OCT 2024 | VOL. 26 • NO.5 • ISSUE 214

ZTE TECHNOLOGIES

VIP Voice

ClaroVTR: Delivering a Differentiated Experience to Customers in Chile

Expert Views

Facilitating Digital Transformation of Railways with FRMCS

Special Topic

Future Railway Mobile Communication System (FRMCS)

Scan for mobile reading

Cover Figure | *Patricio Olivares de la Barra, CTO of ClaroVTR in Chile*

ZTE TECHNOLOGIES

OCT 2024 | VOL. 26 • NO. 5 • ISSUE 214

Sponsor: ZTE Corporation

Edited By Shenzhen Editorial Office
General Editor: Lin Xiaodong
Deputy General Editor: Huang Xinming
Editor-in-Chief: Liu Yang
Executive Editor-in-Chief: Yue Lihua
Special Topic Editors: Tang Xue, Hu Yunhua
Circulation Manager: Wang Pingping

Editorial Office

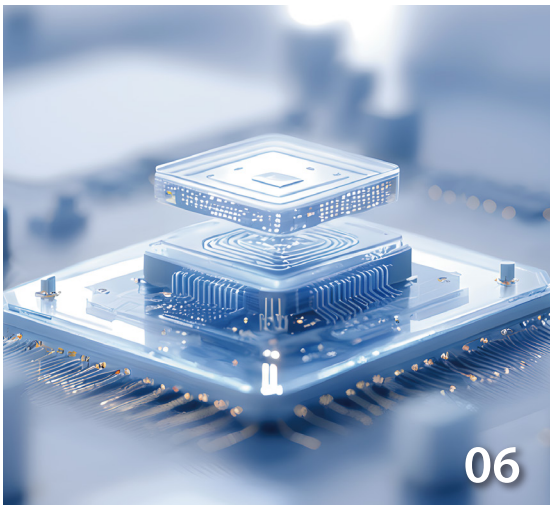
Address: NO. 55, Hi-tech Road South, Shenzhen, P.R. China
Postcode: 518075
Website: wwwen.zte.com.cn/en/about/publications
Email: yue.lihua@zte.com.cn

CONTENTS

VIP Voice

Expert Views

Special Topic: FRMCS



Success Story

Press Clipping

ClaroVTR

Delivering a Differentiated Experience to Customers in Chile

Reporter: Liu Yang

Patricio Olivares de la Barra

CTO of ClaroVTR in Chile

Chile, one of the longest countries in the world, is a leading economy and a growing technology hub in Latin America. It boasts one of the most mature and competitive telecom markets in the region. Patricio Olivares de la Barra, CTO of ClaroVTR, discussed their strategy to navigate the highly competitive and fast evolving market at MWC Shanghai 2024. He highlighted their solid fixed network performance post-merger and their plan for 5G deployment, emphasizing the company's commitment to providing the best network quality in both fixed and mobile sectors.

Based in Santiago, Chile, ClaroVTR offers a range of services, including mobile and fixed telephony, broadband internet, and television services. In October 2022, Liberty Latin America and América Móvil combined their Chilean operations—VTR, a leading provider of high-speed consumer fixed products with close to 3 million subscribers nationwide, and Claro Chile, one of Chile's leading telecommunications service providers with over 6.5 million mobile customers—to establish ClaroVTR.

The Chilean telecom market has witnessed strong growth in recent years. How would you assess ClaroVTR's transformation throughout the years?

Just as you said, Chile is one of the most competitive markets in the world. That's why it's really important to for people to understand what's happening in Chile. With a relatively small market size for operators—Chile has a population of 20 million people—we have to find ways to thrive. The only way, as we believe, lies in customer experience. That's why we were always looking to have the best technology to enhance customer experience.

I believe the assets of ClaroVTR have proven to be very good at the end, as we have achieved the lowest churn in the fixed sector. We continue growing our customers in the fixed sector, and achieved the top position in Chile at the end of last year. Therefore, the value of the assets of this merge was very good.

However, it's important to tell you, one week ago, América Móvil took control again of the company, acquiring a 91% stake of the company while Liberty holds the remaining 9% (Editor's note: the transaction is subject to obtaining the required approval from Chile's National Economic Prosecutor's Office). We achieved great success in terms of technology and the merger. Integrating the companies was not easy, but we have been doing it very well. Now, with América Móvil holding a majority stake in ClaroVTR, we believe we'll have a bright future ahead.

What are your plans to achieve fixed and mobile convergence (FMC)?

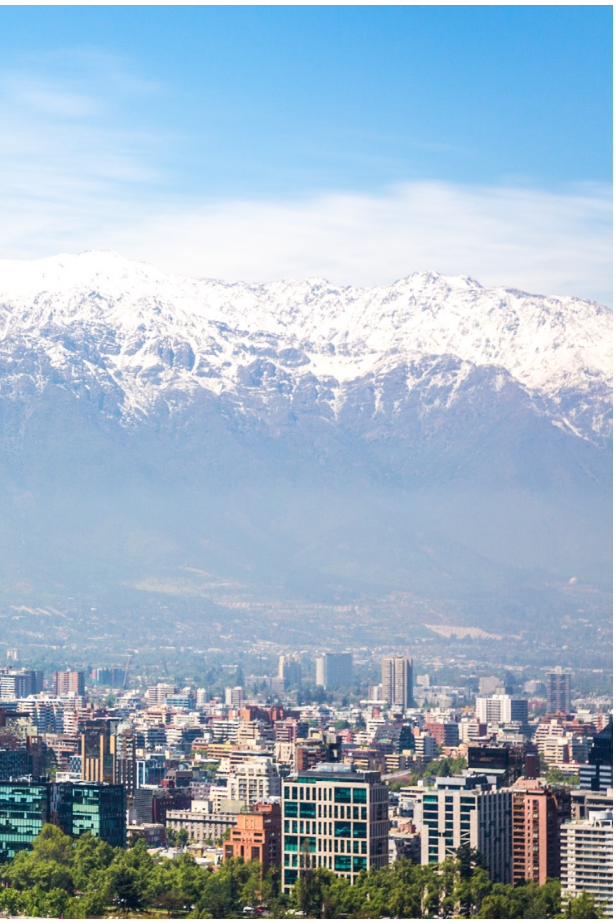
About a week ago, we won 50 MHz in 5G. This was very good news for our company. One of the reasons that I am here is because of that. We were actively pursuing the 50 MHz, and finally we won, so we are going to deploy 5G. We believe we are in the right moment to deploy it. And the network we are installing will adopt the latest technology.

What's your approach to implementing FMC?

The first thing is to create a core with very good quality. After creating a high-quality core, we can merge the fixed network with the mobile one for better reliability. We are working on putting some chips on the ONTs in the houses of the customers. When we have some issues with the fixed network, it can recover from the mobile network. This is the most important thing. All operators are trying to merge the mobile and the fixed network because, finally, there is one customer and we have to be available for the customers in their house and also in the city.

Chilean operators have lower EBITDA margins compared to neighboring countries such as Columbia. How challenging is it to be profitable in Chile, and what strategies do you have to enhance your profitability in the saturated Chilean market?

That's a good question. As you mentioned,



the EBITDA margin in Chile is the lowest in the world. Why is that? Because, as I said in the beginning, we face intense competition in the market. How can you compete with that? By offering decent prices. However, after many years, we know that customers request more services and more experiences. Then, it is time to give them a differentiated experience. That's the most important aspect. And we believe we are going to provide the best quality of the network in both the mobile and fixed sectors.

Our strategy is to keep the customers with us. While we gain new customers every month and the amount of new customers is very good, we need to reduce the churn. The only way to do this is to figure out why they are going down and address these issues. We are working very hard putting the customers at the center of the company. Everybody in the company is going to work for the customers, and the structure of the company is related to give the customers the best experience. That's the only way to survive. We are going to provide the best technology and best experience for them.

How do you enhance customer experience specifically?

We are working to provide all the capacity that customers needs. We give them more capacity, more availability and less latency. If we have a problem, we have to recover as soon as possible.

ClaroVTR have collaborated with ZTE in sectors like transport networks. How would you describe ZTE as a partner?

We have been working with ZTE in some places. It's an IP RAN that has some mix and ZTE is part of our network. This partnership has delivered very good results and high-quality services for our customers. We have supported each other as a team.

What are your aspirations for ClaroVTR's future trajectory, and what are your primary goals for the upcoming three years?

Our aim is to enhance our customers' connectivity experience and promote the digital development of Chile. In the upcoming years, we are going to deploy the best 5G network in Chile. We are going to provide the best fixed service with FTTH, which is our focus. Additionally, for the enterprise sector, we have the biggest data center in Chile, where we can give services such as data center security and many other things. ZTE TECHNOLOGIES

Facilitating Digital Transformation of Railways with FRMCS

Wang Wei

Chief Engineer of Railway Wireless Products, ZTE

Zhong Zhangdui

Director of the Institute of Modern Communications, Beijing Jiaotong University

Railway development has undergone three eras and two transformations: the steam engine railway, the electrified railway, and now the information railway. To embrace digital economy and promote high-quality railway development, the railway industry is actively exploring new ways of digital development, marking its third transformation, namely, digitalization. Since the 18th CPC National Congress, China has issued a series of policy documents to systematically promote the digital transformation of all industries. In February 2023, China rolled out a plan for the overall layout of the country's digital development, which provides direction and a basis for digital transformation and high-quality development of the railway industry. In September 2023, China State Railway Group (China Railway for short) released the "Digital Railway Plan", which serves as an important basis and action guide for digital railway construction. The plan emphasizes the need to strengthen the construction of private 5G networks and broadband wireless access capabilities at stations and yards, and to make every effort to promote the construction of the future railway mobile communication system (FRMCS).

On September 26, 2023, the Ministry of Industry and Information Technology approved the test frequency for China Railway's FRMCS system. This approval is a powerful driver for the digital transformation and high-quality development of the railway industry and is of great significance for promoting the upgrade and sustainable development of China's railway mobile communications technologies. Following the approval of the FRMCS test frequency, the railway mobile communication system will be fully tested,

verified, and applied on high-speed railways, plateau railways, alpine railways, and heavy-load railways. Through large-scale experiments and tests, world-leading comprehensive supporting systems and network equipment will be built.

By promoting the construction and application of the FRMCS system, railway communications are facing both new opportunities and various challenges. In terms of FRMCS system construction, China Railway proposes the overall development concepts of “Four Intelligences” and “Six Abilities”. The “Four Intelligences” refer to the development directions of intelligent network operation, intelligent resource management, intelligent system maintenance, and intelligent service applications. The “Six Abilities” refer to the development goals of an intelligent railway communication network that is visualizable, manageable, controllable, testable, reliable, and credible (see Fig. 1).

Among the development goals of the FRMCS system, being visualizable is the basis. Being manageable, controllable, and testable are the pathways, while being reliable and credible are the cores.

FRMCS Visualization

FRMCS visualization aims to establish a railway visualization platform, advancing from graph visualization to 3D, virtual reality, and digital twin visualization. Digital twin visualization is implemented by using technologies such as the Internet of things (IoT), full HD video, and virtual reality (VR)/augmented reality (AR). Network state visualization is achieved by using technologies such as artificial intelligence (AI) and big data, employing AR for remote decision making.

The FRMCS system provides visibility into network resources, network status, maintenance management, network performance, and network security. This visibility spans the entire lifecycle of FRMCS planning, construction, maintenance, optimization, and operation. The goal of FRMCS visualization is to make network construction more accurate, network operation more transparent, network maintenance more intelligent, network security better guaranteed, improving the overall FRMCS network experience and management level.

FRMCS Manageability

FRMCS manageability reconstructs the O&M management processes and modes for the railway communication network, enhancing the safety management and control capabilities across the entire process and network, thereby achieving automation, intelligence, and integration of management methods and modes.

As a new generation of railway mobile communication system, FRMCS develops its network management system architecture towards large capacity, centralization, intelligence, and openness, while still meeting traditional management capabilities. The FRMCS "manageable” application system architecture is shown in Fig. 2, comprising four layers: manageable applications, manageable capabilities, manageable technologies, and manageable objects.

A “manageable” application is a specific application platform or NF management system. A FRMCS network’s manageable application includes both the existing internal part of the system and the extended or incremental part. The internal manageability of the system includes resource manageability, operation manageability, quality manageability, and security manageability. The extended part mainly refers to the manageability of system services.

Fig. 1. Development goals of an intelligent railway communication network.

FRMCS Controllability

FRMCS controllability mainly includes independent control over core technologies, the supply chain, security, and the network. It aims to achieve independent control over software, hardware, instruments, meters, and chips, integrating advantages to build an independent and controllable industry chain while overcoming technical barriers.

Core technologies that are independently controllable include chip design, embedded software R&D, cloud platform R&D, equipment redundancy solutions, and reliability solutions.

Supply chain controllability refers to ensuring the security of downstream industry ecosystems related to production materials and suppliers. It involves avoiding risks associated with single suppliers, implementing security management for material products, and ensuring manufacturing security management by vendors. Key core components should have domestic options.

Security controllability involves the security of infrastructure, access, transmission, data, and O&M for the FRMCS network. Controllable technical requirements should be considered in end-to-end product design.

Network controllability includes coverage control, capacity control, and network service quality control. Coverage control involves using the wireless network planning technology, coverage enhancement technology, and multi-antenna technology to achieve full coverage of the targets along the railway line while avoiding issues such as overshooting and weak coverage. Capacity control means utilizing interference detection and coordination technology to improve the anti-interference capability of the equipment and avoid the interference within the FRMCS system, as well as between the FRMCS and other systems such as the ITU-T system and the Tiantong 1 satellite system. This improves the system capacity and ensures that capacity planning meets the requirements of railway users. QoS control means applying FRMCS 5QI technology to formulate QoS policies tailored to specific railway service requirements in terms of bandwidth, delay, and packet loss rates.

FRMCS Testability

FRMCS testability targets different network construction phases with various objectives, including software functions, hardware RF indicators, dynamic inspection and detection, and daily operation and maintenance. Sub-systems are tested

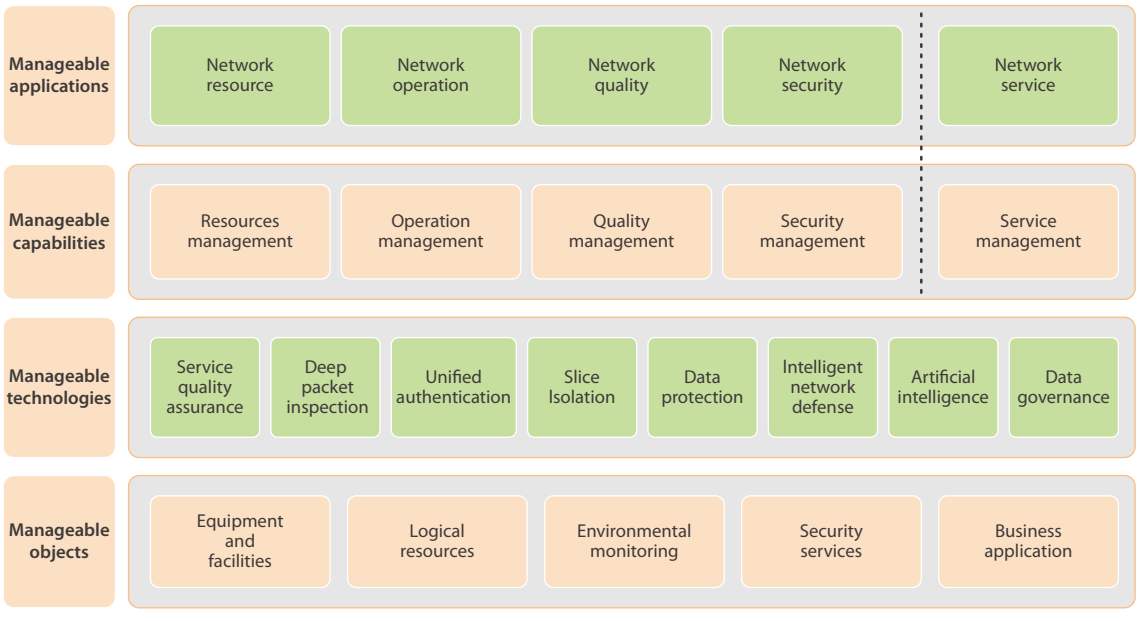
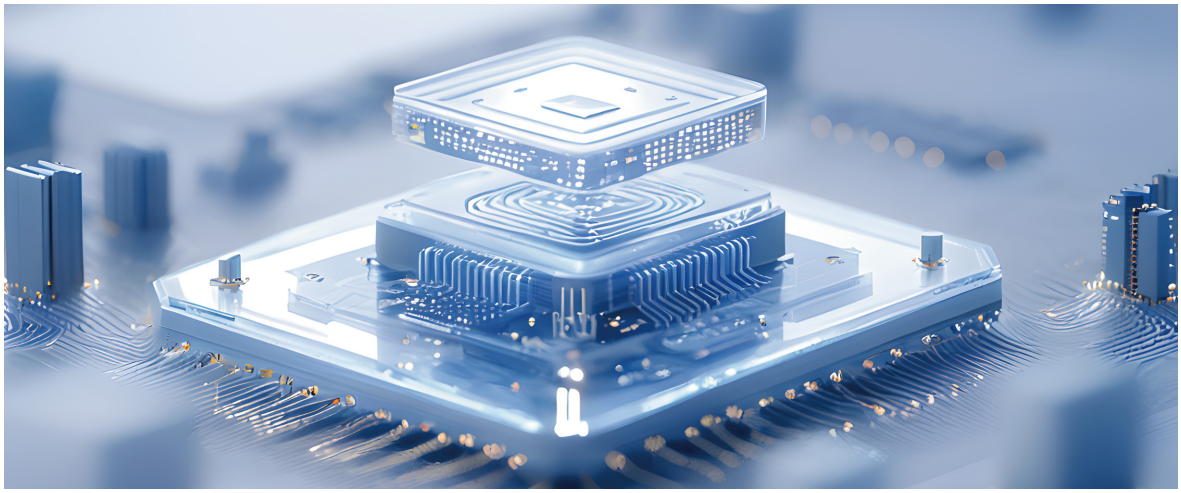


Fig. 2. FRMCS "manageable" application system architecture.



using terminals, base stations, and core networks as test objects, while field tests involve coverage, electromagnetic environment, interference, and drive tests as test objects. In addition, product security testing and independent security assessments are indispensable parts of testability.

- **Software function tests:** Perform both laboratory and field tests according to the functional requirements specified in the "Interim Technical Specifications for FRMCS System Base Station Equipment" to evaluate the extent to which railway equipment meets user requirements.
- **Hardware RF tests:** Analyze the baseband spectrum, receiving spectrum, passive intermodulation, VSWR position measurement, and carrier frequency spectrum of the base station to test whether the base station hardware meets the protocol consistency requirements.
- **Dynamic acceptance tests:** Conduct tests to determine whether network optimization meets expectations and whether the current network meets the application requirements by setting different speed levels during dynamic vehicle inspection.
- **Routine O&M tests:** Periodically test devices and networks in accordance with the O&M specifications of the communication center to evaluate their health.

FRMCS Reliability

The FRMCS reliability technology, which integrates FRMCS redundancy network architecture and software algorithms, improves the overall performance and reliability of the FRMCS system. Redundancy networking technologies include access control-level, device-level, RF module-level, and baseband board-level redundancy. Software algorithms include Doppler frequency offset compensation, super cell technology, and uplink joint reception technology.

FRMCS Credibility

FRMCS credibility involves using key technologies such as secure storage, secure boot, and secure version to build a trustworthy environment for wireless devices, and implements system hardening, transmission hardening, and account hardening to achieve product trustworthiness. Additionally, the need to pass 5G product security certification further enhances the product's trustworthiness level.

ZTE is a global leader in 5G networks and has been researching next-generation railway mobile communication systems for more than 10 years. As a major global supplier of GSM-R, ZTE strives to achieve the "Six Abilities" of the FRMCS railway system through managing and controlling the entire process of product design, planning, R&D, and production. In the era of digital transformation and intelligent railway communication network construction, ZTE has always been the most powerful partner for railway users. ZTE TECHNOLOGIES

GSM-R to FRMCS Evolution: A New Era for Railway Communications

Han Ying

Industry Planning Director, ZTE

Ma Wende

Wireless Product Manager, ZTE

The Intelligent railway, characterized by the deep integration of new-generation information technology with railways, is a crucial direction for the high-quality development of the railway industry. The railway-dedicated mobile communication system, as a vital component of the Intelligent railway technology system, is currently undergoing an intergenerational evolution from GSM-R to FRMCS. With the approval of FRMCS test frequencies and the comprehensive rollout of FRMCS tests, China's railway-dedicated mobile communication is entering the 5G era.

FRMCS Ushers in Rapid Development for Railway Construction

China's railway construction ranks among the world's leading levels, with rapid growth in high-speed railway mileage. According to the latest statistics from China Railway Corporation, by the end of 2023, China's total railway operating mileage had reached 159,000 kilometers, including 45,000 kilometers of high-speed railway.

In line with the "Outline of the Plan for Building a Powerful Transportation Country with Railways Taking the Lead in the New Era," by 2035, the nationwide railway operating mileage is expected to reach 200,000 kilometers, including 70,000 kilometers of high-speed railway. With an average annual construction of 3,500 kilometers, this will create a transportation network that covers cities with populations exceeding 200,000 and ensures high-speed railway accessibility for cities with populations

over 500,000, thus establishing China as a powerful transportation country.

Following the conventional practice of adopting new standards for newly constructed railways, the FRMCS dedicated communication network is set to develop rapidly alongside China's future railway construction. Since 2015, China has promoted FRMCS standard projects systematically. In 2020, the China Railway Corporation issued the "Implementation Opinions on Accelerating the Application and Development of 5G Technology in the Railway Industry" and the "Three-Year Action Plan for Scientific and Technological Research on the Application of 5G Technology in the Railway Industry." It also proposed to complete key technological research and develop major equipment for the railway 5G private network by 2023, conduct urgent business tests and trials in areas like safety and travel services, and establish major technical standards. This laid the foundation for the railway 5G private network's construction and application. With the three-year period now concluded, FRMCS is poised for rapid development.

Advantages of FRMCS Development

As the nerve center of the railway transportation system, railway communication is crucial for ensuring safety and efficiency. Since the introduction of GSM-R technology in the 1990s, railway communication has entered the digital era, providing a solid foundation for railway transportation. However, the rapid development of high-speed railways and the widespread application of cutting-edge technologies such as the Internet of things, big data, and cloud computing have highlighted the limitations of the GSM-R system. Its shortcomings in data transmission rates, network coverage, and device compatibility have made it inadequate for meeting the demands of modern railway communication.

Against this backdrop, the FRMCS technology has emerged, leveraging the advantages of 5G, such as high-speed data transmission, low-latency communication, and the capability to connect massive devices. FRMCS not only provides more stable and efficient communication services but also supports diverse service applications like autonomous driving, remote control, and intelligent scheduling. This significantly enhances the performance of railway communication networks and provides robust technical support for intelligent and automated development of railway transportation.

From a technical maturity perspective, China has achieved remarkable milestones in 5G, with mature and reliable products. By the end of 2023, China had built the world's largest 5G network, with 3.377 million 5G base stations, serving 805 million 5G users and shipping over 810 million 5G terminals. Module prices have dropped to the hundred-yuan level. In the industrial applications, 5G has penetrated 71 major economic sectors, with over 29,000 virtual private networks, more than 240 industrial Internet platforms, and over 89 million industrial devices connected to 5G networks. Leveraging its substantial progress in 5G development, China is well-positioned to advance the digital transformation of the railway industry. 5G will provide faster and more reliable wireless communication, enhance railway operations and management, and drive modernization and intelligent development in the railway sector.

The transition from GSM-R to FRMCS in railway communication networks represents both an upgrade of existing services and an introduction of new ones, such as multimedia and video communication. Technically, FRMCS outperforms GSM-R in bandwidth, uplink and downlink speeds, system latency, and security performance. Leveraging 5G technology, FRMCS offers up to 20 times the capacity and reliability of of GSM-R, enabling interconnectivity among intelligent devices like trains and signaling equipment. The FRMCS voice dispatching system, a broadband communication system based on IP switching technology, can drive upgrades in dispatching technology and enhance system reliability. Additionally, FRMCS supports network slicing and edge computing, ensuring quality of service for critical railway functions. The "5G" capabilities of

FRMCS will also introduce new scenarios and applications, advancing railway informatization.

Future Technological Evolution

The three visions of 5G are enhanced mobile broadband (eMBB), massive machine type communications (mMTC), and ultra-reliable low latency communications (URLLC). Currently, 5G supports gigabit speeds and billions of connections. Looking ahead, it will evolve into 5G-Advanced, which aims to deliver terabit speeds and trillions of connections. This advancement will fulfill the three core 5G visions.

5G-Advanced will support key technologies for industrial digital upgrades across six areas: terabit experience, integrated sensing and communication (ISAC), trillion-level IoT, deterministic networking, built-in intelligence, and space-air-ground integration. These technologies will facilitate the 3D and cloud-based transformation of the internet industry, intelligent interconnection of everything, integration of communication and sensing, and flexible intelligent manufacturing. Applying these advancements to railway communication networks will drive the intelligent development of FRMCS (Fig. 1).

Millimeter Wave

In hotspot areas such as high-speed railway hubs, where communication coverage and capacity are critical, traditional networks are limited. However, leveraging millimeter waves with their large bandwidth and low latency can significantly enhance user experience in these areas, offering the most robust air interface data channel with downlink speeds of 25 Gbps and uplink speeds of 16 Gbps.

Millimeter wave technology can excel in railway vehicle-to-ground data transfer and storage. The millimeter wave-based high-speed vehicle-to-ground data transfer and storage solution establishes an ultra-large bandwidth transmission channel between locomotives and ground data centers. This eliminates the need for manual data transfer after locomotives enter depots, supporting efficient locomotive data transmission and intelligent operation and maintenance. By deploying millimeter wave base stations at stations and depots, the solution

Fig. 1. Evolution to 5G-Advanced for railway communication networks.

> **The transition from GSM-R to FRMCS in railway communication networks upgrades existing services and introduces new features like multimedia and video communication. Technically, FRMCS outperforms GSM-R in bandwidth, speeds, latency, and security.**

enables ultra-high-speed uploading of onboard data to ground data centers. Through internal networks, video data analysts can remotely view, download, and analyze data online, significantly improving efficiency and reducing labor and time costs.

RedCap Terminals

Reduced capability (RedCap) terminals are designed to simplify terminal devices by reducing complexity, cost, and power consumption while extending their lifespan. This is achieved by decreasing bandwidth, reducing the number of transceiver antennas, lowering transmission rates, adjusting modulation schemes, and introducing half-duplex modes, all while meeting application requirements and performance standards. This approach facilitates the large-scale commercial adoption of 5G networks.

Along railway lines, the communication needs of infrastructure are also significant. In the era of the Internet of everything, enhancing safety requires real-time monitoring of infrastructure, including electrical and engineering facilities. In recent years, natural disasters like floods and landslides have been more frequent along railway lines. To monitor these events, railway authorities have deployed numerous IoT monitoring nodes, which require extensive connections and high-speed video transmission. 5G RedCap is well-suited for this scenario, enabling rapid and cost-effective comprehensive monitoring.

ISAC Base Station

To ensure the safe operation of high-speed rail, it is crucial to prevent unauthorized personnel and objects from entering the railway track area. Efficient monitoring and protective measures are necessary for high-speed rail security. An electronic fence created with a wireless base station that integrates sensing and communication capabilities can monitor train tracks in real time and prevent unauthorized access, including illegal entry by drones. Currently, the ISAC technology has been validated for low-altitude drone monitoring and vehicle-road coordination, with commercial deployment on the horizon.

As travel needs grow, the importance of railway transportation becomes increasingly prominent. The evolution from GSM-R to FRMCS is specifically designed to address the market's demand for more efficient, safer, and more Intelligent railway communication systems. With ongoing technological advancements and socio-economic development, we can expect future railway communication systems to be even more advanced and intelligent, providing greater convenience and safety for railway operations. ZTE TECHNOLOGIES

ZTE FRMCS: Empowering Railway Digitalization

Chen Qiang

General Manager of Railway Mobile Network, ZTE

Hu Yunhua

Director of Railway Mobile Network Solutions, ZTE

Being a GSM-R provider, ZTE plays an important role in the future railway mobile communication system (FRMCS). Proactively addressing the supply chain vulnerabilities stemming from the phasing out of 2G technology, ZTE embarked on FRMCS research around 2014 and launched the LTE-R system in 2016. Focused on the enduring evolution potential of railway communication systems and requirements from China Railway and International Union of Railways (UIC), ZTE transitioned towards 5G-R standard research and system development back in 2000.

5G-R, or FRMCS, is not only the successor to GSM-R but also serves as crucial infrastructure and key technological equipment for railway digitalization and intelligence. It plays an essential role in supporting railway operations, ensuring train safety, improving transportation efficiency, and elevating maintenance standards.

ZTE has launched a series of customized 5G-R (hereinafter referred to as FRMCS) products for China Railway. The system supports railway customization solutions such as multi-level reliability solutions, ultracell networks, and intelligent O&M. It can cover all railway services and scenarios, providing secure, efficient, intelligent, and green FRMCS networks. This will improve railway operation safety, production efficiency, and service capabilities, and facilitate railway digitalization. Fig. 1 shows the ZTE FRMCS network architecture.

Customized Railway Products Enables Advanced and Efficient FRMCS Network

ZTE offers a series of railway-dedicated FRMCS products, including the BBU, RRU, and pRRU. These products are developed based on high-performance SOC and ASIC chips. The RRU features a high-efficiency power amplifier with the innovative Super-N architecture, achieving the lowest overall power consumption in the industry. The products meet the requirements for multi-layer redundancy, hot standby, and RRU ring networking. They are capable of operating stably in harsh environments such as low temperatures and high altitudes.

ZTE's distributed remote RF module R9018R is designed based on the latest ZTE RAN unified platform and supports eight transmit and eight receive channels (8T8R). The R9018R is a dedicated 2.1 GHz-band, 10 MHz bandwidth product customized for China Railway. It can effectively

reduce mutual interference with external systems. Advanced technologies such as Doherty, digital pre-distortion (DPD), and power tracking enable the amplifier to dynamically adjust the power supply voltage according to output power requirements, thereby improving amplifier efficiency and reducing total cost of ownership (TCO). The module is compact and lightweight, suitable for wall or pole mounting. Compared with 4T4R, the 8T8R RRU can significantly improve network coverage capability.

Moreover, installing 8T8R on towers can reduce feeder loss by 3 dB, increase the downlink rate at cell edges by around 27%, and boost the uplink rate by 80% to 100%. Compared with the under-tower solution, the on-tower solution can reduce the cable weight by around 90%. This reduction significantly decreases cable purchase and installation costs, as well as tower load and wind load requirements. Tower installation can also reduce the need for equipment room construction and cooling, thereby lowering air conditioning procurement costs and equipment room energy consumption, which supports green railway construction.

With a series of customized products, the ZTE FRMCS solution can meet the coverage requirements of railway main lines, tunnels, stations, dispatch centers, freight yards, and office buildings. It provides comprehensive coverage solutions for railway communications, achieves full network coverage, and reduces the difficulty and costs of railway wireless network management and O&M (Fig. 2). The deployment of the FRMCS network will greatly improve the intelligence of railway operation and maintenance. All GSM-R services and new broadband services will be carried over the FRMCS network to ensure modern railway operations such as multimedia dispatch communication, train video observation, natural disaster monitoring, and foreign object monitoring.

Multi-level Reliability Solution Ensures Service Continuity

As an important infrastructure for railway transportation, the wireless communication system is responsible for train control and scheduling tasks. ZTE provides a multi-level reliability solution to improve the reliability and security of FRMCS, addressing network, node, link,

board, and component levels to ensure the safe operation of railways.

Furthermore, ZTE FRMCS employs the 5G QoS identifier (5QI) technology for precise management of various service types, allowing railway operators to flexibly allocate network resources based on actual needs, ensuring high-priority handling of critical services. 5QI not only improves network resource utilization but also drives innovation and development in railway operations.

Multiple Patented Technologies Ensure Stable Signal Connection for High-Speed Trains

The high-speed moving trains pose challenges to the communication system, mainly including Doppler frequency shift and frequent signal switching. ZTE's Doppler frequency offset compensation algorithm supports more flexible and adaptive demodulation reference signal (DMRS). This patented technology can detect and compensate for Doppler frequency shifts generated during the high-speed movement of the UE, greatly improving radio link performance and supporting a maximum speed of 500 km/h. To address the signal switching issue, ZTE's proprietary ultracell technology can significantly reduce handover frequency and optimize mobile performance.

Intelligent O&M Solution Enhances Visibility, Manageability, and Control for FRMCS

The diversity of FRMCS application scenarios and services presents challenges to network O&M and service quality assurance. Leveraging intrinsic intelligence, ZTE's uSmartNet intelligent network solution achieves multi-scenario intelligence through intelligent computing integration, twin evolution, and intent-driven approaches. It is key to creating visualized, manageable, and controllable FRMCS networks, enhancing intelligence in maintenance and service applications, and facilitating the intelligent development of railway mobile communication networks.

Continuous Innovation Supports FRMCS Evolution

In response to the challenges and pain points in railway services, ZTE actively researches new technologies and solutions to facilitate intelligent, green, and efficient railway operations.

For the train-to-ground data dump service, ZTE is collaborating with railway research institutes to

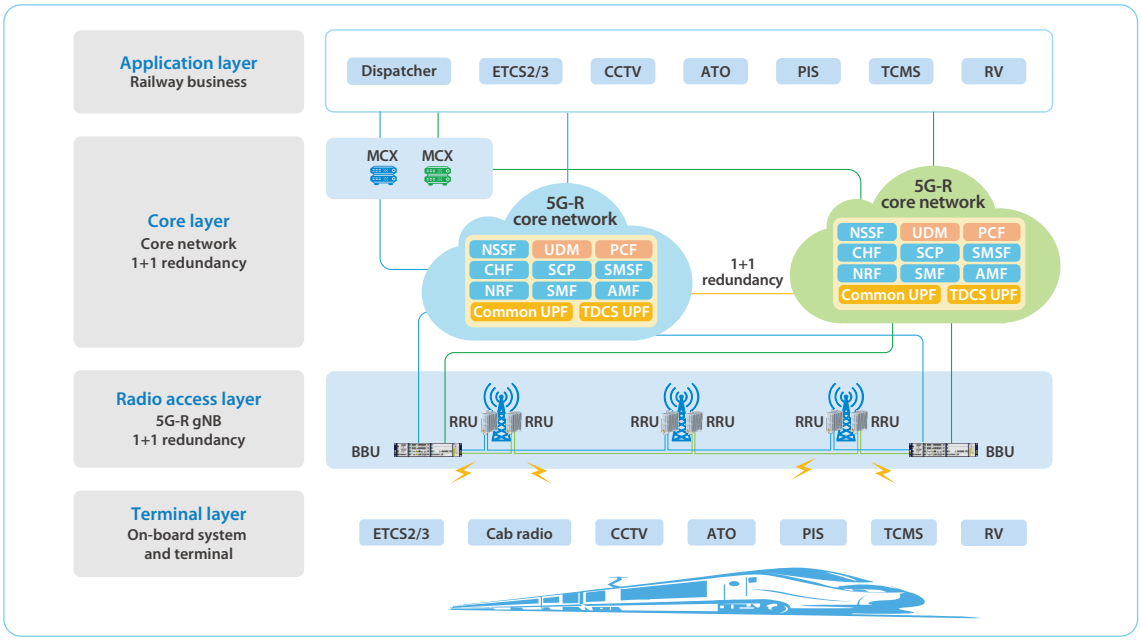


Fig. 1. ZTE FRMCS network architecture.

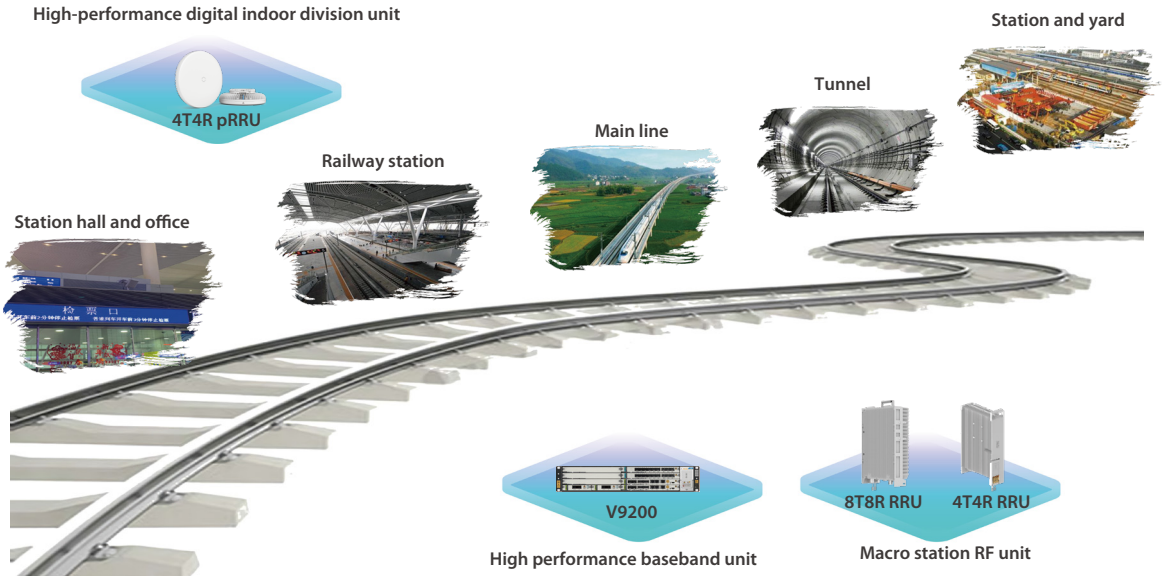


Fig. 2. Full scenario and service coverage of FRMCS.

explore the technology and application of millimeter waves for automatic data dumping. Millimeter waves offer ultra-large bandwidth, ultra-low latency, and strong anti-interference capabilities. 5G millimeter waves can be used for vehicle-to-ground data transmission, ensuring complete, secure, and efficient data dumps and enhancing operational efficiency.

In mission-critical communication services (MCx) for railways, there is a significant need for point-to-multipoint information transmission in train operation, management, and maintenance applications, where system transmission bandwidth can become a bottleneck. The 5G multicast and broadcast service (MBS) technology effectively addresses this challenge by allowing multiple application data streams to share a single set of transmission resources. Regarding data transmission in access networks, transport networks, and core networks, ZTE devices support not only point-to-point data transmission but also point-to-multipoint multicast data transmission, significantly saving backhaul network transmission bandwidth.

For monitoring railway equipment and the environment along the tracks, ZTE actively explores RedCap technology to enable real-time monitoring of railway infrastructure and the natural environment. This approach supports low-cost, comprehensive monitoring of railways to ensure safe train operations.

ZTE is a global GSM-R supplier, a key participant in China's railway FRMCS standards, and an active practitioner of FRMCS. The ZTE GSM-R system covers nearly 20,000 km of railway lines.

In China, as a key contributor to the development of 5G-R standards, ZTE actively participates in the drafting of the *General Technical Requirements for Railway 5G-R System* and the *Temporary Technical Specifications for Railway 5G-R System Base Station Equipment*. ZTE is also a core member of the 5G-R specification drafting team.

To further improve its R&D capabilities for the FRMCS technology, ZTE has established the FRMCS Innovation Center in the Xi'an R&D Institute. This center is dedicated to advancing FRMCS research, developing new services, and fostering future innovations.

ZTE will continue to uphold the principles of innovation, reliability, and efficiency to deliver the highest quality railway wireless products and services to the global railway industry. It will work closely with global railway partners to drive digital transformation and intelligent development in the railway industry, working towards a more intelligent, efficient, and sustainable future for railways. ZTE TECHNOLOGIES

ZTE 5G-R Core Network Drives High-Quality Development of Digital Railways

Zhang Fan

Chief Planning Engineer of ZTE Core Network Products

Jing Sheng

Director of ZTE Core Network Product Solutions

Since China officially launched commercial 5G services in 2019, 5G has penetrated all sectors of the economy and society, becoming a key infrastructure that supports their digital, network-based, and intelligent transformation. As a critical transportation infrastructure of the country, the railway has very stringent requirements on communications technologies. 5G for railway (5G-R) is a new-generation railway mobile communication system based on 5G technology. It features ultra-large bandwidth, ultra-low latency, and massive connections, promising to bring revolutionary changes to railway communication networks.

As the backbone of the 5G-R system, the 5G-R core network supports a variety of key services, including wireless scheduling communication, train operation control, train operation command, and operation and maintenance (O&M) information transmission. Focusing on the future intelligent railway communication and with the development goals of being "visible, manageable, controllable, measurable, reliable, and credible", building an autonomous and controllable high-quality 5G-R core network is crucial for the evolution of the new-generation railway mobile communication system.

5G-R Core Network Architecture

The 5G-R core network is divided into a two-level architecture: railway bureau equipment and shared equipment. The railway bureau core network equipment includes 5G core (5GC) equipment, mission critical (MC) equipment, DNS, RADIUS, and location service equipment (optional). The shared core network equipment includes 5G equipment identity register (5G-EIR), level-1 NRF, level-1 service communication proxy (SCP), level-1 DNS, and short message service center (SMSC). The dual data center (DC) disaster recovery and backup network architecture is used for both railway bureau devices and shared devices to ensure network reliability. For railway application services requiring large bandwidth or low latency, edge computing nodes can be deployed close to the service side.

The 5GC equipment complies with the 3GPP standards and uses the service based architecture (SBA), which includes network functions such as AMF, SMF/I-SMF, PCF, NRF, UDM, AUSF, NSSF, SMSF, UPF/I-UPF, CHF, and SCP.

ZTE 5G-R Core Network Products and Solutions

The ZTE 5G-R core network products align with the overall development objectives of intelligent railways and fully comply with the overall technical requirements of the 5G-R system in terms of architecture, function, and performance, as well as the interim technical conditions of 5GC equipment released by China State Railway Group. The ZTE 5G-R core network supports a two-level architecture for railway bureaus and bureau-shared equipment, inter-site dual-DC disaster recovery, on-demand distributed deployment of edge computing nodes, exposure of intelligent O&M capabilities, and offers

intrinsic security capabilities. It delivers 5G network support for data, voice, and video services of the new digital railways.

The ZTE 5G-R core network products introduce brand-new designs and innovative solutions in four areas: cloudified architecture, reliable disaster recovery, security and control, and intelligent O&M, providing new infrastructure for the future railway services and facilitating the upgrade and evolution of the railway wireless private network to a new-generation mobile communication system as shown in Fig. 1.

Cloudified Architecture

The ZTE 5G-R core network product adopts a mature NFV architecture and microservice-based component design, runs on a carrier-class dual-core cloud platform, and is deployed in a unified cloud resource pool. This setup provides an elastic and scalable virtualized network for the new-generation railway-dedicated communication system.

ZTE's virtualized NFs comply with the 3GPP Release 16 standards. Control plane NFs and user plane NFs can be deployed either separately or together. Control plane NFs related to signaling processing are deployed at railway bureaus in a centralized manner, providing high concurrent processing capability and continuous capacity expansion. User plane NFs related to railway applications can be deployed centrally at railway bureaus or at nearby railway edge data centers as needed, and they can provide high-bandwidth and low-latency network services for new railway applications through innovative software and hardware traffic acceleration technologies.

Reliable Disaster Recovery

Railways impose extremely high reliability and disaster recovery requirements on wireless private networks. The ZTE 5G-R core network equipment provides multi-level and multi-dimensional high-reliability technology innovations, ranging from hardware to software and from components to NFs, meeting long-term stable operation and disaster recovery requirements of railways.

- **High-reliability cloud resource pool:** The resource redundancy mechanism prevents services from being affected by software and hardware faults. The dual-network and dual-plane mechanism ensures reliable networking, while distributed storage provides multi-copy data security.
- **NF-level disaster recovery protection:** NF-level or device-level remote disaster recovery is implemented through the NF Pool or AMF sets. The

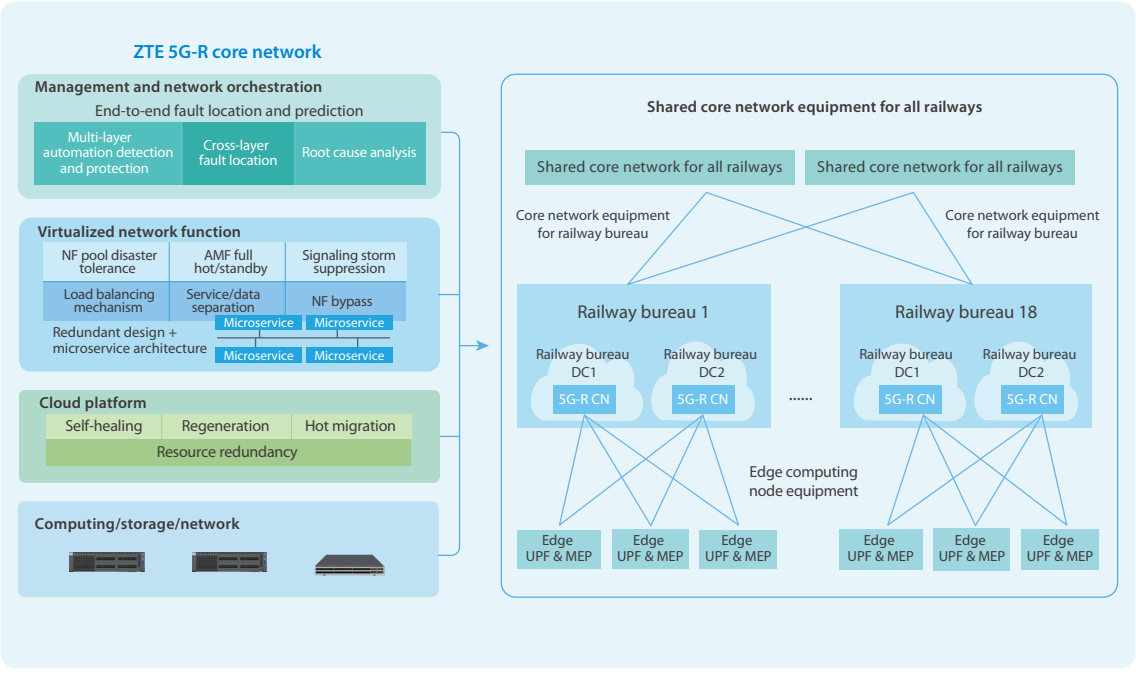


Fig. 1. ZTE 5G-R core network architecture.

signaling storm suppression function can withstand over 64 times the network signaling impact, and the NF bypass function provides service degradation and availability in extreme fault scenarios.

- For major changes in the core network, such as disaster recovery switchover and device version updates in the data center, automation pipelines and operation dashboards are introduced. This enables the automatic execution of operational steps in a navigational manner and monitoring of network operation via an easy-to-use large screen, reducing engineering operation risks and improving operation efficiency.

Secure and Controllable

To ensure the security of the railway communication system's supply chain, the ZTE 5G-R core network supports diversified and high-performance servers, and achieves independent control over key software and hardware, ensuring the long-term sustainable supply and maintenance of private network products.

ZTE is committed to providing a multi-layered and three-dimensional endogenous security protection solution. It provides differentiated security capabilities that can be extended and orchestrated at the infrastructure layer, network function layer, service data layer, and O&M management layer, thereby building a 5G-R core network with a high security level.

Intelligent O&M

The O&M of cloud resource pools is a critical and challenging aspect of cloud core network devices. ZTE provides powerful network orchestration and management functions to intelligently and uniformly monitor, configure, and scale core network resources, significantly reducing the O&M difficulty after the NFV is introduced and effectively improving O&M efficiency.

In fault scenarios, ZTE's core network equipment provides multi-dimensional intelligent O&M capabilities. By utilizing multi-layer fault detection and prediction methods (such as key performance indicators, alarms, and O&M kits), fault root cause analysis, and cross-layer fault linkage solutions, it assists railway O&M personnel in accurately locating and rapidly resolving faults.

Relying on the experience gained from large-scale commercial deployment of public 5G core network for Chinese operators, the ZTE 5G-R core network provides a one-stop commercial delivery process including network design, hardware installation, NF deployment, data configuration, security hardening and service testing. With the help of mature end-to-end delivery tools, the ZTE 5G-R core network achieves "zero potential risks and quality self-control" before the core network is provisioned, providing a full-process guarantee for the delivery of high-quality commercial networks to China State Railway Group.

Conclusion

As the world's leading provider of integrated communications and information solutions, ZTE provides core network products to more than 100 operators and over 500 industry customers worldwide, acquiring extensive and leading experience in large-scale commercial use of 5G networks. In the 5G-R market, ZTE actively participates in the formulation of 5G-R technical specifications and laboratory tests. Leveraging its profound technical accumulation and rich practical experience, ZTE accelerates the maturity of 5G-R technologies and continuously fosters the high-quality development of digital railways. ZTE TECHNOLOGIES

5G-R Reliability Solution Ensures Railway Digitalization

Liu Shi

5G-R System Engineer of ZTE

Yan Pengzhou

5G-R System Director of ZTE

Wang Lingbin

5G-R System Senior Expert of ZTE

With the development and popularization of 5G technologies, they are being extensively applied in various fields. In September 2023, the approval of the 5G for railway (5G-R) test frequency has garnered wide attention, indicating that railway communication is also entering the 5G era.

The services carried by the 5G-R system include high-speed railway dispatch, command, operation control, security monitoring, emergency handling, and automatic driving. Ensuring the system's reliability and security is paramount. ZTE has actively explored this area and proposed a comprehensive reliability solution (see Fig. 1). This solution incorporates a hardware redundancy and backup architecture. Leveraging various network innovation solutions, the network reliability is assured at multiple levels, including the network level, node level, link level, board level, and component level, thereby facilitating the safe operation of railway trains.

Network-Level Reliability Solution

ZTE's 5G-R core network meets the requirements for railway application scenarios and reliability, and provides a redundancy backup mechanism at multiple layers, including network-level disaster recovery backup, intra-device redundancy design, inter-NF redundancy design, and link-layer redundancy design, comprehensively guaranteeing the robustness and reliability of the 5G-R network.

For network deployment, the core network is structured around railway bureaus. Two sets of core networks are deployed for each railway bureau to form a remote dual-DC disaster recovery and backup network. Redundant NFs are deployed in separate DCs. When one DC or NF is faulty, the peer NF automatically switches over to recover services upon detecting the fault.

At the core network device level, ZTE's 5G-R core network employs an NFV cloud architecture design. Various types of VMs or containers that compose the NF use the active/standby or load sharing mechanisms and anti-affinity deployment. The core network is built on highly reliable cloud resource pools, and provides elastic scaling and redundancy of resources through the self-healing, regeneration, and migration capabilities of the virtualization platform.

At the NF layer of the core network, active/standby or load sharing mechanisms are in place, with NF faults rapidly detected through the dynamic registration and discovery mechanism of the network repository function (NRF). The core network provides an enhanced redundancy solution for access and mobility management function (AMF) sets and optimizes service recovery experience through a hot-standby redundancy mechanism between two AMF sets. The core network supports the NF bypass function. If multiple NFs in a remote dual-DC scenario are faulty simultaneously, basic services can be degraded and remain available.

At the link layer of the core network, each link of the core network employs dual-plane dual-network architecture. If any link fails, a backup link is available. When the N4 link between the control plane of the core network and the UPF encounters a fault, inertial operation ensures that

services in a connected state are not affected.

Node-Level Reliability Solution

The node provides both base band unit (BBU)-level and remote radio unit (RRU)-level backup solutions.

The BBU operates in hot standby mode, with the active and standby BBUs connected in a star or chain topology. Both BBUs are connected to multi-level RRUs via optical fibers and are deployed remotely along the railway or at the same site. Two RRUs are deployed at the same site. The RRUs are split first, and then connected side by side to achieve 10 MHz network coverage. After the dual-BBU system is activated, the RRUs establish a connection with the active BBU, which provides services. If the active BBU fails, the RRU switches over to the standby BBU via the optical interface, establishing a connection with the standby BBU, which provides services, minimizing service impact time to just seconds. When a single point of failure occurs on the RRU, the BBU ensures that services are maintained with only a reduction in service quality level.

In hot standby dual-active mode, two RRUs are deployed at the same site. After the RRU system starts normally, the two RRUs are split and then connected side by side to establish a hot standby dual-active configuration. Each 8T8R RRU is split into two 4T4R logical cells, and the baseband unit combines one 4T4R logical cell from each RRU into an 8T8R logical cell. This improves spectrum efficiency and supports large-capacity services. When one RRU device fails, services continue smoothly with only a reduction in quality, effectively combining spectrum efficiency and reliability.

The RRU devices support fast switchover in different single-point fault scenarios. They support fast switchover of optical ports in free-competition mode after the RRU devices are started, fast switchover of optical ports in forced mode that is determined and initiated by the BBU side, and directional switchover of optical ports in active-active mode if an RRU is faulty.

Board-Level Reliability Solution

For a single BBU shelf, the solution includes redundancy for the transmission main control board, baseband processing board, and power board to deal with potential board faults.

The transmission main control board operates in hot standby mode. When the main control board is functioning normally, the containers providing services are deployed on both the active and standby boards in a 1:1 ratio. It performs real-time backup of the public data, including the database, the private data stored on the service module, base

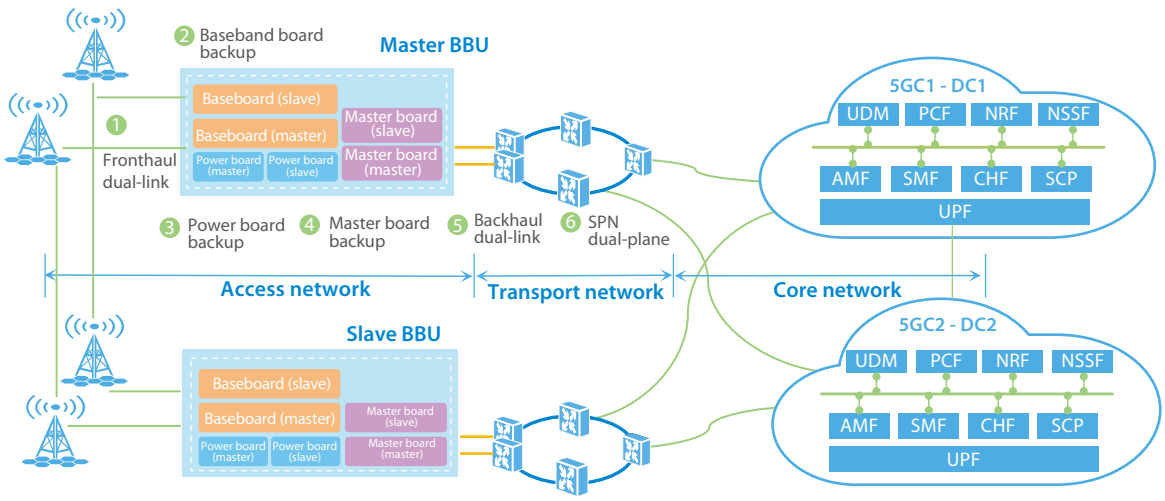


Fig. 1. ZTE 5G-R reliability solution.

station clocks, and communication data. Data consistency is audited periodically during operation to ensure that the backup data is timely and accurate. The combination of hardware interrupt signals and a software fast detection mechanism shortens the fault detection time, enhances the system's sensitivity to faults, and can identify faults at the second level and trigger a switchover.

When the system detects a fault and triggers the switchover of the main control board, the container of the standby board operates quickly. The service logic cell is neither deleted nor re-established, reducing service recovery time. Additionally, the baseband board and RRU device are not reset. The external clock, communication and data link are quickly switched over to the new active board, allowing services to be recovered within seconds.

Link-Level Reliability Solution

Links include fronthaul links between the BBU and the RRU, as well as backhaul links between the BBU and the bearer devices. The BBU and RRU are connected via optical fibers. The optical fiber link-level reliability solution mainly relies on the RRU ring network, which requires two pairs of optical fibers. When an optical fiber CPRI link bearing services is faulty, fast detection through the millisecond-level optical interface triggers the forward optical interface switchover, ensuring that services are not interrupted.

Transmission protection is implemented for the backhaul link between the BBU and the bearer devices. When a transmission link experiences an abnormality, the transmission protection mechanism is triggered through a millisecond-level fast detection mechanism, without triggering board switchover. This improves switchover performance while reducing the impact on services.

Component-Level Reliability Solution

Based on years of R&D experience in the industry, ZTE selects top-tier components and processing technologies and uses advanced chip technologies and high-quality materials in production, ensuring product stability while enhancing flame retardant and anti-corrosion properties. For the 5G-R scenario, a specialized reliability solution is developed and manufactured using a dedicated line in an automated factory. All-around intelligent testing and verification are performed to ensure product reliability and adaptability in various harsh installation and deployment scenarios.

With the widespread application of 5G technologies, the 5G industry chain has become increasingly mature, laying a solid foundation for upgrading railway private networks. Accelerating the technical research, promotion, and application of the 5G-R system in the railway industry will further enhance China's railway informatization and intelligence, advance China's railway innovation capability, and contribute to the global development of high-speed railways. ZTE will continue to innovate and work with China State Railway Group to safeguard railway operation security. ZTE TECHNOLOGIES

5G-R Security Solution: Safeguarding Network Security Standards

Zhang Song

Senior Engineer of ZTE Wireless Product Security Planning

GSM-R is a communication system optimized from GSM technology to meet railway requirements, specifically designed for railway private networks. It is widely used in Europe and China. However, with the growing demand for modern communication services, GSM-R is increasingly unable to meet the expanding needs of railway communication. As a result, 5G-R will gradually replace the GSM-R system, with network security becoming a critical cornerstone in the development and deployment of 5G-R.

To achieve its 5G-R development goals, ZTE is committed to maintaining network security and has developed a multi-layered, endogenous 5G-R security solution. ZTE's 5G-R product security solution provides both basic and enhanced security capabilities across various areas, including terminal security, air interface security, transmission security, core network security, O&M security, and infrastructure security, addressing different levels of security requirements. In addition, throughout the security design, R&D process control, delivery, and service phases, ZTE employs a range of security services, such as supply chain management, security tools, security assessments, security products, incident response, vulnerability management, and security laboratories, to ensure the security of 5G-R products throughout their lifecycle.

Complete Terminal Security to Establish a Comprehensive Management and Control System

There are many types of 5G-R network terminals in various forms, and their computing and security protection capabilities vary significantly, creating a weak link in 5G access security. The 5G-R terminal security solution addresses this by providing multiple authentication modes at the 5G network, slice, and service levels, allowing for flexible deployment according to the service security level. Additionally, it provides basic terminal access control through terminal-SIM binding and access location control. The solution also introduces a terminal security management and control platform that integrates various security functions, such as asset management, baseline security, trust management, and security hardening, to establish a comprehensive, defense-in-depth terminal security system.

Based on Standards to Strengthen Air Interface Protection

The radio air interface provides confidentiality and integrity protection based on 3GPP standards to safeguard the signaling and data security of railway services. The 5G network enhances security on the air interface, adds user-plane integrity protection solution, and implements subscription permanent identifier (SUPI) protection for key private data.

To address the risks of interference, DDOS, and pseudo base station attacks that can be easily initiated on the air interface, ZTE has developed an enhanced protection solution. This includes pseudo base station detection, air interface anti-DDOS attack, wireless anti-interference, and interference

detection capabilities to protect the air interface environment within the 5G-R coverage area.

Flexible Deployment to Ensure Transmission Security

In the wireless network architecture, the transport layer provides security protocols such as VLAN, IPsec, TLS, HTTPS, and SFTP, which establish the fundamental security protections for the 5G-R transport domain. These functions can be flexibly configured to meet the security requirements of different application scenarios.

To meet the requirements of various 5G-R service types, ZTE has developed two solutions based on basic transmission security functions: the transmission link backup solution and the physical isolation solution. The physical isolation solution provides refined security isolation for different services and allows for flexible customization of physical isolation channels, ensuring that service transmission channels with high security requirements remain free from interference.

Improving Border Protection to Build a Security Core

As a key infrastructure of the railway mobile communication system, the 5G-R core network enhances endogenous security protection and builds a secure, reliable software platform using a range of virtual machine (VM) platform security technologies. It offers slice isolation technology to ensure the independence of service resources and manages data resources in accordance with industry-standard security technologies to ensure data security.

As a core asset of 5G-R, core network devices require enhanced security protection. Additionally, deploying security devices such as firewalls, bastion hosts, and cloud WAFs can further strengthen border protection.

Horizontal Coordination in O&M to Expand Security Depth

In terms of O&M security, ZTE's security design focuses on confidentiality, integrity, and availability to protect the security of management channels and service data. The 5G-R network system is managed and controlled through access control, log auditing, version security, and data protection solutions. For more comprehensive security, the EMS integrates NE security baseline checks, with clear southbound security. In addition, the EMS can connect with the northbound 4A audit system, enabling dynamic log analysis through external capability linkage and enhancing the depth of security management.

Enhancing Infrastructure for Comprehensive Situational Awareness

In addition to enhancing the basic security of hardware, operating systems, and VM platforms, the infrastructure layer must include functions such as secure startup and secure storage for important 5G-R data and services. This forms a foundational protection solution for communication system facilities.

Looking ahead to 5G-R development objectives, we have taken into account the security situation awareness to implement an enhanced endogenous 5G-R security solution. This solution features unified management, active protection, and flexible deployment.

The 5G-R security solution not only provides security technologies for each module but also ensures the security of each link in network delivery. This is achieved through a comprehensive approach that includes the security supply chain, security assessment, vulnerability management, and incident response, covering the entire product design, R&D, and delivery lifecycle.

ZTE's 5G system products comply with both domestic and international communications security standards and have actively incorporated new network security technologies. With a focus on delivering secure networks, ZTE has supported China Railway Group in accelerating the deployment and application of 5G-R. ZTE TECHNOLOGIES

FRMCS Simplified Site Solution: Advancing Smart and Green Railway Development

He Xiwen

Chief Engineer of ZTE Wireless Product Operation

Qiu Xuemei

Wireless Site Deployment Solution Manager, ZTE

The approval of China's 5G railway test frequency has attracted global attention. 5G will be deeply integrated into the railway industry across various applications. Its high bandwidth, low latency and Internet of everything features can fully meet diverse requirements of railway scenarios and support digital and intelligent high-quality development of the railway industry. However, the high-frequency band and dense networking features of 5G pose great challenges to network coverage capability and engineering construction, often resulting in difficulties related to power supply, engineering, and land acquisition. Therefore, ZTE is actively exploring and launching the future railway mobile communication system (FRMCS) simplified site solution, designed to simplify infrastructure, engineering and site form for the rapid, reliable, and low-carbon deployment of FRMCS.

Simplified Infrastructure: Highly Integrated Design for Flexible Applications

For remote GSM-R sites, the power supply of site equipment typically involves an uninterruptible power supply (UPS) and an AC/DC conversion module. The power goes through AC-DC rectification, DC-AC inversion and AC-DC rectification processes, resulting in a power supply efficiency of no more than 80% for RRUs. In addition, the mainstream UPS has strict environmental requirements, with an operating temperature range of only 0°C to +40°C. Therefore, it cannot be directly used in unprotected outdoor environments and must be used with a protective cabinet and environmental control devices. Standby batteries are effective only when the mains power is interrupted, so in most cases, the entire site may experience a power outage or disconnection if the UPS fails.

For FRMCS, ZTE has launched a new integrated power supply solution that combines UPS functions with power rectification. It provides 220V AC and −48V DC outputs: the −48V DC output powers the FRMCS RRUs with up to 97% power supply efficiency, while the AC output powers low-power AC devices such as cameras. It has the following highlights:

- **Wide applications:** With an IP65 protection class and an operating temperature range of −40°C to +55°C, it supports a wide range of environments, including equipment rooms, tunnels and other indoor settings, as well as outdoor environments.
- **High reliability:** In the event of a mains supply failure or power supply issue, it automatically switches to standby batteries to ensure continued operation of RRUs and other devices.
- **Flexible installation:** It can be installed in a cabinet, on a wall, or on a pole.

Simplified Engineering: Reducing Construction Challenges for Improved Efficiency

In the GSM-R system, 2T2R RRUs are usually used and installed on the floor with only four feeder cables per tower, which makes the engineering simple. For the FRMCS system, 8T8R RRUs will be used, and if the

RRUs are still installed on the floor, there will be at least 18 feeder cables per tower at each site. A large number of feeder cables and many connectors will lead to high loss, complicated engineering, and a high fault rate.

To avoid these problems, installing FRMCS RRUs on the tower is a good solution. When the FRMCS RRUs are installed on the tower, the number of cables is reduced from 18 to 4, feeder loss is decreased, and the edge rate is increased. Combined with technical measures such as power line carriers, built-in lightning protectors, and armored cables, the approach reduces the complexity of network architecture, lowers engineering construction difficulties, and mitigates installation risks, making the deployment simple. According to test data, when FRMCS RRUs are installed on a tower, feeder loss can be reduced by over 3 dB, the downlink rate at the cell edge increases by about 27%, the uplink rate at the cell edge for a 200 mW signal increases by about 100%, and the uplink rate at the cell edge for a 2W signal increases by about 80%.

ZTE FRMCS RRUs incorporates power line carrier (PLC) technology to combine the RS485 signal and DC power lines into a single cable solution. With this single power cable, the RS485 signal is also transmitted, eliminating the need for a separate RS485 signal cable. Additionally, ZTE FRMCS RRUs use a multi-core optical fiber cable, which allows 18 feeder cables to be replaced by just two optical fiber cables. Compared with the floor-mounted installation solution, the tower-mounted installation solution reduces the number of cables by 80% and the weight of the cables by 90%.

Drawing on long-term operational experience with public-network RRUs, the ports of FRMCS RRUs—including the power supply and RF ports—come with built-in lightning arresters, eliminating the need for on-site lightning arresters. This design reduces installation time and ensures better lightning protection for the equipment. To better protect cables from damage by animals and further simplify engineering installation, armored cables are used, which exempts the need for flexible metal conduit protection and associated engineering. Two-ring fixing clamps are used to secure cables on the tower, simplifying the installation process. Waterproof RF jumpers are used, eliminating the need for on-site waterproof measures for the jumpers. These features can save approximately 120 minutes in engineering operations.

Simplified Site Form: Saving Space for Improved Energy Efficiency

The power supply, distribution, UPS, air conditioner, and other devices are placed separately in the railway equipment room, occupying more space and increasing deployment difficulty. Therefore, to save site space, reduce energy consumption and cut construction costs, ZTE has been committed to building simplified sites. For outdoor scenarios, ZTE has launched the all-on-pole site solution. This solution features a fan-free design, with the outdoor power supply and battery installed on the tower together with the RRUs, eliminating the need for cabinets and environmental control devices. This approach results in a 'zero-footprint' design, zero cooling energy consumption, and offers a simple, easy-to-install solution that is energy-efficient and reduces carbon emissions.

For indoor scenarios, ZTE has launched an integrated indoor cabinet solution. The power supply, distribution, UPS, battery, and other devices can all be placed in a cabinet with dimensions of 600 mm (width) × 600 mm (depth) × 2200 mm (height). The solution makes full use of cabinet space, reducing the space requirement for the equipment room and increasing the effective space by more than 50%.

As the new benchmark for next-generation railway systems, FRMCS will lead the global railway industry towards high-quality digital and intelligent development. ZTE will continue to explore and seek breakthroughs in FRMCS site construction by introducing intensive, modular, intelligent, and low-carbon technologies to ensure that the railway operates reliably, safely, efficiently, and sustainably. ZTE is committed to continuously contributing to the creation of a modern, smart, and green railway infrastructure. ZTE TECHNOLOGIES

mmWave Empowers High-Speed Rail with Intelligent Data Dumps

Chang Hong

Chief R&D Engineer for Wireless Planning, ZTE

Xu Dai

Chief R&D Engineer for Wireless Planning, ZTE

In China, high-speed rail has become the preferred mode of long-distance travel, with about 50 million people using the continuously expanding high-speed rail network every year. During train operations, a large amount of data is generated, including information on train scheduling, composition, and the status of locomotives and carriages. This data needs to be synchronized in real-time with the operation control center and railway locomotive maintenance facilities. The amount of data that each train needs to dump can reach several hundred gigabytes, or even up to terabytes. In the past, manual hard disk copy was the only option, which was inefficient and prone to data loss or leakage, posing security risks.

With the widespread use of high-definition cameras, the amount of inspection data is increasing, making the bottleneck in train-to-ground data dumping increasingly prominent. Millimeter wave (mmWave) technology, characterized by large bandwidth, low latency, and strong anti-interference, can reach speeds of up to 10 Gbps with a single CPE. By using 5G mmWave transmission equipment, high-speed wireless data transfer between the train and the ground can be achieved. This not only enables the automatic and efficient transfer of train data but also ensures the integrity and security of onboard data.

Based on a deep understanding of railway communication requirements and rich experience in millimeter wave technology, ZTE has proposed a high-bandwidth automatic data dump solution based on mmWave transmission as shown in Fig. 1.

The automatic dumping system based on mmWave transmission consists of a train-mounted data monitoring subsystem, a train-to-ground data transmission subsystem, and a ground data processing center.

The train-mounted data monitoring subsystem completes data collection, processing, recording, transmission, and dumping. It communicates with the locomotive network control systems, train operation control recording devices, and locomotive onboard safety protection systems using Ethernet data acquisition.

The wireless network of the train-to-ground data transmission subsystem uses mmWave to complete data transmission from the vehicle to the ground. The wired network utilizes the existing comprehensive railway IT network to complete data transmission within the three-level network framework of the railway corporation, railway bureau, and locomotive/maintenance depot.

The main function of the ground data processing center is to process, store, manage, and diagnose real-time locomotive operational status and fault information forwarded by the train-to-ground transmission subsystem. It also performs big data analysis and statistical evaluations based on locomotive service data and provides data interfaces for other information systems.

The following focuses on the train-to-ground data transmission subsystem, which mainly includes a train-mounted router, a train-mounted CPE (TAU), a ground mmWave base station (mmW gNB), a relay gateway, and an intelligent computing unit NE (NodeEngine).

- **Train-mounted router:** The train-mounted router connects monitoring cameras, storage, and other onboard devices. It establishes a VPN tunnel with the relay gateway. Video surveillance data and other data collected onboard are sent to the mmW CPE, mmW gNB and relay gateway through the aggregation router, and then forwarded to the

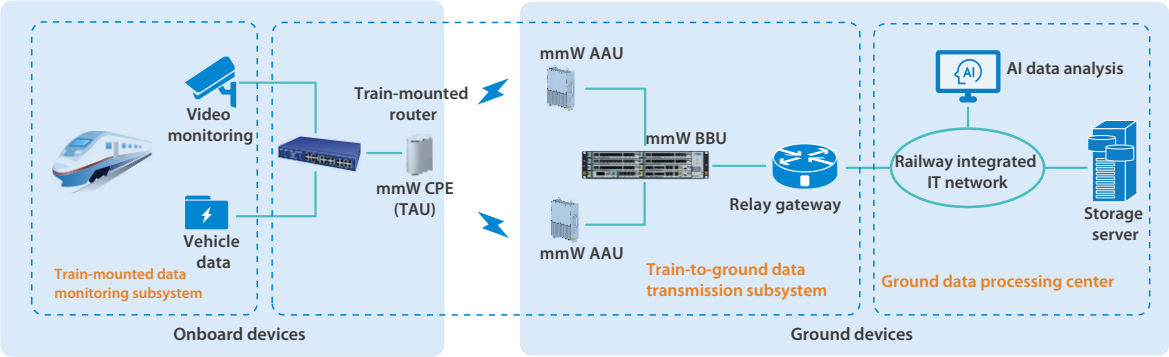


Fig. 1. Railway automatic dumping scheme based on mmWave transmission.

railway's comprehensive IT network via a newly built UPF. The processing of downlink stream data follows a similar process, but in the opposite direction.

- **Train-mounted CPE (TAU):** The TAU is installed on the roof of the train and is mainly responsible for automatically establishing a connection with the ground mmW gNB and uploading data from the train-mounted router at high speed.
- **mmW gNB:** The mmW AAU is a radio unit installed on the walls of the high-speed train station or on both sides of the platform. It establishes a wireless connection with the train-mounted CPE through large-scale antenna array beamforming and transmits the baseband digital signal to the mmW BBU in the central computer room via optical fiber. The mmW BBU is a baseband processing unit connected to the relay gateway in the data center via optical fiber or Ethernet cables.
- **Relay gateway:** The relay gateway module receives data sent by the onboard TAU and forwards it to the corresponding network element, such as a storage server or monitoring data analysis platform.
- **Intelligent computing unit NE:** On the one hand, the intelligent computing board supports authentication technologies such as whitelisting for the air interface, addressing security issues. On the other hand, it supports service recognition, service perception, and service guarantee strategies based on artificial intelligence algorithms, ensuring the efficiency and security of the vehicle-to-ground transmission system.

ZTE's mmWave products support the 26 GHz and 28 GHz frequency bands, with a maximum working bandwidth of 1600 MHz. They utilize large-scale antenna arrays and analog beamforming, providing a maximum coverage distance of over 10 km. The products also support dynamic frame structures, allowing for dynamic adjustments of uplink and downlink frame ratios to meet the bandwidth requirements of different services. With the DDDSU frame structure, the maximum downlink speed can reach 25 Gbps, while with the DSUUU frame structure, the uplink speed can reach 16 Gbps. They support various networking modes, such as NSA, NR-DC, NR-CA, FR2 Only, accommodating different networking scenarios.

Compared to the traditional sub-6G frequency band, mmWave offers a greater bandwidth advantage. Unlike Wi-Fi, it operates in licensed frequency bands, providing less interference and more reliable transmission performance. Compared to microwave, it supports not only point-to-multi-point transmission but also CPE mobility, making it more suitable for scenarios where multiple trains transmit data simultaneously. Additionally, compared to wired transmission, it has lower construction costs and is easier to deploy.

At present, the mmWave-based automatic train-to-ground data dump solution has been successfully implemented in Shanghai Shentong Metro, achieving a transmission rate of over 7 Gbps. This solution features simplified deployment, one-key dump, one-key detection, and automatic backup. It enables automatic docking, rapid storage and processing of data from each subsystem of the railway locomotives and vehicles. At the same time, it provides strong edge data computing capabilities, including video image analysis, and is expected to become the primary solution for data dump in future railway systems. ZTE TECHNOLOGIES

ZTE FRMCS Innovation Center Advancing 5G-R Commercialization and Industry Innovation

Li Bin

Chief R&D Engineer of ZTE 5G Products

Tai Chunling

Chief R&D Engineer of ZTE 5G-R Products

Wang Bo

System Test Engineer of ZTE 5G-R Products

China's Ministry of Industry and Information Technology approved the 5G-R frequency band in October 2023, accelerating its commercialization. To support this, ZTE set up the FRMCS Innovation Center, which is equipped for comprehensive software and hardware testing and verification of 5G-R products. The center will handle the R&D, testing, and innovation for ZTE's 5G-R products. In addition, ZTE has established close partnerships with China Academy of Railway Sciences, Beijing Jiaotong University, and other manufacturers in the industry to advance digital transformation and technological innovation in the railway sector.

Full Range of 5G-R Hardware Products Covering All Commercial Scenarios

The FRMCS Innovation Center has deployed a full range of 5G-R hardware products that cover all railway communication scenarios and has the capability for end-to-end service testing and verification.

Covering CTCS-2 and CTCS-3 Scenarios

The FRMCS Innovation Center deploys all ZTE 5G-R hardware products, including macro-coverage 8T RRU, 4T RRU, and indoor-coverage Qcell products. ZTE focuses on two key scenarios: single-BBU scenarios for CTCS-2 and dual-BBU scenarios for CTCS-3. Additionally, the network deployment covers various scenarios such as tunnels, stations, and cross-connected lines.

Offering 5G-R End-to-End Service Testing

Professional testing in a comprehensive environment for 5G-R ensures the efficient, stable, and secure operation of the FRMCS system. The FRMCS Innovation Center also allows for thorough testing of railway-dedicated terminals, base stations, core networks, mission critical x-service (MCX) and multimedia dispatching system (MDS).

System Software and Hardware Development and Testing Facilitating Field Commercial Deployment and Operational Assurance

The FRMCS Innovation Center plays a critical role in 5G-R R&D and field commercial testing, and has undertaken a number of key tasks.

- **Preliminary research and transformation of innovative topics in the railway industry:** ZTE actively participates in topic innovation and key technology research within the railway industry. By studying 5G-R features and application challenges, ZTE delves into cutting-edge technologies and actual industry needs. At present, ZTE has planned 12 preliminary research topics focused on 5G-R system reliability. These research initiatives aim to enhance the reliability of FRMCS and promote its commercial deployment.
- **Software and hardware development and testing:** In the FRMCS Innovation Center, hardware and software are deployed and tested. ZTE has developed the 4T, 8T, and Qcell series equipment and completed the software

development and verification for tests conducted by China Academy of Railway Sciences and for commercial use.

- **Interoperability testing:** The FRMCS Innovation Center has worked closely with industry manufacturers to actively introduce terminals, dispatching consoles, MCX, and MDS from various sources. It has conducted interconnection tests to ensure that the end-to-end railway-dedicated mobile communication system operate stably and in coordination.
- **End-to-end testing:** all NEs including onboard terminal, BBU, RRU, 5G core, MCX and MDS can be tested at the FRMCS Innovation Center. Before commercial deployment, the FRMCS Innovation Center conducts preliminary testing of various network scenarios and services to ensure the stability and reliability of the entire system.
- **Troubleshooting:** The FRMCS Innovation Center can quickly respond to and reproduce faults, assisting R&D personnel in rapid troubleshooting and field fault location, ensuring the continuous operation of FRMCS.

The FRMCS Innovation Center handles all topics of 5G-R wireless research, all-product software and hardware R&D, all-interoperability testing, all-NE verification, and all-field fault reproduction. Through these key tasks, the FRMCS Innovation Center will play an important role in the R&D and commercial deployment of FRMCS, driving technological innovation and development while contributing to the digital transformation and intelligent advancement of the railway industry.

Collaborative Innovation

ZTE will continue to enhance its collaboration with China Academy of Railway Sciences and Beijing Jiaotong University by leveraging each party's technical strengths, integrating resources, and pursuing research on cutting-edge technologies and applications. The establishment of the FRMCS Innovation Center further strengthens and expands this partnership. In addition, ZTE will actively work with industry manufacturers on interoperability testing and verification, broaden industry cooperation, and jointly promote the development and progress of the entire sector.

The FRMCS Innovation Center is dedicated to establishing a comprehensive and reliable FRMCS. It provides the deployment of a full range of 5G-R products and oversees preliminary research, development, testing, and other related tasks. By strengthening collaboration with third-party research institutions and manufacturers, it contributes to the digital transformation and intelligent development of the railway industry, driving the sector towards a brighter future. ZTE TECHNOLOGIES

Intelligent O&M Solution for New-Generation Railway Mobile Communication System

Yan Haibo

Chief Planning Engineer of ZTE Intelligent RAN Solution

The future railway mobile communication system (FRMCS) has entered an accelerated phase of development. Its mission to enable and facilitate digitalization will pave the way for train modernization, improving security, punctuality, services and capacity. In September 2023, China's Ministry of Industry and Information Technology (MIIT) approved the test frequency for new-generation railway mobile communication system (5G-R), based on 5G technology, to China State Railway Group Co., Ltd. This approval marks the beginning of a new era of China's railway mobile communication.

With a new architecture, the 5G network fully supports three communication scenarios: ultra-reliable low-latency communication (URLLC), enhanced mobile broadband (eMBB), and massive machine-type communication (mMTC). It brings new experience to railway main-line train-to-ground communication, station/hub communication, infrastructure monitoring along railways, and internal vehicle communication. However, the diversity of application scenarios and services presents greater challenges for network O&M and service quality assurance. Based on intrinsic intelligence, ZTE's uSmartNet intelligent network solution focuses on network collaborative intelligent O&M and service collaborative intelligent O&M at the NE layer, single-domain layer, and cross-domain layer through intelligent convergence, digital twins , and intent-driven approaches. This solution is essential for visualizing, managing, and controlling 5G-R networks and lays a solid foundation for intelligent network maintenance and service deployment in the future. The ZTE uSmarNet solution architecture is illustrated in Fig. 1.

Network Collaborative Intelligent O&M for E2E Closed-Loop Management of Network Events

The 5G-R network consists of the core network, radio access network, bearer network, and management system. Traditionally, O&M has been handled independently for each domain, leading to poor coordinate between low efficiency. For the new-generation railway mobile communication system FRMCS, a shift is needed from "equipment fault-oriented monitoring" to a sustainable, intelligent O&M mode focused on "network event-oriented management". This approach involves each domain providing alarm management and performance monitoring capabilities. By exposing these capabilities for upper-layer applications to invoke and integrate, a scenario-based end-to-end (E2E) event management O&M mode can be established. In addition, AI technology will be introduced to implement comprehensive intelligent O&M management.

Based on intelligent O&M technologies and application components, the E2E network event management implements policy orchestration and rule deployment tailored to each O&M scenario and service objective. It ensures closed-loop event management from perception and analysis to

decision-making and execution. Key capabilities of the E2E network event management include:

- **Key capability 1: Building an E2E closed-loop event management**

The system offers comprehensive event lifecycle management, including event perception, analysis and diagnosis, decision-making, execution, and verification, with automatic and intelligent process handling. By collecting and reporting standardized data from each domain, the system identifies events through multi-source feature association, locates root causes based on the rule library and intelligent algorithms, and provides diagnostic insights and handling suggestions. For certain faults, the system can automatically orchestrate, schedule, deliver instructions, and implement self-healing.

- **Key capability 2: Building AI integration to achieve intelligent O&M visualization**

The NEs have intrinsic intelligence, with the AI engine embedded in network management. It supports multi-type data adaptation, and uses self-developed Adlik inference acceleration and automatic model optimization to integrate AI training, inference, and application. Through visual modeling and pipeline orchestration, event rules can be configured more flexibly, and multidimensional event billboards can be provided to visualize the management process.

Service Collaborative Intelligent O&M for Full Lifecycle Management of Service Quality

5G-R network service quality is crucial for ensuring safe and stable train operations. Oriented to 5G-R services, it focuses on four areas: indicator modeling, quality monitoring, problem tracing, and perception repair. Using solutions such as end-to-end problem delimiting, signaling backtracking and detail tracing, and one-click user exception delimiting, it develops capabilities for service quality evaluation, problem tracing, and closed-loop control, supporting the full lifecycle management of 5G-R network service quality and becoming the core of future O&M work. To achieve this goal, it is essential to focus on the following aspects:

- Service quality data collection is fundamental to service quality analysis and collaborative O&M. A a multi-dimensional data collection channel is established to collect, parse, integrate, and trace 5G-R control-plane, user-plane, and wireless interface data, and support signaling analysis

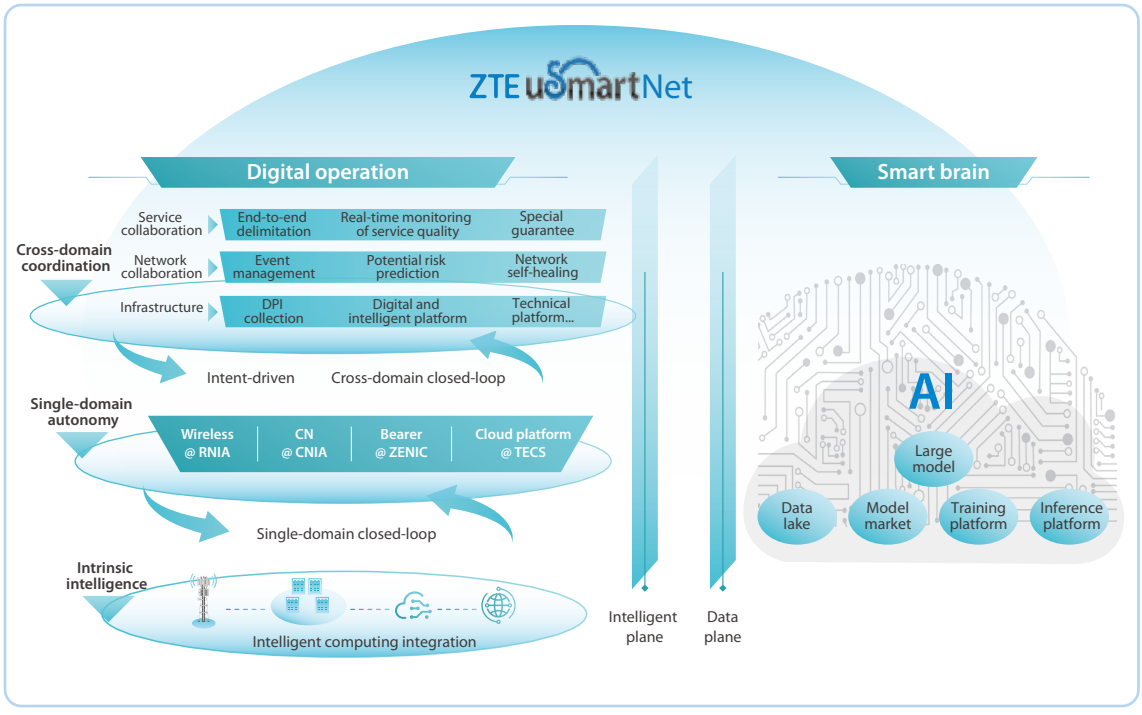


Fig. 1. ZTE uSmartNet architecture.

across all interfaces and end-to-end service quality analysis.

- Service quality is monitored in real time, and faults are addressed promptly. By modeling network-layer, transport-layer, and service-layer KPIs and focusing on service development, network quality, and service perception, multi-granularity visual monitoring capabilities are established. This includes real-time control-plane guarantee and indicator alarm configuration across railway bureaus, marshalling yards, and DNNs, supporting real-time monitoring of network and service quality. Additionally, timely problem detection and immediate response are enabled to minimize impact.
- Cross-domain coordination and one-click delimitation make problem tracing easier. By utilizing unified modeling and data association, the single-domain self-intelligence capabilities of the 5G-R core network, wireless network, and bearer network are enhanced to enable root cause self-diagnosis and self-optimization of perception degradation. This approach further improves end-to-end cross-domain analysis and problem closed-loop management capabilities, effectively supporting service perception improvement. When a user service is abnormal, the one-click delimiting function can analyze end-to-end service perception problems based on the service ID, user ID, and occurrence time and location. It automatically outputs diagnostic results and provides optimization suggestions, so that the perception problem can be traced and handled easily.

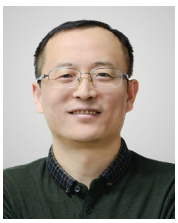
Both network collaborative and service collaborative intelligent O&M have been applied in various 5G network scenarios, such as intelligently reducing orders from the alarm ticket system. By refining the alarm correlation knowledge map, alarm correlation rules, and network resource topology, the accuracy of fault delimiting and positioning is improved. This leads to effective online analysis and precise dispatch of alarm tickets. With an average number of 682 alarm tickets per day, intelligent analysis reduces 48 repeated tickets daily, achieving a 7% reduction rate. This fully proves the great potential of network collaborative intelligent O&M to improve work efficiency. Based on real-time service experience guarantees, dynamic identification of poor quality, real-time cross-domain analysis, and event closed-loop management, the unified O&M of 5G private networks has established a quality closed-loop management and control mechanism. This approach has been applied in the operator market to improve both service quality and efficiency.

The 5G-R system is a key infrastructure that will carry core services in the future, such as railway control, command, dispatch, and communication, ensuring safe and smooth railway operations. ZTE and industry partners are actively researching technologies and applications based on the intelligent development goals of "intelligent network operation, intelligent resource management, intelligent system maintenance, and intelligent service applications". They aim to meet the development objectives of "visualized, manageable, controllable, measurable, reliable, and trustworthy" railway communications. Their commitment is to build a new generation of high-quality, highly reliable, and intelligent railway mobile communications system, advancing China's railway mobile communications infrastructure. ZTE TECHNOLOGIES

5G MBS Facilitating Efficient Deployment of Railway MCS Applications

Sang Jian

5G-R Senior Expert, ZTE



Wu Jinlong

5G-R Project Manager, ZTE

With the rapid development of railways, especially high-speed railways, the number of mobile terminals in communication networks has multiplied. Railway train-to-ground wireless communication services now extend beyond traditional train control and scheduling to include intelligent operations such as the Internet of things (IoT) and video surveillance. Consequently, railway mobile communication systems are confronted with challenges in handling mass data transmission and digital transformation.

Since the specifications for GSM-R were finalized in 2000, its application ecosystem has faced inevitable decline and is gradually exiting the market. The current GSM-R railway communication system, with a narrowband data bandwidth of only 100 Kbps+, cannot meet the demands for digitalization, networking, and intelligent transformation in railway transportation. The high-speed and low-latency features of the 5G communication system can address the emerging requirements for new functions, services, and scenarios in railways. The future railway mobile communication system (FRMCS), based on 5G, will succeed GSM-R and serve as a key enabler for rail transport digitalization.

In railway mission critical services (MCS), there are numerous point-to-multipoint data transmission requirements in train signaling communication applications, train operation applications, and trackside maintenance applications. Examples include broadcasting warning notifications, group call communications between dispatch consoles and train group members, and transmitting surveillance videos. With numerous group users and a large amount of application data, and the system's transmission bandwidth becomes a bottleneck restricting service development. Thus, it is imperative for railway communication networks to efficiently and reliably support such point-to-multipoint transmission services. The 5G multicast and broadcast services (MBS) technology addresses this issue by sharing transmission resources with multiple application data streams.

Without changing the existing SA network architecture, the 5G MBS technology enhances and optimizes network functions to transmit data from a single source to multiple UEs, thus achieving network resource sharing. In addition to sharing mobile core network and access network resources, a key advantage of this technology is its capability to share increasingly scarce spectrum resources. Fig. 1 shows the MBS network architecture.

The 5G MBS specifications inherit the large bandwidth techniques, slicing capabilities, and QOS framework of the 5G system. By introducing point-to-multipoint transmission, group scheduling, and the conversion of transmission modes on the air interface, the 5G MBS technology has achieved substantial improvements in system efficiency and user experience.

- **High bandwidth and high rates: Building a**

highway for MCS

If the UE capability is sufficient, the available bandwidth for MBS data transmission can theoretically reach 100 MHz. The flexible subframe design and scheduling bandwidth of the MBS ensure adequate capacity for MCS data transmission across various scenarios. ZTE's 5G MBS product solution supports flexible MBS data scheduling on the air interface to meet transmission bandwidth requirements in different scenarios.

- **Point-to-multipoint transmission: Saving transmission bandwidth**

To meet the point-to-multipoint transmission requirements of mission critical push-to-talk (MCPTT), mission critical video (MCVideo), and mission critical data (MCData) services in railway applications, 3GPP has enhanced the 5G MBS technology in MCS.

The 5G MBS optimizes frequency usage by providing a logical channel shared by all users on the radio interface, eliminating the need to allocate spectrum resources to each UE and greatly saving radio transmission bandwidth.

In terms of data transmission for bearer and core networks, ZTE's devices support both point-to-point and point-to-multipoint data transmission modes, which greatly reduces the transmission bandwidth required for the backhaul network.

- **Flexible point-to-point and point-to-multipoint conversion: Ensuring efficient and reliable wireless transmission**

In terms of multicast data transmission at the air interface, the MBS mechanism provides a feedback function at the link layer. When the network receives feedback from the UE about data reception failures, it will selectively repeat the transmission to ensure that each UE in the group can reliably receive downlink data, and the mechanism is suitable for those UEs at the cell edge or in areas with weak wireless coverage. The point-to-point and point-to-multipoint conversion mechanism at the link layer enhances both downlink data transmission and the reliability of individual UE data reception, achieving efficient transmission while ensuring a high user experience.

- **Two transmission modes: Facilitating MCS deployment and expansion**

The 5G MBS technology defines two modes for point-to-multipoint data transmission: 5GC individual delivery method and 5GC shared delivery method. For MCS application data, the individual delivery method uses 5G unicast technology to implement point-to-multipoint data

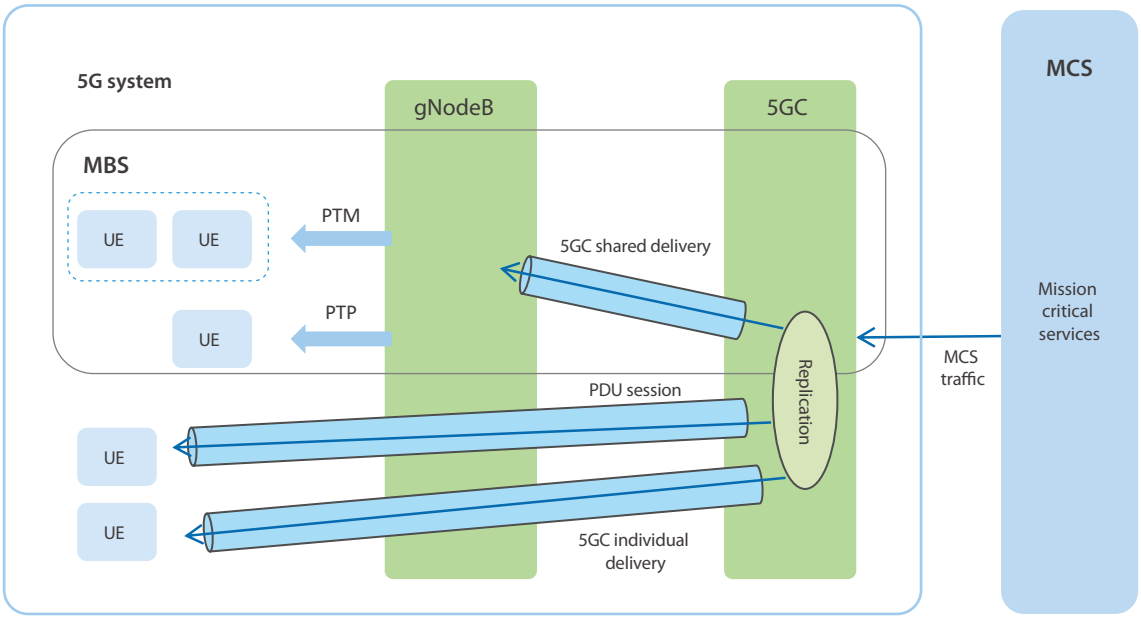
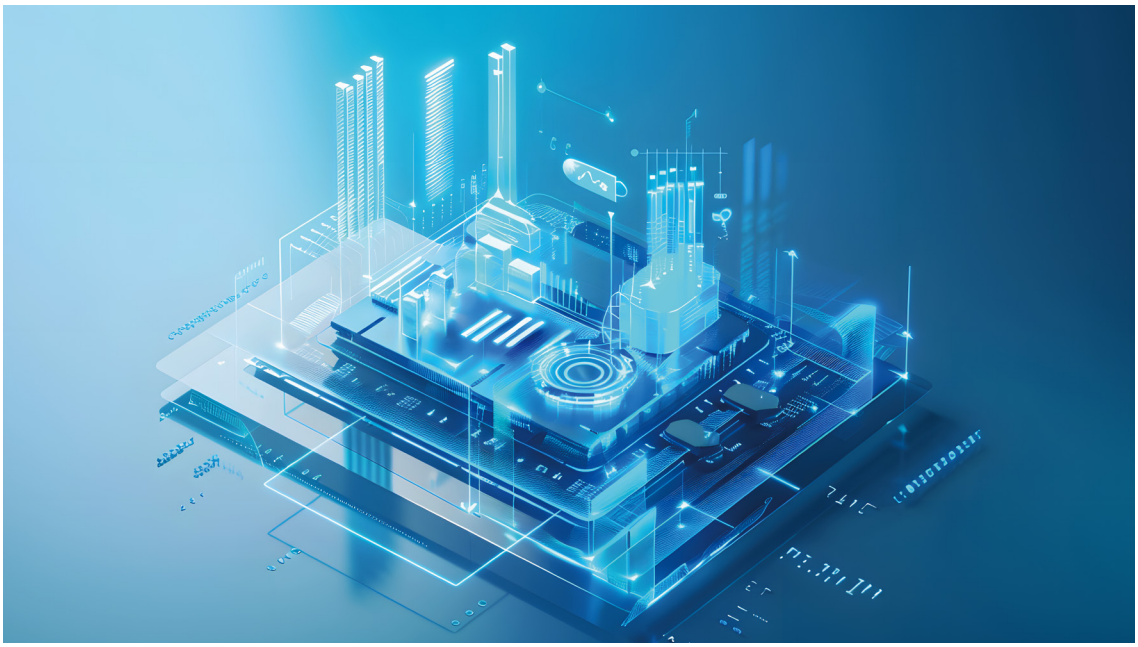


Fig. 1. Architecture for MCS over MBS.



transmission. This method is suitable in the early stages of industry chain development when one or more parties (UE, gNodeB, or 5GC) do not have the MBS capability, or when there are few MCS point-to-multipoint service scenarios and data volumes are small. The shared delivery method, on the other hand, utilizes real multicast technology to enable end-to-end resource sharing across the network, greatly saving resources and reducing future investment.

- **End-to-end network slicing: Providing differentiated SLA services in multiple scenarios**

Train signals, and operation and maintenance applications in the railway system are supported by the railway 5G private network. While traffic applications generally involve small data volumes, they are sensitive to transmission delay and reliability. In contrast, operation and maintenance data volumes are large, with lower sensitivity to delay and reliability. Leveraging the 5G MBS technology, ZTE provides an end-to-end network slicing solution in the radio access network, bearer transmission network, and core network. This solution meets varying QoS requirements, isolates different user groups, and ensures differentiated SLA services.

The MBS technology is widely used in public security, emergency push notifications, V2X applications, IPTV, wireless software push, group call conferencing, IoT applications, and various vertical industries and consumer sectors. In 2014, ZTE helped China Telecom complete the IPRAN multicast TV service based on 4G MBS technology. In 2020, ZTE launched the first 5G MBS demonstration at the Ultra-High-Definition Video Production Technology Collaboration Center in Beijing, implementing end-to-end multi-channel high-definition video broadcast services on the 700 MHz frequency band. In 2023, ZTE, China Broadcast Network Co., Ltd., Migu Culture Technology Co., Ltd, and leading terminal manufacturers collaborated on 5G MBS broadcast TV and multicast services to accelerate technological development and industrial maturity.

As the pioneer in MBS technology, ZTE offers customized MCS services for users in the railway industry, aiming to improve communication quality and reduce operational costs in a secure, reliable, and effective manner. This not only helps industry users improve operation efficiency and service quality but also positively impacts the development of the entire railway industry. ZTE TECHNOLOGIES

ZTE Aids Launch of China's First Cross-Sea High-Speed Railway Between Fuzhou and Xiamen

Zhu Qing

Senior Expert of ZTE R&D Delivery

Tian Zhiji

Deputy General Manager of ZTE RAN Products

On September 28, 2023, China's first high-speed cross-sea railway, designed for speeds of up to 350 km/h, was put into operation. This high-speed line connects Fuzhou, the provincial capital, with Xiamen, a deputy provincial city. Spanning a total length of 277 km, it traverses mountains and seas, and is a key route in China's "eight vertical and eight horizontal" high-speed railway network.

To meet the high-speed and efficient operation requirements of the railway, constructing robust communication systems is crucial. The communication system plays a role similar to that of the nervous system in the human body, ensuring the rapid transmission of information and maintaining system stability and security. ZTE uses a full-system redundancy communication solution to ensure high reliability and service continuity. This approach addresses challenges in network optimization in cross-sea bridges and complex cross-parallel scenarios, facilitating successful project delivery.

Full-System Redundancy Guarantees Secure Railway Operations

The GSM-R system carries key control commands in the train control system. Once a fault occurs, it may result in reduced train speed or a complete stop. In severe cases, a fault could disrupt the entire railway system, leading to significant losses in railway transportation. For network design, ZTE uses a single-layer interleaving redundancy coverage solution as the primary method and a same-site redundancy coverage solution as the secondary method. This ensures that the failure of any site on the line does not affect overall network performance. Regarding system equipment, ZTE employs an all-system redundancy and high-reliability solution. All boards, including BSC and BTS, implement redundancy through hot backup or resource pool backup to ensure secure and stable operation of communication equipment and reliable railway operations.

Meeting Delivery Challenges to Ensure Smooth Project Launch

The high-speed railway project from Fuzhou to Xiamen features China's first redundant network, including a 10-kilometer cross-sea bridge and up to a dozen complex cross-connection scenarios,

presenting significant challenges for project delivery.

First, the difficulty lies in optimizing the network for cross-sea bridges. The railway crosses three bays: Meizhou Bay, Quanzhou Bay, and Anzhou Bay. Both the Meizhou Bay and Quanzhou Bay cross-sea bridges are nearly 10 kilometers long. The communication network on these cross-sea bridges is intricate, involving high-antenna sites at the bridge heads and low-antenna sites on multiple bridges, creating a co-cell network.

Considering the safety of high-speed railway operations, antenna for communication equipment cannot be installed independently. They must be mounted on the existing four-meter-high columns on either side of the railway, with each site providing a maximum coverage distance of 2.5 kilometers. This network architecture makes it prone to multi-path interference and poor uplink and downlink quality in high-speed scenarios, which presents great challenges for acceptance tests and project delivery.

During the dynamic test phase, the delivery team continuously optimized the network based on the test results from daily dynamic inspection vehicles, addressing each test issue as it arose. By repeatedly adjusting the coverage and network optimization parameters of each site, the team effectively resolved complex problems such as multi-path interference and poor signal quality, ensuring a smooth acceptance test.

Second, multiple sections of the high-speed railway intersect with existing lines, which poses challenges for networking. Eleven sections (about 213 km) are involved. For the complex scenario of the high-speed railway from Fuzhou to Xiamen, the Nanchang Railway Bureau and ZTE's professional team conducted thorough research and analyzed the cross-connection areas one by one. To ensure network performance in these areas, they adjusted networking solutions, shared sites with existing lines, modified regional frequency planning, and optimized signal coverage and neighbor cell relationships. Each cross-connection area was specially analyzed, and a tailored network optimization solution was developed. Finally, a specialized cross-connection network optimization solution for the high-speed railway from Fuzhou to Xiamen has been established.

With the efforts of the delivery team, the communication system for the high-speed railway from Fuzhou to Xiamen was successfully delivered and put into operation. After strict acceptance tests, all network indicators met the requirements, and the stability and reliability of the communication system were fully validated. This ensures a robust foundation for the safe and efficient operation of the high-speed railway between Fuzhou and Xiamen.

Creating a One-Hour Living Circle Between Fuzhou and Xiamen

After the high-speed railway between Fuzhou and Xiamen is put into operation, the travel time between the two cities has been shortened to less than one hour, creating a "one-hour living circle". Additionally, the "Golden Triangle" of Xiamen, Quanzhou, and Zhangzhou has been connected within a half-hour transportation circle. This will enable the southeast coastal city cluster of Fujian province to be linked into a "golden tourist belt".

The Fuzhou to Xiamen high-speed railway project is another successful delivery by ZTE in the railway sector. ZTE's GSM-R network has been widely used in railway systems, with nearly 100 successful GSM-R communications projects completed. These projects cover many key railway lines and sites across China, providing a solid communication guarantee for safe and efficient railway operations. As 5G-R technology matures, railway communications are entering in a new phase of technological advancement. As a leading provider of communications equipment, ZTE has conducted extensive research and experiments in the field of 5G-R technology. ZTE will continue to leverage its expertise in railway communications to offer more advanced, efficient, and secure communication solutions for the industry. ZTE TECHNOLOGIES

CelcomDigi, U Mobile and ZTE Claim New Record in Live 5G-A Trial

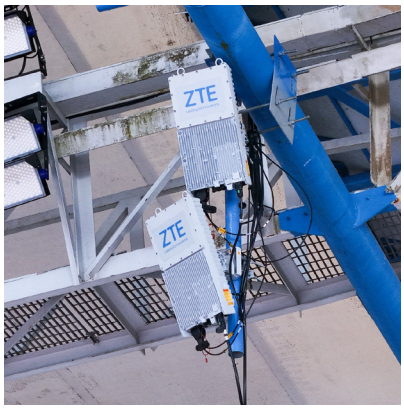
Source: RCRWireless.com

Malaysian carriers CelcomDigi and U Mobile and Chinese vendor ZTE claimed a new record with mobile speeds at 30.8 Gbps with 5G-Advanced (5G-A) technology during a live trial conducted in Kuching, Sarawak, Malaysia.

In addition to this new benchmark, the partners also recorded individual users experiencing speeds of up to 8.5 Gbps.

ZTE noted that the trio intends to showcase 5G-A technology with what it claims to be Malaysia's first-ever 5G-A live broadcast from the Opening Ceremony of SUKMA 2024 in Sarawak to viewers across the nation through Radio Televisyen Malaysia (RTM).

The public who visit the CelcomDigi, U Mobile, and ZTE 5G-A Pavilion located outside Stadium Sarawak will also have the opportunity to experience 5G-A enhanced XR technology. By



The grand opening ceremony of SUKMA 2024 took place on August 17, 2024, at Stadium Sarawak, marking a significant milestone in Malaysia's broadcasting history. ZTE, CelcomDigi and U Mobile collaborated to deliver a 5G-A wireless UHD live broadcast solution. This groundbreaking broadcast utilized SumaVision's shallow compression codec technology to provide a high-quality live stream of the event through RTM.

utilizing 5G-Advanced in 360-degree cameras installed at various locations inside the stadium, visitors can experience the atmosphere of the stadium's action by putting on a pair of VR goggles, the vendor said.

Viewers will be able to enjoy an immersive experience, as the broadcast will consist of high-resolution streams with minimal delay, the Chinese vendor added.

Datuk Idham Nawawi, CEO of CelcomDigi, said: "This achievement reflects the importance of industry collaboration and partnerships, especially in realizing the potentials of 5G and 5G-A. We continue to execute on our multi-partner strategy of bringing together the best technologies from the East and West to deliver the best experiences to Malaysians, and enable the nation's transformation into a 5G-AI powered digital society."

Wong Heang Tuck, CEO of U Mobile, said: "We are proud to achieve this record-breaking 5G-Advanced accomplishment of 30.8 Gbps with our industry partner CelcomDigi and technology partner ZTE as it showcases the possibilities of what 5G-A can do for enterprise solutions across various verticals."

Also in Malaysia, local carrier Maxis has partnered with Singaporean operator Singtel to introduce what it claims to be Malaysia's first all-in-one platform for 5G network, edge computing, cloud and services orchestration, built on Singtel's Paragon for telco networks.

The platform will make 5G-Advanced and 5G technology, edge and multi-cloud computing more accessible to Malaysian businesses and accelerate digital transformation across various verticals such as manufacturing, logistics, healthcare and public services, Maxis said.

Bill Chang, CEO of Singtel Digital InfraCo, said: "We've seen a strong shift in demand from enterprises for 5G and edge computing capabilities to accelerate their digital transformation. Paragon enables faster monetization of 5G infrastructure by reducing complexities for telcos to deliver and scale 5G use cases."

Singtel added that the platform will be locally hosted and deployed in Malaysia, to cater to the cybersecurity and data sovereignty requirements for Malaysian businesses.

Singtel said its Paragon is a comprehensive solution that enables enterprises to connect with the 5G network and securely deploy their edge computing applications and services rapidly on the telco's infrastructure, thus reducing time-to-market. ZTE TECHNOLOGIES

ZTE

To enable connectivity and trust everywhere