Research on 5G Key Technologies and Applications in Urban Rail Transit

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Abstract

With the rapid development of science and technology, Chinese urban rail transit has entered a new stage of intelligent development from the stage of rapid construction. Urban rail transit has the advantages of high speed, large capacity and high density, which greatly facilitates modern life. However, urban rail transit is quite different from conventional ground transportation. Traditional information transmission methods cannot be well applied to urban rail transit. The maturity and commercial use of 5G mobile communication technology provide new ideas for solving the problem of information transmission in urban rail transit. Based on the salient features and key technologies of 5G communication technology, this paper researches on key technonlgies 5G in rail transit scenarios to achieve fast and efficient processing efficiency. It is a solution for intelligent operation and maintenance of urban rail transit and high-definition video surveillance, and studies and analyzes the security of the system solution. This fills the gap of rail transit in these two fields, and provides dual guarantees of safety and service for urban rail transit construction. It provides a new direction for the application of future urban rail transit system.

Keywords: 5G, Rail Transit, IoT, Intelligent Transportation

1 Introduction

As the economy continues to grow, urban rail transportation is becoming more and more popular. With its small occupation and fast operation, it can not only weaken the traffic burden of the city, but also greatly facilitate the transportation mode of people.The use of advanced technology can play a role in promoting the development of society, and 5G communication technology is one of the new technologies born in the context of today's society. In the process of rapid development of information technology, the use of 5G communication technology in urban rail transportation is becoming more and more extensive.The application of 5G communication technology in urban rail transportation has become a new practical approach to ensure the proper and efficient operation of urban rail transportation systems. It can be said that 5G communication technology has become an important part of urban rail transportation.

Compared to traditional 2G, 3G and 4G communication technologies, 5G communication technology has three main significant advantages. First, 5G technology adopts a new cellular network structure with large bandwidth [1], and the transmission rate is a hundred times more efficient than the information

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transmission in 4G network environment, which greatly facilitates the interconnection of information. Second, the application of 5G technology can reduce the network time delay to 1 millisecond, making it more responsive and powerful. This significant advantage of low 5G network latency can meet the high standards and requirements of fine fields such as telemedicine, autonomous driving, and virtual reality, and has a wide potential development space in the future. Finally, 5G technology is capable of providing 1 million access ports per square kilometer, significantly increasing connection density and traffic density. The large network capacity extends the information dissemination channels and lays the technical foundation for IoT construction and wide-area communication.

This project studies the application and implementation of 5G in rail transportation by tracking the latest 5G technology and applications. The project is carried out in the areas of metro 5G network architecture convergence, intelligent operation and maintenance, HD video monitoring and information security, respectively, to provide support for innovative applications such as fully automated operation of rail transit and build an intelligent system for rail transit based on 5G technology.

5G network, as the underlying technology of new infrastructure, brings a revolutionary upgrade to the whole information environment. 5G also brings effective improvement to the intelligent transformation of rail transportation and the operation, service and operation, and maintenance of smart city rail. In the new era, the development of urban intelligent transportation systems will be the inevitable trend of urban transportation management in the future. 5G network can break the most important technical barriers in the development process of urban intelligent transportation and bring a new dawn to intelligent transportation which is stuck in the development bottleneck.

2 Related Works

2.1 5G technical features

Compared to traditional network technologies, 5G puts higher demands on mobile communications.The performance goals of 5G are to have high data rates, save energy, reduce latency, increase system capacity, reduce costs and connect large devices.The three major application scenarios of 5G defined by the ITU are [2], enhanced mobile broadband to meet the needs of continuous wide coverage and high capacity scenarios of hot spots, ultra-high reliability and low latency communications to meet the needs of industrial automation, remote autonomous driving and other low latency and high-reliability applications, and massive machine-like communications to meet the needs of the IoT with low power consumption and large connections.There are three main applications:

The purpose of enhanced mobile broadband is to provide high-throughput connectivity [3], the main feature of which is a significantly higher data rate, the ability to accommodate more traffic as well as complete coverage, including densely populated areas and transit paths, to meet the demand for continuous wide area coverage as well as hotspot high-capacity scenarios.The main application scenarios of eMBB include live and shared 3D/Ultra HD video, virtual reality, anytime and anywhere cloud access, high-speed mobile Internet access, and other high-volume mobile broadband services.

URLLC is characterized by high reliability [4], low latency, and high availability, with a one-way null delay of only 1ms or less, and reliability of 99.999%.Low latency is mainly used for fast wireless transmission and return of data and control commands to achieve timely information transmission and improve the accuracy of collaboration.High reliability is mainly used to improve the correct rate of wireless information transmission to enhance the effectiveness of application command transmission and ensure the safety of operation.The main application scenarios include driverless cars, industrial interconnection, automation, and so on, which require extremely low latency and high reliability.This requires improvements to the service processing of existing networks, so that the bandwidth and latency of high-reliability services are predictable and guaranteeable, and will not be impacted by other services.

mMTC is characterized by low power consumption and large connectivity [5], which achieves low power consumption and low-cost requirements while ensuring a connection number density of 10^6/square of km.It focuses on solving the problem that traditional mobile communication cannot well support IoT and vertical industry applications.The main application scenarios include Telematics, smart logistics, smart asset management, etc. It requires the provision of multi-connected bearer channels so as to realize the interconnection of everything. In order to reduce network blocking bottlenecks, base stations and collaboration between base stations require higher clock synchronization accuracy.

2.2 Application of 5G in Rail Transit

The urban rail transit scenario is characterized by high mobility, high throughput, high penetration loss, user concentration, frequent switching and so on.However, existing mobile communication systems cannot fully adapt to the various characteristics of the rail transportation scenario, which prompted the three major application scenarios of 5G to provide cash network architecture and key technologies for rail transportation to provide continuous, reliable, secure and high-speed mobile communication services for users in the rail transportation scenario [6].From the perspective of 5G technology standard evolution and current commercial deployment, eMBB scenario has completed standardization and scale application, and gradually penetrate to URLLC scenario, and finally will develop mMTC Internet of everything, which is also applicable to 5G application in rail transportation.

eMBB, as the first wave of 5G application in rail transit, is reflected in video monitoring, HD video, VR live broadcast and AR remote support [7].It is mainly oriented to high-speed mobile communication, ultra-high-definition video transmission and other large bandwidth mobile broadband applications where there is a huge bandwidth demand for the bearer network, and can meet the demand of urban rail transit for a network bearing multiple services and comprehensive bearing vehicle-ground wireless transmission.In the traditional rail transit high-speed bandwidth bearing solution, it is difficult to meet the demand for large bandwidth transmission of vehicle-ground wireless communication under the environment of restricted dedicated frequency band.The emergence of eMBB meets the urban rail transit train control business, video transmission needs and provides large bandwidth transmission channel for intelligent operation and maintenance of rail transit.It ensures the real-time transmission of massive onboard operation and maintenance data, and provides a new solution for the multi-network convergence of large bandwidth rail transit vehicle-to-ground wireless communication system.

uRLLC as the second wave of applications, mainly for metro safety and control, vehicle networking and station service AI robot aspects.In the vertical industry of rail transportation class [8], it is very important for the bearer network to have ultra-low latency and high reliability capability. High reliability and low latency wireless communication solves the transmission demand of vehicle-ground wireless information.The key is to solve the contradiction between the change in channel environment caused by high-speed mobile scenario and transmission reliability and transmission delay.At the same time, it is also a key leap to realize the network from the access pipeline to the intelligent platform of information service.Compared with 4G networks, deploying high-speed 5G networks at the trackside can achieve high-speed transmission and extremely low latency, providing rail transit with a more accurate train safety protection envelope that is closer to the actual train location for train control accuracy.The high reliability and low latency of 5G can improve the operational efficiency of the overall rail transportation system.Smaller communication latency can improve the control accuracy and load level of trains to a greater extent, and improve the safety and scheduling capability of train operation.

mMTC is the third wave of 5G applications, mainly oriented to IoT application scenarios with sensing and data collection as the theme.Among them, NB-IoT and eMTC are oriented to 5G mMTC scenarios, which are the basis of the future towards 5G IoT. 3GPP has taken the subsequent evolution of NB-IoT and eMTC as the technology of 5G mMTC [9].In rail transit, 5G bearer network has the features of high precision synchronization, multi-connection channels, low power consumption and low cost, easy deployment. Building rail transit 5G information IoT network can realize wireless data collection in application environments such as on-board, trackside and road base, and assist rail transit in operation and maintenance.In the 5G era, the scale of rail transportation assets and equipment is huge, and the passenger flow of metro in major cities has exploded and the structure has become more and more complex.mMTC can perfectly solve the data collection scenarios under different complex management scenarios.With the support of 5G high-speed communication network of rail transit, mMTC integrates various professional operation and management, collects and mines the data gathered in the platform, and better realizes intelligent service, intelligent operation and maintenance, intelligent vehicles and other intelligent service platforms based on IOT.

The three characteristics of 5G low latency, large broadband and large connectivity will significantly improve the quality and efficiency of rail transportation communication.Based on the metro's 4G network, the operator's 5G slicing network is adopted.Through 5G base stations set up at the trackside, 5G inter-area coverage as well as vehicle section coverage is realized.The operator's 5G core network is accessed through the operator's transmission network to build a vehicle-to-ground high-speed wireless channel.In rail transit, different networks can be set up in different areas, with statistical access to the central core network, and access units through the vehicle network to achieve communication between vehicles and the ground.Use MEC(Mobile Edge Computing) technology for big data analysis [10], video analysis, multimedia services, etc.Through 5G backhaul network access to the core network, it can realize onboard video monitoring, PIS, contact network monitoring, walking section, etc. to achieve high-speed real-time upload and download, safe and reliable transmission of train safety control information, and realize high-speed safe operation of rail transit.

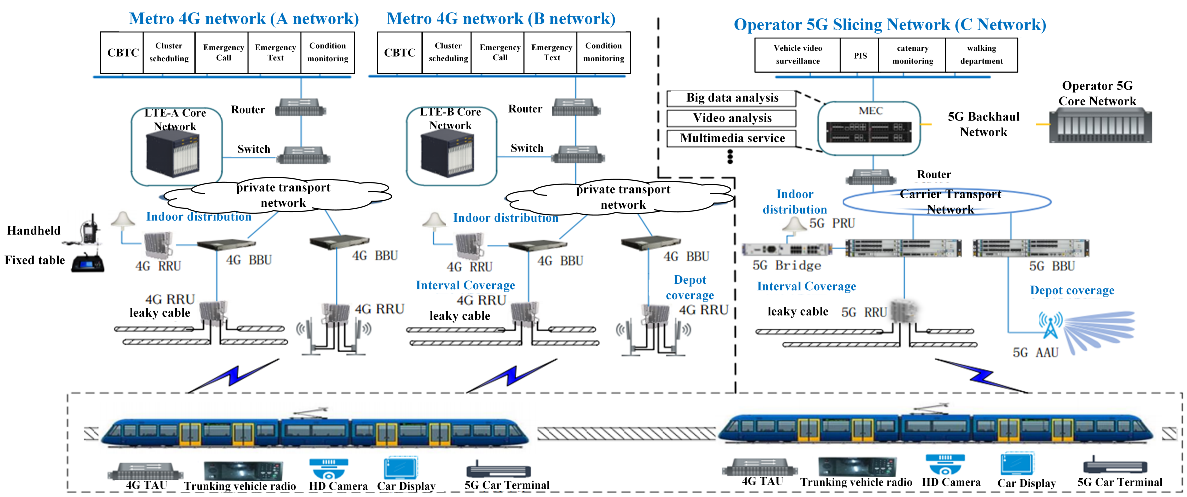

Figure 1: 5G in Rail Transit

3 Research Objective

3.1 Research on 5G network construction plan for urban rail transit

The rising urban rail transportation is developing towards more safety, reliability, comfort and convenience.Among them, the communication network system of urban rail transit carries the communication and transmission of a large amount of data such as transmission of train operation control information, system or equipment real-time monitoring information and passenger service information.This requires the mobile communication technology applied in urban rail transportation to further satisfy the new demands as well.Since the method of communication using satellite in railroad system is not fully applicable to urban rail transit in many underground areas, because the signal received when the train is running around underground is not always stable and timely, and may be discontinuous.Therefore, from WLAN technology to 3G communication to 4G communication, the wireless communication technology applied in urban rail transit has developed with the rapid development of wireless communication.Most of the current urban rail transit lines choose to use 4G communication technology.However, with the new breakthrough of 5G technology, 5G communication will be widely used in urban rail transit of major cities in the near future [11].

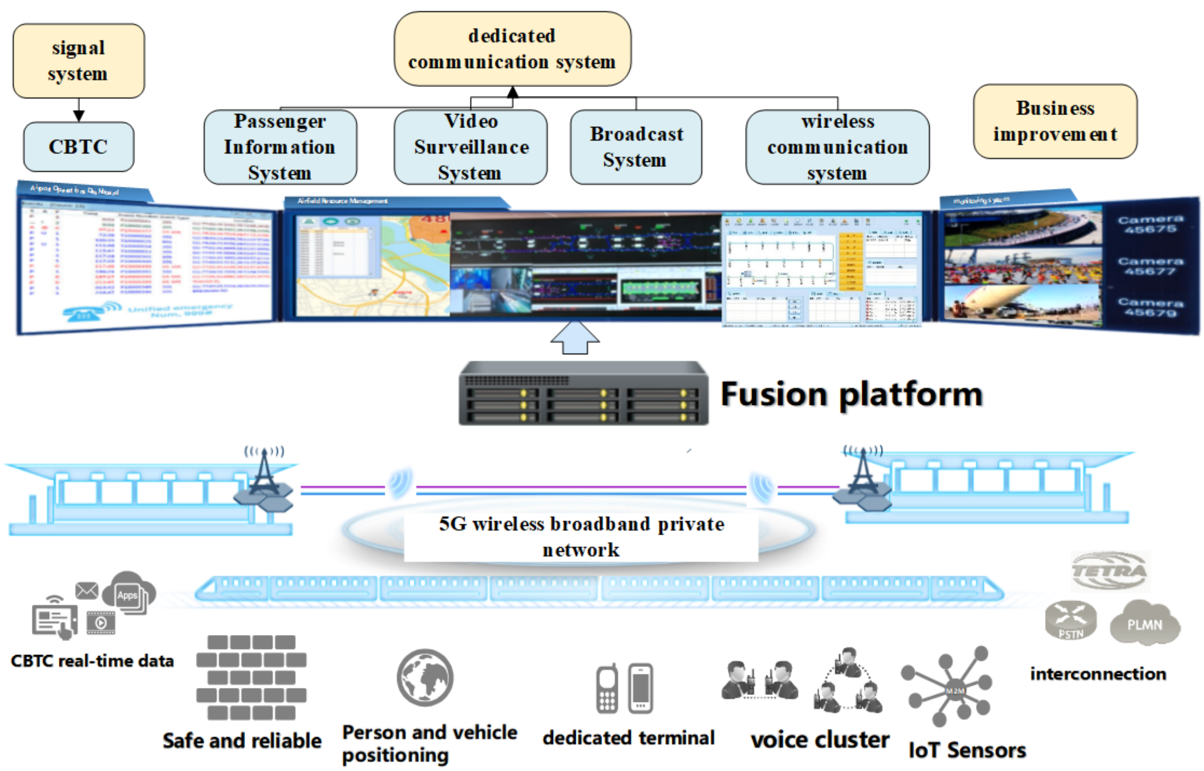

Figure 2: 5G network construction program

In transportation operations, it is not only necessary to scientifically apply the already developed and mature 4G communication and trunking system technologies, but also to make use of cutting-edge technological means such as 5G, big data analysis and artificial intelligence to improve the convenience and satisfaction of people's travel and reduce operation costs.Currently, in urban railroad transportation, the fourth generation mobile communication standard is able to achieve signal coverage in urban rail transportation.The 4G network with mature development is applied to transmit the column control and trunking services from the 4G terminals of the metro to the core network EPC (evolved packet core) through the 4G base stations (eNB).The 4G network is capable of fast data transmission with a speed of 100Mbps or more, which can fully satisfy the needs of the subway terminal for sending and receiving column control data and cluster services.The 5G communication technology has the advantage of high transmission bandwidth and is used to process video data with high speed and efficiency.The urban rail transit platform uses both 4G and 5G communication technologies to process different aspects of data to achieve fast, efficient, real-time, and accurate data combing effects [12].

This project designs a 5G network construction system along the development of modern urban rail transit based on the requirements of integrated information communication and services of modern urban rail transit system.This project proposes four different modes of urban rail transit 5G network construction, which are metro self-built 5G network, metro self-built 5G core network with shared operator base stations, deployment of local MEC using operator 5G network, and full use of operator 5G network.

(1)The subway builds its own 5G network. The 4G communication technology is applied to send the column control data and trunking service from the 4G metro terminal, through the base station eNB, to the core network EPC, and then from the core network to the rail transit service platform, completing the data transmission of column control and trunking service.On the other hand, the metro builds its own 5G network to send video streams from the 5G metro terminal to the core network 5GC via the base station GNB, and then from the core network to the rail transit service platform.

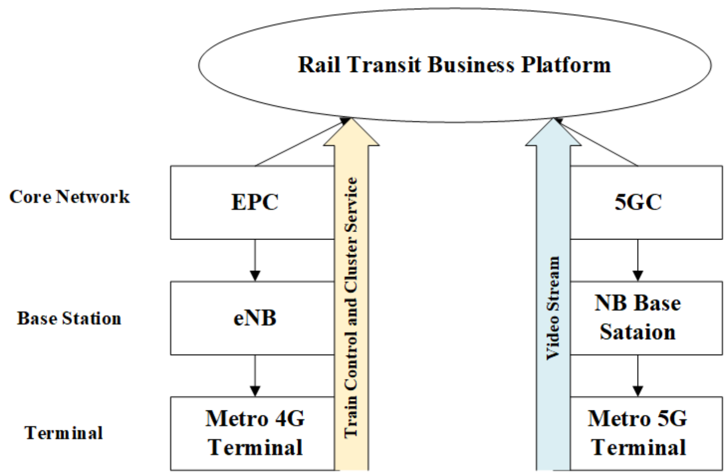

Figure 3: Mode1:Metro self-built 5G network

(2)The subway builds its own 5G core network and shares the operator's base station.The 4G communication technology is applied to send the column control data and clustering service from the 4G metro terminal to the core network EPC via the base station eNB, and then from the core network to the transmission rail transit service platform to complete the data transmission of column control and clustering service.On the other hand, the video stream information from 5G metro terminal is delivered to the operator's base station, which sifts the 5G metro terminal data and public 5G terminal data and then sends the required video information to the 5GC metro core network, which is then uploaded to the rail transit service platform.This solution shares the operator's base station and can eliminate the need for metro base station construction.

(3)Using the operator's 5G network, deploy local MEC to divert data.The 4G communication technology is applied to send the column control data and cluster services from the 4G metro terminal, through the base station eNB, to the core network EPC, and then from the core network to the rail transit service platform, completing the data transmission of column control and cluster services.On the other hand, the metro builds a multi-access edge computing network so that the video stream collected at the terminal is processed by MEC and then transmitted to the rail transit service platform.MEC can not only provide the arithmetic resources required for edge deployment services.At the same time, the arithmetic power can be flexibly scheduled according to the business needs.By deploying local MEC, this solution can shorten the end-to-end service latency to meet the application scenario of urban transportation that is super sensitive to latency; shorten the occupation of transmission resources by large-bandwidth services to improve network quality; safely and reliably deploy arithmetic power in the vicinity to reduce the risk

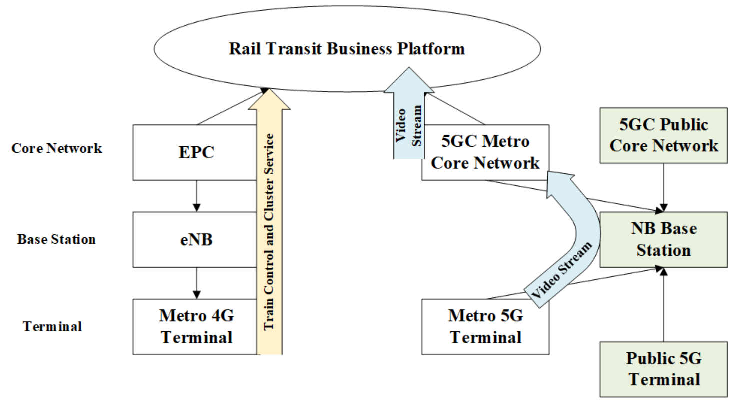

Figure 4: Mode2:Metro builds its own 5G core network and shares operator base stations

of network attacks on data during network transmission.

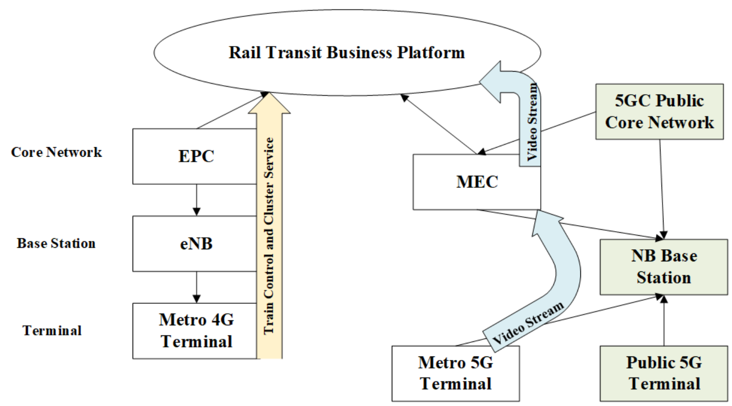

Figure 5: Mode3:Utilize the operator's 5G network to deploy local MEC to offload data

(4)Completely use the operator's 5G network.The 4G communication technology is applied to send the column control data and trunking service from the 4G metro terminal to the core network EPC through the base station eNB, and then from the core network to the rail transit service platform to complete the data transmission of column control and trunking service.On the other hand, the video streaming data from the 5G metro terminal is sent to the 5GC public network core network via the operator's NR base station and then uploaded to the rail transit service platform by fully utilizing the operator's 5G network.By fully utilizing the operator's 5G network, it can save costs by eliminating the need to build a metro 5G network or MEC.

3.2 Intelligent operation and maintenance and transmission scheme

3.2.1 Analysis of the current situation of O&M

With the vigorous development of Internet of Things, artificial intelligence, big data, cloud computing and other technologies, new technical means are provided for urban rail transit maintenance.Intelligent operation and maintenance refers to the use of advanced detection and monitoring, cloud computing, Internet of things, big data, artificial intelligence and other technical means to promote the intelligent upgrade of operation and maintenance mode and improve the ability of daily operation and maintenance and fault diagnosis of rail transit operation equipment.Intelligent operation and maintenance takes opera-

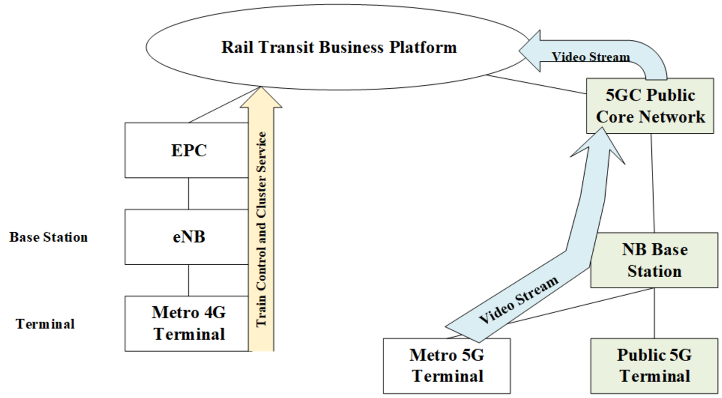

Figure 6: Mode4:Fully utilize the operator's 5G network

tion and maintenance business as the carrier, scene application as the core, and IOT, artificial intelligence, big data, cloud computing and other technical means as the basis.It provides a smarter, safer, more efficient and more economical urban rail transit intelligent operation and maintenance system, which is the development direction of digital transformation of rail transit operation and maintenance.

Based on the analysis of the current situation of urban rail transit operation and maintenance, this project combines technologies such as Internet of Things and cloud computing to propose the construction scheme of intelligent operation and maintenance collection and transmission system for urban rail transit in order to improve the reliability of rail transit equipment, optimize the maintenance mode, reduce labor intensity and improve the operation service level.

3.2.2 Traffic intelligent O&M collection and transportation method overall architecture

Urban rail transit is divided into signal system, communication system, vehicle system, power supply system, station facilities and equipment from the professional point of view.In the existing intelligent O&M system, each professional subsystem operates independently and the data is not yet interconnected.Based on the idea of comprehensive state awareness, interconnection, big data analysis and sharing, according to the demand of intelligent operation and maintenance management of urban rail transit, the existing and future new data sources are considered, and modern information technology means such as Internet of Things, artificial intelligence, big data and cloud computing are used to build the intelligent operation and maintenance system of urban rail transit, so as to realize the system mode of cross-professional data sharing, algorithm common and application interconnection. system mode.The intelligent operation and maintenance system of urban rail transit consists of four parts, which are basic sensing layer, data aggregation layer, intelligent analysis and business process.The overall architecture of the intelligent operation and maintenance collection and transportation method of urban rail transportation based on 5G network is shown in Figure 7.

(1) As the basic data collection layer of urban rail transit intelligent operation and maintenance system, the basic sensing layer is responsible for the information sensing of site environment and the status of underlying physical equipment.The basic sensing layer mainly collects data from three perspectives: vehicle, trackside and station.The objects of perception include mechanical characteristics, audio and video, information flow, electrical characteristics, etc.The information collection mainly includes facility and equipment objects such as vehicle system (vehicle gateway, bogie, pantograph, etc.), trackside system (signal, track, tunnel and other information), station system (power supply, lighting, wireless, etc.) and other specialized subsystems.The construction of the basic sensing layer can realize the unification of hardware collection equipment and collection data format, and reduce the cost of equipment

maintenance and spare parts management.It provides basic conditions for subsequent data analysis and information sharing.

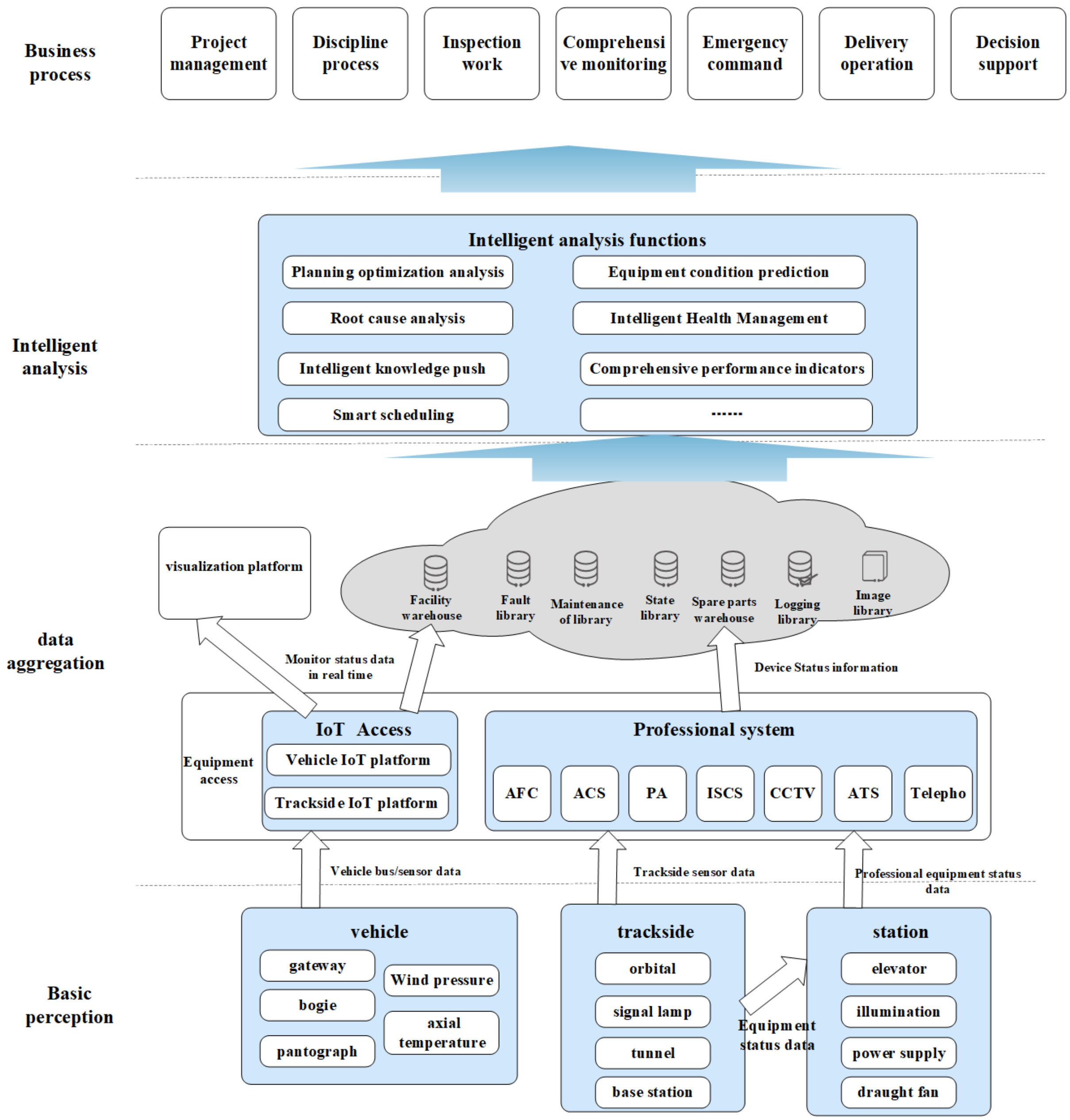

Figure 7: Overall architecture of intelligent operation and maintenance collection and transportation method for urban rail transportation based on 5G network

(2) The data aggregation layer is built on top of the basic sensing layer, based on modern information technology such as big data analysis and cloud platform, including two parts: device access and operation and maintenance big data.Equipment access is divided into IOT access and professional system access, receiving sensor data and professional equipment status data from the basic sensing layer.At the same time, the data is defined and stored in a unified format, and the cloud platform provides a convenient way to call for subsequent data analysis through the O&M data resource pool to achieve data interconnection

and information integration among systems.It effectively breaks the information silo and lays the foundation for using big data theory to mine information value.

(3) Intelligent analysis part, through the application of operation and maintenance algorithms to achieve the root cause of failure analysis of urban rail transit equipment, equipment status prediction, intelligent health management and other functions.It provides technical support for subsequent business applications and improves operation and maintenance efficiency.

(4) Following the concept of rail transit interconnection, the business process part is based on the intrinsic data and algorithm support to show the efficient information processing and service functions of the intelligent operation and maintenance system in the way of providing services.

3.2.3 Predictive O&M solution based on 5G network data

Based on big data analysis technology, it builds a smart high-speed O&M platform to realize accurate management of the whole life cycle.The intelligent O&M system for urban rail transit has the following functions:First, providing an integrated intelligent O&M management platform for intelligent transportation applications, capable of realizing real-time/offline assessment of equipment, facility health status and optimizing O&M plans.Second, constructing a trend prediction model based on collision, correlation and other mining analysis of historical data of inspection, monitoring, fault and maintenance.Third, based on sensor data collection, real-time/offline evaluation information and prediction information of equipment and facility health status, build a visualized operation and maintenance system based on status.Fourth, to provide various data, technology and knowledge support for O&M management through O&M think tank.It provides one-stop knowledge service for O&M business.Intelligent transportation O&M management platform can realize intelligent and refined management of all aspects of O&M work and improve O&M management level and service quality.

The visualized O&M system requires the system to display the real-time data received from each sub-module after cleaning and processing.Spark Streaming is a streaming processing system that performs high-throughput and fault-tolerant processing of real-time data streams.The data platform visualization and monitoring can use Spark Streaming to obtain real-time data of signal equipment from data sources.Advanced functions are used to perform complex data calculations and graphical calculations on the data, and output the results to display the real-time status of the equipment on the system.

Urban rail transit trend prediction is not only affected by time and space, but also interfered by various factors such as vehicles and environment, which has great suddenness and randomness.

The trend prediction model can realize the management of intelligent transportation O&M information, and the detailed functions include fault tracking, fault alarm, and equipment status evaluation, etc.The fault tracking module can analyze the correlation between the root cause of the fault and the phenomenon in the operation and maintenance of intelligent transportation equipment by mining and refining the collected data.Then build the probability distribution model of the root cause of the fault and the phenomenon, so as to infer the root cause of the fault.The module can be divided into three units, including a fault root cause tracing unit, an association probability matrix unit, and a fault warning unit.An object may contain many fault phenomena, and there may be faults of the same cause in multiple object fault chains corresponding to many fault phenomena.Combining these faults can form a fault probability matrix relationship to filter the large probability of accident faults.The constructed correlation probability matrix can build a fault probability model to realize the process of screening the original event.The fault warning unit can match the intelligent transportation business data, construct data warning indicators, and issue early warnings for abnormal data to prevent serious consequences.

3.3 Research on the scheme of high-definition video surveillance system based on 5G network

3.3.1 Analysis of the current situation of urban rail transit video surveillance

4G era data bandwidth initially to meet the needs of monitoring, raised to 1-5M, wireless surveillance has been faster development.However, lack of bandwidth, poor coverage, unstable network, high latency and expensive tariffs are still limiting the development of HD video wireless surveillance compared to wired networks.Compared to 4G network, 5G network capability is greatly improved mainly in three aspects: large bandwidth, large connection and low latency. And HD video surveillance system solution based on 5G network becomes possible.

The core of HD video surveillance lies in improving the computing performance and breaking the bottleneck of transmission and storage.Intelligent control of cameras should also be carried out to ensure fast and real-time transmission of video streaming signals [13].At the same time the overall system should use strict internal and external isolation to ensure security performance, 5G network slicing technology can achieve the security and isolation of the private network level [14].Also using edge computing methods, video processing data can be transmitted to the monitoring interface at the edge of the 5G communication network to meet the local storage function of the camera collection information under the base station.

3.3.2 Overall architecture of HD video surveillance system based on 5G network

The overall architecture of HD video surveillance system based on 5G network is schematically shown in Figure 8.

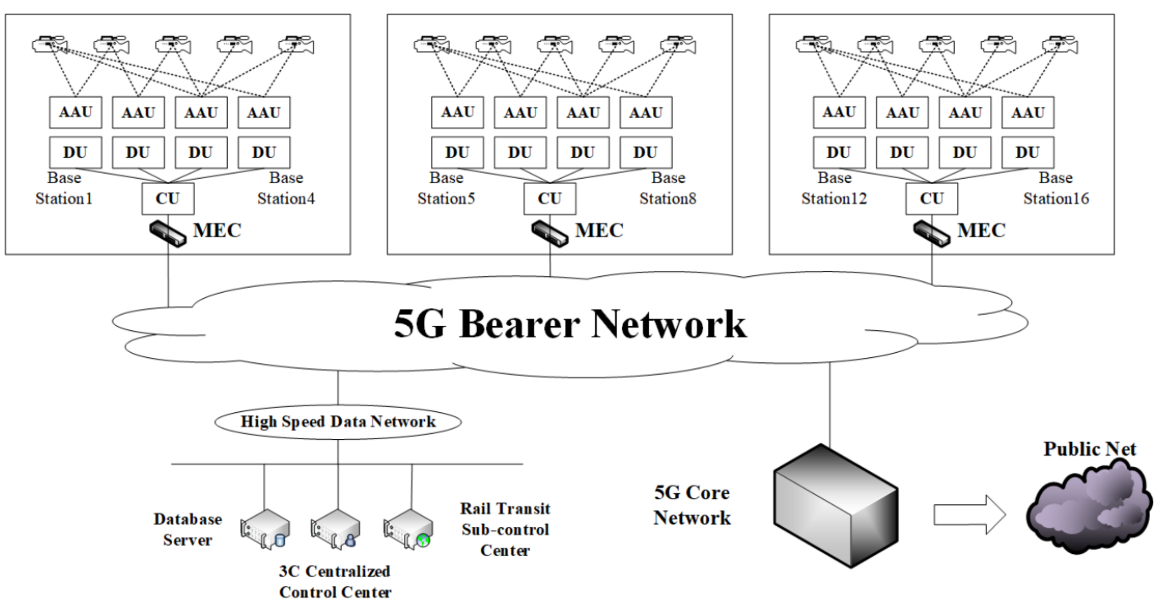

Figure 8: Schematic diagram of the overall architecture of HD video surveillance system based on 5G network

We divide the overall video surveillance system into three layers to carry out the architecture, from top to bottom are the monitoring and processing layer, 5G bearing layer and intelligent control layer.The monitoring and processing layer adopts distributed base station construction and 5G signal coverage in the region, using CU/DU two-level architecture, where CU is the centralized unit, base station attribute; DU is the distribution unit; AAU is the active antenna unit.

A regional processing center is established at the CU, while the MEC is deployed.Both of them can provide support for line operation and maintenance linkage management such as train control, in addition to fulfilling video monitoring needs.

The 5G bearer layer mainly provides connectivity services for the 5G network to meet the demands of ultra-large bandwidth and ultra-low latency.It bearer layer serves the three major application scenarios of 5G, with network slicing function, so that different scenarios or services have their own independent logical network [15].And to ensure simultaneous support for 4G, 5G, private lines and other integrated services to meet the requirements of the update iteration, while the introduction of SDN (software-defined network) for end-to-end flexible control and intelligent operation and maintenance operations.The intelligent control layer is responsible for connecting the monitoring system to the 5G communication bearer network, and the 5G communication network isolates the rail transit video monitoring service from the 5G public network service through network slicing.When the staff needs to retrieve the video surveillance, the HD camera can intercept the video according to the command issued by the video surveillance system of the intelligent control layer.At the meantime, the edge computing server cluster is built as the core local processing center, which can perform data analysis, detection and identification and other storage processing on the returned HD video, and at the same time, it can execute the monitoring strategy according to the upper layer requirements to achieve intelligent control.

3.3.3 HD video surveillance system solution based on 5G network

According to the different application scenarios of rail transportation, two different solutions of station HD video surveillance system and train HD video surveillance system are designed.

In the 5G signal coverage areas such as station halls, platforms, gates and escalators of urban rail transit underground stations, distributed base station solutions can be used for construction.Firstly, HD cameras are deployed in suitable areas and connected to 5G CPE [16]. 5G CPE can ensure the signal to carry out secondary relay and extend the coverage range.Its role is equivalent to a 5G industrial router.This can convert 5G network signals into WiFi signals for transmission on the one hand, and convert data received from WiFi networks into 5G network signals for upload on the other.At the same time, the edge computing server is deployed near the 5G base station for O&M linkage management support.The HD video signal is transmitted to the operation control center, duty room, vehicle control room and other video monitoring systems through the 5G communication bearer network to achieve high-speed video signal back transmission, and the station HD video monitoring system scheme is shown in Figure 9.

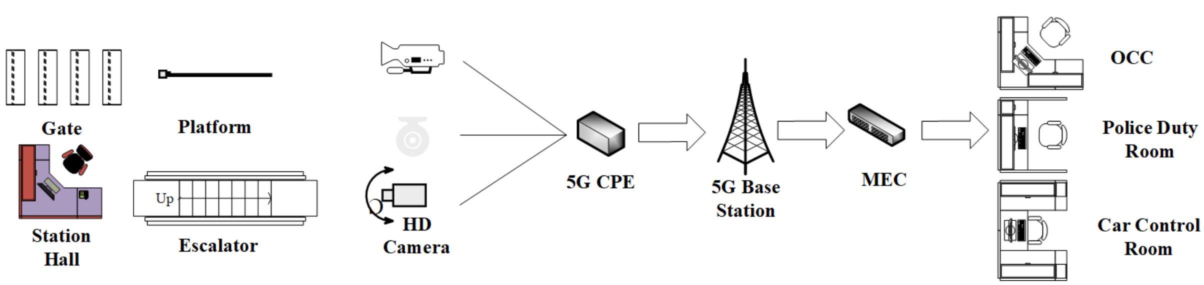

Figure 9: Station HD video surveillance system solution

Due to its fast mobility and continuous wide area, the train requires a high-speed 5G communication network to be deployed trackside.First, HD cameras and 5G TAU/CPE equipment for data access are deployed in carriages and cabins.The equipment needs to be able to carry data access services such as metro train control, video surveillance, and passenger information systems, and has to have high data bandwidth to ensure high reliability and low latency.5G base stations and edge computing servers are mainly deployed in carriages, trackside and roadbed environments to ensure reliable transmission of wireless data and video analysis.Then they upload video signals to the OCC hall and video monitoring workstations through a dedicated 5G transmission network using switches to achieve high speed return transmission of HD video as well as intelligent control, and the train HD video monitoring system scheme is shown in Figure 10.

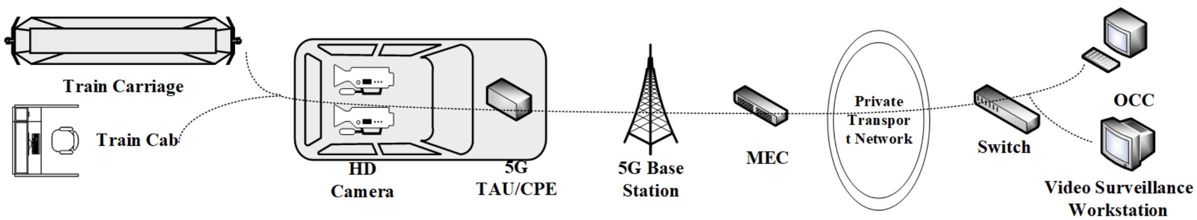

Figure 10: Train HD video surveillance system solution

Based on the study of HD video surveillance system solution based on 5G network, the overall network can be divided into three levels of structure:The head as a station/train video monitoring point, the middle as an operator 5G communication network, and the tail as a cluster monitoring point.This division is more conducive to daily operation and maintenance work, reducing potential failure points and improving the overall intelligent management of the monitoring system.The scalability is also greatly improved to meet the requirements of the growth in the number of video devices and the growth in bandwidth demand, as well as the rapid upgrade of the operator's service deployment to adapt to the development of future mMTC application scenarios.In besides, different capital investment can be made according to the scale of the station and operation and maintenance needs to achieve different degrees of monitoring intelligent functions.

3.4 Research on 5G-based urban rail transit information security technology

3.4.1 A unified security framework for rail transit 5G network scenarios

The main application of 5G communication technology in the field of urban rail transit is the vehicle-to-ground communication [17], which is used to enhance the communication between trains and the ground and realize the bidirectional data transmission between vehicle-to-ground communication.Stable and reliable communication technology can improve the safety of rail transit, enhance work efficiency, and improve the automation and intelligence of urban rail transit field.

In the 5G urban rail transit network, there exist a large number of terminals facing the industry or used to serve the public infrastructure of passengers, including various sensors, mobile terminals, HD cameras, professional facilities, etc.These terminals are huge in number, widely distributed, scattered in distribution areas, and relatively uncontrollable in hardware and software, which are prone to network intrusion and launching attacks on the system, and can cause significant losses to urban rail transit network and business.

However, although MEC deployed in stations, trains, and trackside in rail networks can greatly reduce service latency, it faces security threats.First, MEC is deployed in the access convergence point of operators, trackside facilities and other areas, and the physical environment is relatively weak in terms of security. It is vulnerable to physical attacks and network attacks, triggering cross-network penetration and infection invasion.Second, MEC's network and IT systems are prone to attacks causing network disruption and data theft.Third, the rail transit industry users' own networks and application systems in MEC are vulnerable to attacks and damage from external networks.

From the network level, the main threats faced are the following.(1) Access to the network in the air port user data eavesdropping or tampering, air port DDoS attacks, pseudo-base station malicious interference, and so on.(2) For 5G bearer network, being invaded and damaged will lead to extensive damage or interruption of business, while for almost all business traffic needs to warn the bearer network for transmission, its security isolation risk, the risk of eavesdropping on business data should also be included.(3)The core network system invasion damage and implantation of Trojan horse will also cause harm to the equipment system, and only need to breach the internal single network element can affect the entire core network protection security.

Combined with the 5G urban rail transit network architecture and security requirements, a unified security framework for rail transit 5G network scenarios is proposed, as shown in Fig.11.The unified security framework for rail transit 5G network scenarios includes data security, infrastructure security, O&M security, and application security technologies.The focus is on protecting infrastructure security.

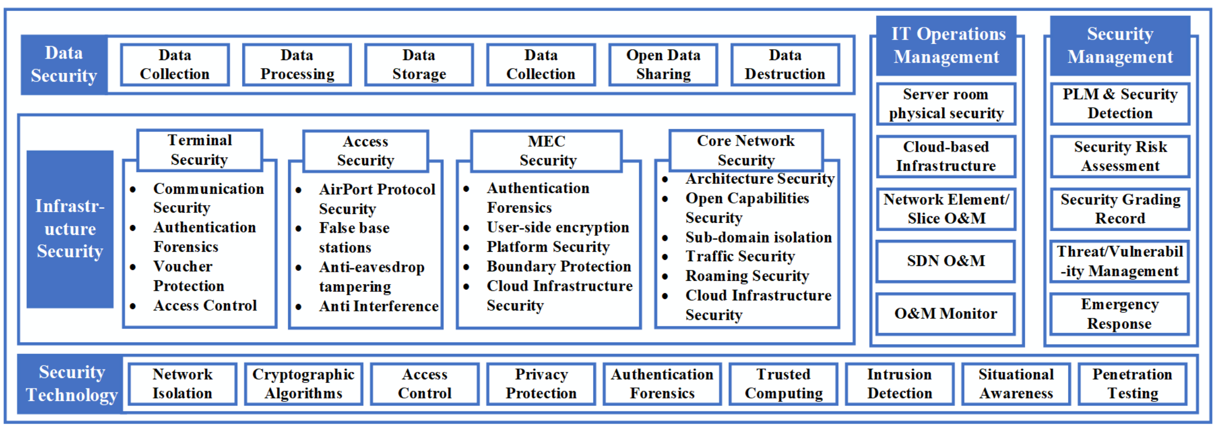

Figure 11: A unified security framework for rail transit 5G network scenarios

(1)For data security, in terms of data collection, the data should be well classified and managed.Sensitive data should be encrypted and detailed logs should be recorded for later auditing.In the data storage stage, differentiated security storage should be carried out according to the data level, and the access control and risk assessment of storage devices should be done.In terms of data processing, we should strengthen data classification and control and adhere to the principle of minimum distribution.In terms of data opening and sharing, the internal approval system should be strictly enforced and the security responsibilities borne by both sides of the shared data should be clarified.In terms of data destruction, different destruction systems and methods need to be implemented for various scenarios, and destruction measures need to be implemented as required.

(2)For infrastructure security, it is divided into four major parts, namely: terminal security, access security, MEC security and core network security.

In terminal security, access authentication of devices can be completed through authentication and key negotiation mechanisms to improve the security of the intervention process at one time.The improvement of terminal capability affects the user data confidentiality, integrity protection capability and the maximum data rate that the terminal can support [18].When establishing a secure dialogue with the terminal, the integrity and confidentiality of data are protected by encryption to the maximum extent possible.For sensitive data, encryption techniques such as Zuchon's algorithm or SM2 data signature algorithm can be used for encryption.Besides, access control should be done so that no one has the right to access the terminal unless authorized.

In access security, first of all, to determine the security of the air port protocol, due to the vulnerability of the 3GPP protocol itself may face the risk of identity impersonation, replay attacks, etc., which will have an impact on the authenticity of the terminal.terminal manufacturers will choose to turn off the option of encryption or integrity protection of user data to improve the quality of service and reduce latency, but this will lead to malicious tampering of user data.We have to turn on the identity mark and the encryption function of the air port packets to secure the air port protocol.And because pseudo base stations in the wireless environment can interfere with the wireless signal, resulting in degraded access to the terminal.

Furthermore, IoT devices with lower security will be attacked to launch DDoS attacks on the base station or core network, reducing the availability of network device functions.To choose to deploy DDoS detection defense system, deploy a unified pseudo base station detection system and spectrum interference detection system to prevent user data from being eavesdropped or tampered with.

In MEC security, the first thing is to ensure the security measures at the physical level to prevent MEC equipment from being physically damaged and causing losses.Secondly, to protect the boundary of MEC system, deploy boundary isolation measures such as firewall to prevent the invasion and damage of MEC by external network.It is also necessary to ensure the security of MEC cloud infrastructure, safeguard the security of applications, and secure interface calls by encrypting API communication interfaces and interface security authentication.At the same time, we should select encrypted storage for sensitive data of specific business and adopt encrypted transmission methods such as TLS/IPSec to prevent data leakage in the process of communication.

In the core network part, we have to carry out corresponding authorization according to the needs of operators to ensure that security and openness can coexist.Different encryption levels are set according to the confidentiality of services to achieve the protection of end-user data information, and different security control levels are also implemented for different network slices.The network security domain is segregated into domains, and the security division standard is clearly defined.Define the security level, and divide different security domains according to the functional attributes of network elements and the network requirements of users.In these the resources within the domain are integrated and allocated to ensure that the resources in different domains are not shared, and the data in the domain can be opened according to user needs.It is also necessary to ensure the traffic, cloud base settings and roaming security in the core network.

(3) For O&M security management, it mainly involves the protection and monitoring of the physical level.O&M system will generally be managed in a hierarchical manner, but low-level system deployment dispersion will lead to data storage dispersion, security and defense capabilities decline, which will cause the leakage or loss of business data.And, if there are security loopholes in the system, an attack will lead to the destruction of network functions.So it is necessary to ensure strict grading management, regular security testing of product life cycle, security risk assessment, good security grading filing, strict designation of threat and vulnerability management system, and ensure the normal work of emergency response filing.

3.4.2 Analysis of 5G terminal security service flow for urban rail transit

The 5G terminals of urban rail transit are characterized by low power consumption and limited computing and storage resources, making it difficult to deploy complex security policies.These vulnerabilities are exposed in the relatively open 5G network, which can easily serve as a source of DDoS attacks and form a large-scale botnet, causing network interruptions, paralysis and other security risks.For the hardware of the terminal, due to the diversity of 5G network support for the terminal, the security problems it faces are mostly vulnerabilities on the terminal chip and the lack of effective protection of system security, resulting in the risk of sensitive data being leaked and tampered with.For the software of the terminal, there is always the potential risk of attackers launching attacks through the terminal software system, causing security risks.

Dividing all terminal devices into three business streams for analysis.For personal SDP terminals, a zero-trust business flow is used for terminal access.For IOT smart terminals, 2B business flow is used.Some of them are passed into the edge cloud through local business streams, and all terminals are unified and controlled through the security console.

Unlike traditional authentication, zero-trust business flows treat all networks as untrustworthy, and all service access is subject to authentication and authorization encryption.The core lies in ”never trust, always verify”, providing the most controlled access to the network users within the smallest resource range.The biggest difference between 2B service flow and zero-trust service flow lies in the network slicing isolation of 5GC, and the core network needs to provide effective security isolation mechanism for user terminals and infrastructure terminals.When the terminal accesses the sliced network, the strictest and most sensitive dynamic authentication is performed for the zero-trust service flow, and the complete isolation from other slices is ensured.

For 2B service streams, a secondary authentication mechanism can ensure the security of terminal access.Different slices are set for different business flows and different confidentiality and integrity protection mechanisms are set to better secure terminal access.In the local business flow, mainly involving IOT intelligent terminals using MEC to upload to the edge cloud.The key is to ensure the secure connection between MEC and UPF(User Plane Function) [19], and the independent deployment of UPF.The priority should be deployed in the operator-controlled location with physical security environment guarantee.And do a good job in access control, identity and authentication operations to prevent privacy leakage, network paralysis and other security risks.The schematic diagram of 5G terminal security service flow for urban rail transit is shown in Figure 13.

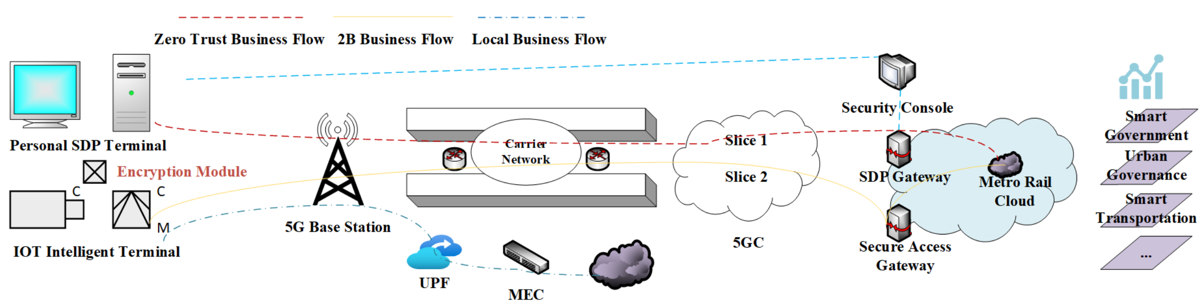

Figure 12: Schematic diagram of 5G terminal security service flow for urban rail transit

In terms of terminal access authentication, we can choose a variety of different authentication methods such as slice authentication, secondary authentication, and primary authentication to restrict specific terminals from accessing the metro rail 5G network.Using slicing authentication technology, the data between different slices can be isolated.Only authorized terminals can access the data in the slice, thus ensuring the security of terminal access [20].In the face of the demand for multiple access control of terminals, the main authentication authentication of 5G network is completed.The underlying authentication channel can be provided, and the authentication algorithm and protocol can be selected independently to achieve autonomous and controllable secondary authentication.In addition, it is necessary to carry out regional restrictions on access, for the core network and the bearer network whether to allow terminal access as well as to do a good job of network slicing to restrict access control.The subsequent access to the 5G network terminal to take zero trust mechanism to implement identity verification and restrictions, zero trust dynamic authentication, all-round ruling on the security level, to provide the smallest resource range of the most controllable access, to minimize the risk of network security.

4 Conclusion

5G network, as the underlying technology of new infrastructure, generates upgrading changes in information infrastructure.It also brings effective improvement for intelligent transformation of rail transportation, intelligent urban rail operation, service, and operation and maintenance.This paper studies the application and realization of 5G in rail transit from three major application scenarios of 5G network, which are urban rail transit 5G network construction, intelligent operation and maintenance, high-definition video monitoring, and information security, etc. It provides theoretical and systematic support for innovative applications such as fully automatic operation of rail transit, and applies the key technology of 5G to the intelligent operation, intelligent service and intelligent operation of rail transit. The application of 5G key technology to the intelligent operation, intelligent service and intelligent maintenance of rail transit will effectively save labor cost, improve efficiency and save economic expenditure.The research on 5G key technologies and applications in urban rail transit will enhance the independent innovation capability of rail consulting, maintain the advanced and forward-looking technology of rail consulting, and accelerate the transformation of scientific research achievements in the field of 5G and intelligent urban rail transit.Based on the "Development Outline of Smart City Rail for China's Urban Rail Transit", we will use digital technologies such as cloud computing, big data, 5G, block chain and network slicing to further improve system efficiency, reduce energy consumption and save costs, and build a new generation of Chinese style smart urban rail transit that is safe, convenient, efficient, green and economical.

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