... Networks and coal seam networks.

6.1.2 The external network should include the interconnection between the coal mine and the superior management platform, government regulatory platform, cloud service platform, or operator network. part.

6.1.3 The coal mine network should include a core mining network and an integrated bearer network (convergence layer, surface communication layer, and underground communication layer), ensuring... To ensure unified communication capabilities with low latency, high reliability, and controllable isolation across multiple scenarios in coal mines.

### 6.2 External Network

6.2.1 The external network should have cloud service, AI application and model service, data warehouse and data lake service, and regulatory interface functions, and should support communication with... Interconnection and interoperability of centralized or

distributed core networks ensures secure interface between control functions such as AMF, SMF, PCF, and UDM and the core network, and has... It features a unified security strategy and cross-domain data collaboration mechanism to achieve business interconnection and closed-loop management.

6.2.2 The construction of the cloud service platform shall be implemented in accordance with the deployment scheme in GB/T 37739 and shall meet the following requirements.

- a) The centralized cloud service platform should be built by the superior management network and should be capable of supporting unified management, data analysis, and intelligent decision-making. ability;
- b) Edge computing nodes should be deployed in coal mine layers according to specific scenarios to undertake local real-time business data processing tasks and possess network adaptability. Response capacity and system real-time performance.

6.2.3 AI applications and model services should provide capabilities for model training, model management, online inference, and batch offline inference; and support model version management. Management, performance monitoring, and rollback mechanisms.

6.2.4 Data warehouse and data lake services should support centralized storage and querying of structured, semi-structured, and large object (video, image) data. It provides metadata catalog, data lineage, data governance, ETL/ELT pipeline, and batch/stream integration capabilities.

6.2.5 The regulatory interface should provide standardized data exchange interfaces with government regulatory platforms and industry regulatory systems (including real-time streaming reporting and...). Regular reports are supported, including audit log export, event alarm reporting, and data retention and data anonymization/de-identification strategies that meet regulatory requirements.

### 6.3 Mining Core Network

6.3.1 The mining core network should serve as the core domain within the integrated bearer network, oriented towards production control and business support in the mining area, responsible for business access, resources, and other aspects. Source scheduling, security management, and service orchestration.

6.3.2 Business Access. Ensure secure and reliable access to the core domain for various production, monitoring, operation and maintenance, and regulatory applications; support multiple access methods. (5G/WLAN/wired, etc.) and compatible with IPv4/IPv6, implementing hierarchical access and priority policies according to service category; prioritizing latency-sensitive services. First, it is carried out at the edge (MEC/local UPF), providing standardized interfaces (API/messages/video streams) and access authentication mechanisms.

6.3.3 Resource Scheduling. Implement differentiated allocation and elastic scaling among network, computing, and storage resources to ensure eMBB/URLLC/mMTC performance. Performance requirements of services such as end-to-end QoS, resource isolation (slicing/VRF/VLAN), TSN/clock synchronization and other deterministic capabilities, and It has load balancing and degradation strategies in case of failure.

6.3.4 Service Orchestration. Provides automated service and network function orchestration capabilities to enable application/model deployment, scaling, version management, and... Edge-cloud collaboration. The orchestration platform should support programmable interfaces, closed-loop observation and alarm mechanisms, and integrate with operations, CI/CD/MLOps processes to improve efficiency. Response and recovery efficiency.

## 6.4 Integrated Bearer Network

6.4.1 The integrated bearer network shall comply with the information collaboration architecture requirements in GB/T 34679, and uniformly bear various production, scheduling, safety, and management functions of the coal mine. Data traffic of systems such as data processing.

6.4.2 The integrated bearer network should be able to simultaneously carry multiple services such as voice, video, data acquisition, and control signals. The network should support multiple connection standards. It possesses capabilities for service isolation, resource scheduling, and Quality of Service (QoS) assurance to meet the bandwidth, latency, and reliability requirements of different services. Differentiated needs.

6.4.3 The integrated bearer network shall include a convergence layer, a surface communication layer, and an underground communication layer, with the following requirements.

a) The convergence layer is responsible for distributing mining operations, edge computing, and data aggregation. It should interface with the mining core network to achieve seamless connection between the surface and the well. Unified scheduling and data aggregation of communication resources. 1) Service Distribution. Identify, classify, and schedule access traffic, prioritizing it for distribution to the edge or upper layers, providing protocol conversion and northbound routing. interface; 2) Edge Computing. Hosting latency-sensitive and closed-loop tasks on MEC/local UPF, supporting model deployment and edge-cloud collaboration, ensuring... Local availability; 3) Data Aggregation. Local preprocessing, caching, and compression of large object data, followed by batch/streaming uploads to the data lake/cloud according to strategies, providing a unified... Observation and alerts.

b) The ground communication layer consists of the application layer and the transport layer, and is responsible for data transmission, control command issuance, and information transmission for various ground-based business systems. Information interaction function.

1) Application Layer. Supports various business functions including production, scheduling, video surveillance, office and living environments, enabling coal mine surface production management and equipment... The system provides a unified data interface and sharing mechanism for operation and maintenance, dispatching and command, security monitoring, and logistics support. Information sharing and collaboration between different business systems improve management efficiency and comprehensive service capabilities; 2) Transport Layer. Employing a combined wired and wireless coverage method, it provides a highly reliable communication channel for the application layer. Wired access should... Industrial Ethernet ring networks, F5G, and PON technologies are adopted to achieve wired terminal access and transmission; open-pit coal mines and coal washing plants should... Prioritize fiber-to-the-site or near-end junction planning, and extend to industrial-grade Ethernet where necessary. Wireless access should adopt... Mobile devices can access the network using technologies such as mobile communication and WLAN; open-pit coal mines can use directional microwave backhaul or dedicated wireless... Line links serve as a supplement or backup to fiber optic cables. The transport layer should possess QoS control and link redundancy capabilities to ensure production scheduling and... Stable, secure, and continuous communication for critical business operations such as monitoring.

c) The underground communication layer consists of a transmission layer, an access layer, and an edge layer, and is the foundation supporting the operation of mining, tunneling, transportation, ventilation, and other systems. network. 1) Transmission Layer. Composed of a control ring network, a video ring network, and a security ring network. The control ring network supports real-time control during mining, tunneling, and other operations. The monitoring and identification services require low latency and high reliability; the video ring network carries monitoring, identification, and transmission tasks, ensuring high bandwidth and continuous video output. Continuity; safety ring networks are used for monitoring, personnel location, and emergency communications, emphasizing data reliability and link redundancy. Each ring network is interconnected. Service isolation and resource scheduling are achieved through network slicing and QoS policies, and redundant links are set up at key nodes to ensure smooth operation. Security and stability. 2) Access Layer. Supports industrial Ethernet, CAN bus, WiFi, 5G, LoRa, and other methods, and integrates network slicing to implement services. Classification and isolation. 3) Edge Layer. The control unit is responsible for local task execution and closed-loop control, enabling rapid response to equipment such as coal mining, transportation, and tunneling. The sensing component is responsible for the acquisition, fusion, and preprocessing of various data types, supporting status monitoring, anomaly detection, and intelligent operation. It can be analyzed.

6.4.4 The wired backbone ring network and wireless bearer ring network of the integrated bearer network should be constructed in an integrated manner to achieve unified planning and interconnection, and avoid duplication. Invest in and improve the efficiency of data exchange between devices. New bearer technologies with low latency and network slicing