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Expert Views

Deterministic and Probabilistic
Demands in Network Evolution

Evolution from 5G to 6G:
Key Technologies for Future
Networks

Special Topic:

5G Radio Innovations

Technical Evolution of Ultra-Broadband Radio for 5G and
5G-Advanced Networks





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Deterministic and Probabilistic Demands in Network Evolution

At different stages of 5G deployment, operators have different concerns about their networks. These concerns will be translated into requirements for network construction and deployment.



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It has been over six years since 5G was first commercially launched worldwide. According to the GSA report published this April, 392 operators have launched 5G networks, with 95 offering SA services, and 35 investing in 5G-Advanced. A total of 4,256 5G devices has been announced. Although this is only around 15% of 4G devices, it is sufficient to support thriving 5G services and applications.

However, 5G operators still face challenges in improving monetization despite the scale of the ecosystem. The key issue is the lack of killer applications that can fully utilize 5G capabilities. With the advent of the AI era, operators are expecting new services and applications to improve monetization in the near future. Therefore, it is necessary to understand the demands on network evolution.

Market Classification

Based on the 5G deployment progress, operators can be categorized into three stages: Beyond 5G, During 5G, and Pre 5G.

“Beyond 5G” refers to operators that have completed 5G deployment in major areas, with network coverage exceeding a predetermined threshold. “During 5G” refers to operators that have obtained 5G licenses and started 5G deployment. “Pre 5G” refers to operators that have not yet obtained 5G licenses and therefore have not started commercial deployment.

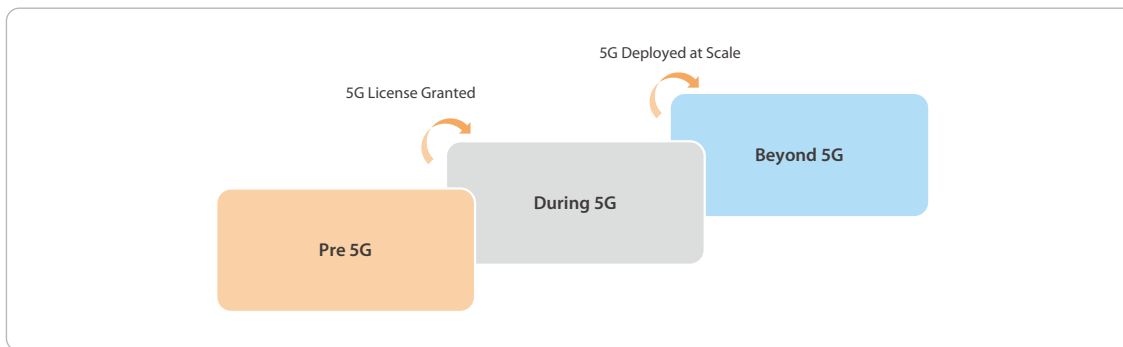
Understanding the concerns of operators at different stages enables us to better address their requirements and help them build their ideal networks.

Concerns of Operators

The three stages are not completely independent, and there is some overlap between adjacent stages. Operators at an earlier stage also need to consider priorities of later stages, although some of these may be less urgent.

● Beyond 5G

Operators with nearly complete 5G networks focus on network monetization after making



substantial investments. Most operate in mature markets, where subscriber penetration is already very high, leaving little room for subscriber growth except through FWA expansion. Monetization depends largely on increasing ARPU by introducing new services and enhanced experiences. Since must-have 5G mobile services are still very limited, improving user experience has become one of the most important ways for operators to increase ARPU. A number of operators have started to introduce experience-oriented packages tailored to different scenarios and services.

At the same time, operators are seeking to reduce OPEX, especially when network utilization has not yet reached its full potential. Energy efficiency is one of the key ways to reduce OPEX over the medium and long term. In addition, AI-enabled autonomous operations and maintenance are becoming increasingly important.

Once operators have achieved their 5G deployment goals, the evolution toward 5G-Advanced and, eventually, 6G will become the next priority. Technologies and features that improve network performance or support new services and scenarios are attracting the most attention. Consequently, technologies such as multi-carrier CA and MIMO, emerging use cases such as ISAC and NTN, and new applications such as XR, are being developed and deployed.

● During 5G

Operators in the During 5G stage are also concerned about the priorities mentioned above. However, their primary concern is accelerating 5G network deployment and rapidly attracting more 5G subscribers. Their technological concerns include spectrum strategies for LTE, NR, as well as

DSS, 5G NSA/SA architectures, and coverage strategies for NR and anchors.

Methods to accelerate engineering, site deployment, or even site swap are considered high priorities. For example, smaller and lighter modules on towers are important because they reduce tower load in terms of space, weight, and wind load. Low power consumption is another important consideration, mainly at the hardware level, as it determines whether power systems need significant changes by tower companies, which can increase deployment time and cost.

Subscriber strategy is also a key consideration at this stage. An aggressive 5G marketing strategy may lead to a poor user experience, especially during the initial phase of network deployment, while a conservative one may hinder 5G user acquisition. The design and appeal of 5G devices, services and packages will all have an impact on subscriber acquisition. The same principle applies to the network side, where parameter design for legacy and 5G networks is important. There is much more involved than simply switching on the 5G network.

● Pre 5G

More factors should be considered at this stage than in the other two stages. The first step is to develop a spectrum strategy based on local regulations and spectrum auction plans. A fundamental question must first be addressed: Is 5G necessary for this network. In most situations, the answer is yes, given the competitive pressure in the market. However, when 5G spectrum licenses or investment budgets are limited, operators have to consider how to reuse existing bands, modes or even networks. Such an approach is very challenging and short-term.

As operators prepare to deploy 5G, the focus will be on network modernization. Different 5G spectrum bands, such as 3.5 GHz, 2.6 GHz, or even 2.3 GHz, will require different network designs. Even for the selected band, different types of radio units, such as 64TR, 32TR, or 8TR, need to be considered for different scenarios and targets. In some cases, pre-installing radio units for a promising future 5G band is also a very cost-effective approach during modernization. That means 5G services can be launched through a software switch once the 5G license is granted.

If 5G deployment is still some time away, LTE modernization may be necessary to bridge the gap until 5G arrives. The use of multiple bands and MIMO solutions, whether for TDD or FDD bands, can be considered key approaches in the short term.

Deterministic and Probabilistic Demands

Based on an analysis of operators' concerns at different stages of 5G deployment, some important demands can be identified. These demands can be classified as either deterministic or probabilistic.

Deterministic Demands

- **Integrated and compact base stations**

For rapid 5G deployment, base stations that support multiple bands, multiple modes, and multiple channels are essential. First, the upcoming 5G bands have to be supported. More importantly, almost all existing bands should be integrated into fewer units to reduce tower loading and make room for new 5G equipment. Meanwhile, these base stations should support multiple modes, including both current and future evolved modes. Furthermore, for coverage and capacity purposes, radio configurations ranging from 2TR, 4TR, and 8TR to 16TR, 32TR, 64TR, and even higher are increasingly required. A key capability is to integrate as many elements as possible while maintaining acceptable unit specifications.

- **Continuous performance improvement**

Networking is not only about individual hardware units but also about scalable capabilities across thousands of units supporting multiple bands, modes, and channels.

The bands include sub-1 GHz FDD bands, sub-3 GHz FDD and TDD bands, and sub-6 GHz TDD bands. Different bands play different roles in the network, and the parameters and priorities designed for them would affect network performance and user experience.

The modes include 2G, 3G, 4G, 5G, and beyond, which are planned for different phases of network evolution. These generations are still too broad to distinguish the modes in today's networks. With voice technologies evolving from GSM and UMTS to CSFB, SRVCC, VoLTE, and VoNR, together with the introduction of IoT as well as NSA and SA architectures, network complexity has increased exponentially.

Deploying units with different channel configurations within a network also require significant expertise in network planning and optimization. Simply deploying units with more channels in dense urban or high-population-density regions is not always the optimal solution. A highly customized network with tailored design and optimization is required.

- **Tools for better performance and less OPEX**

Besides the network itself, tools are also essential. Basic tools such as EMS need not be emphasized, but additional tools for network optimization, user experience awareness, energy saving, and O&M automation are increasingly required.

Tools for network optimization and user experience awareness are mainly used to improve network performance, and also help reduce investment required for large-scale networks. Energy-saving and O&M tools with or without AI agents can significantly reduce OPEX. All these tools have become indispensable in today's networks.

Probabilistic Demands

- **AI-oriented network capability**

With the AI era approaching, deterministic trends are emerging, including the proliferation of AI agents, massive token consumption, physical AI, and many new services and applications. It is expected that the future network will need to support massive connections beyond traditional IoT, lower latency for real-time control, and a much

“ With the AI era approaching, deterministic trends are emerging, including the proliferation of AI agents, massive token consumption, and physical AI ”



This image is generated with the assistance of AI

higher uplink ratio than in current networks. Although these trends are deterministic, the specific demands may vary across different types of networks, and the timeline for these new network demands remains uncertain. Therefore, operators are advised to monitor the development of local AI-related businesses.

- **Full connectivity anywhere and anytime**

Anywhere, anytime connectivity has always been the ultimate goal of the telecom industry. With current technologies, it has become possible to achieve “anytime” connectivity in many regions. However, achieving “anywhere” connectivity remains a challenge. With traditional terrestrial networks, there is still a huge gap in achieving nationwide coverage, let alone coverage of the entire surface of the Earth. That’s why the concept of non-terrestrial network (NTN) has been introduced. The scale and timeline of this demand are still being

explored. Especially, due to the limited resources for this type of connectivity, potential business cooperation models will also be an important topic in the future.

Conclusion

At different stages of 5G deployment, operators have different concerns about their networks. These concerns will be translated into requirements for network construction and deployment. Deterministic demands are being addressed for near-term implementation, while probabilistic demands arising from predictable trends are important for medium- and long-term planning. As a leading vendor, ZTE always focuses on customer concerns, analyzes various network requirements, and strives to deliver optimal solutions to address these requirements. **ZTE TECHNOLOGIES**

Evolution from 5G to 6G: Key Technologies for Future Networks



Xiang Mingfei

Chief Engineer of RAN Product Planning, ZTE

Commercial 5G networks are transitioning from basic coverage to deepening enablement, and large-scale 5G-A deployment has laid a connectivity foundation for industry digital transformation. The explosion of AI applications, the rise of new services such as the low-altitude economy and integrated communication and sensing, and the urgent need for air-space-ground coverage are driving mobile networks from "Internet of Everything" to "Intelligent Convergence." To meet emerging requirements such as massive uplink, deterministic connectivity, compute-network convergence, and ubiquitous wide-area connectivity, wireless networks require systematic upgrades across architecture, air interface, and computing power. This paper explores the evolution of wireless sites toward 6G, with a focus on key technologies including massive MIMO, integrated sensing and communication (ISAC), cellular passive IoT, subband full duplex, AI-RAN collaboration, and satellite phased arrays.

Key Technologies for Evolution from 5G to 6G

Massive MIMO Antenna Array

Massive MIMO, one of the most representative 5G technologies, has achieved widespread commercial

deployment, with mainstream configurations of 32TR and 64TR, typically comprising 192 and 384 antenna elements, respectively.

The U6G (6425-7125 MHz) band is a critical frequency band for 6G. With high propagation loss and short wavelengths, it accommodates up to four times as many array elements as the 3.5 GHz band within the same physical area, easily exceeding one thousand elements. In 2026, ZTE unveiled the industry's first 1500+ element U6G ultra-massive MIMO solution at MWC, adopting a hybrid analog-digital beamforming architecture that balances beamforming accuracy with RF channel costs, providing a practical path toward U6G coverage comparable to 3.5 GHz while enabling a two-fold performance improvement. The current U6G industry chain is maturing, and related products are ready for early commercial deployment in 5G-A networks.

ISAC

5G-A ISAC integrates communication and sensing within a single base station, utilizing enhanced air interfaces to enable target detection and tracking. Currently undergoing pilot projects in multiple locations across China, it is driving emerging applications such as low-altitude security, low-altitude economy, waterway navigation, and

maritime port supervision, evolving from technical validation to large-scale application and laying the foundation for 6G all-domain sensing and intelligent networks.

For 6G ISAC, we are committed to building an integrated system encompassing communication, sensing, positioning, and multimodal fusion. The network is centered on base stations to achieve all-domain communication and advanced sensing. It integrates multimodal data from sources such as optoelectronics and spectrum detection, while leveraging AI to enhance sensing performance. Through high-precision environmental modeling and ray tracing, 6G networks can construct digital twin platforms to enable real-time mapping between physical and virtual spaces.

In the field of 5G-A ISAC, ZTE has pioneered a hybrid waveform combining continuous waves and pulsed waves, launched a self-transmitting/self-receiving wide-angle product to address seamless low-altitude sensing challenges, and continues to explore multimodal fusion solutions based on end-edge-cloud collaboration.

Cellular Passive Internet of Things (A-IoT)

Traditional NB-IoT and RedCap rely on active devices and are unsuitable for passive IoT scenarios. RFID primarily supports point-to-point communication, with limitations in coverage, inventory efficiency, and accuracy that make it difficult to meet the requirements of the Internet of Everything. Cellular passive IoT integrates cellular and passive technologies, combining advantages such as continuous coverage, massive connectivity, low cost, low power consumption, and maintenance-free operation.

Cellular passive IoT base stations enhance the read-write range through interference cancellation, flexible energy storage, and new air-interface coding. They support ultra-massive concurrent tag access and improve inventory efficiency by leveraging time division multiple access, frequency division multiple access, multi-rate transmission, anti-collision scheduling, and group-based inventory while enabling value-added functions such as sensing and positioning. Their low cost, low power consumption, and massive connectivity provide a data foundation

for 6G applications such as digital twins, the metaverse, big data, and artificial intelligence.

Subband Full Duplex and Dynamic

Frame Structure

AI is reshaping the terminal ecosystem, with AI smartphones, AI glasses, smart vehicles, and embodied intelligence continuously emerging. Mobile communications are evolving from "connecting people" to "connecting intelligent devices," creating new requirements for deterministic connectivity, high uplink capacity, and computing-network convergence. To address these challenges, ZTE has introduced two innovative technologies for the 5G-A phase:

- **Subband full duplex (SBFD):** Divides a single carrier into multiple subbands, with each subband independently configurable for time slots, enabling flexible uplink and downlink resource scheduling. ZTE has completed the R&D and deployment validation of pre-commercial SBFD small cells, achieving over 60% latency reduction, more than 4 dB uplink coverage improvement, and over 70% uplink throughput increase. This technology is being extended to macro site scenarios to support broader network deployments.
- **Dynamic frame structure:** Based on AI-predicted service load, the frame structure is dynamically adjusted to align resource allocation with service requirements. By leveraging diverse anti-interference technologies to address coexistence issues between heterogeneous frames, ZTE and operators have successfully completed pre-commercial trials in macro-micro hybrid scenarios, and the solutions have received multiple industry recognitions.

The two innovations jointly leverage time and frequency domains to meet the requirements of uplink-heavy scenarios, laying a foundation for 5G-A deployment and 6G evolution.

AI and RAN Convergence

The 5G-A phase has initially realized AI-enhanced RAN: AI use cases such as L1 CSI compression feedback and beam management have been standardized, while intelligent functions including

L2/L3 intelligent link adaptation, intelligent energy saving, and automated operations and maintenance have been commercially deployed. However, current external AI solutions face pain points such as dispersed computing power and limited protocol adaptation. 6G will evolve towards AI-native RAN by embedding AI into the protocol stack to improve spectrum efficiency, user experience, and energy efficiency, thereby empowering various AI applications.

ZTE has launched its AIR RAN intelligent solution, which leverages a heterogeneous hardware architecture that integrates general-purpose and dedicated computing resources to balance computing power and overhead. Its self-developed intelligent computing boards have been deployed in commercial scenarios such as energy saving, operations and maintenance, and experience optimization. Meanwhile, ZTE is advancing research on 6G AI-native architectures, developing proprietary AI acceleration chips, and building an integrated communication-computing-intelligence system capable of smooth upgrades.

NTN Phased Array Antenna

Based on 3GPP R17/R18, 5G NTN has entered the commercial deployment phase. As a key hardware component, phased array antennas achieve rapid beam switching through coordinated phase control among array elements, overcoming the limitations of mechanical scanning. A single satellite can generate over 100 independent beams, filling coverage gaps and enhancing capacity in high-density areas, with key applications in maritime, aviation, and emergency communication.

To address challenges such as limited access capacity, high costs, and significant latency during inter-satellite handovers, phased array antenna technology is evolving rapidly. Ultra-large-scale multi-beam antenna arrays support massive access; the integration of industrial-grade silicon-based chips with high-gain antennas drives miniaturization, lightweighting, and cost reduction; and multi-satellite collaborative scheduling achieves seamless, low-latency, all-domain access.

As a key driver of global NTN development, ZTE has collaborated with partners across the chip,

module, and application sectors to complete end-to-end technical validation, build a comprehensive NTN industrial ecosystem, and develop proprietary phased array antennas covering S-, Ku-, and Ka-bands, accelerating the evolution toward integrated space-ground networks.

Future Evolution Trends of Wireless Sites

Based on the above six technical directions, wireless sites are evolving from 5G "high-performance connectivity nodes" to 6G "intelligent convergence hubs," which can be summarized into four key trends.

Architectural Trend: From Base Stations to Integrated "Connectivity, Sensing, Computing, and Intelligence" Platforms

Traditional base stations focus on communication connectivity, whereas in the 6G era, they will evolve into integrated platforms combining communication, sensing, computing, and intelligence, transforming from bit pipes to edge intelligent nodes capable of environmental perception, data computation, and intelligent decision-making. Future wireless sites will be centered on base stations, enabling efficient all-domain communication and advanced sensing, deeply integrating multimodal sensing data, and building a service-oriented RAN architecture.

Air Interface Trend: From Static Frame Structures to Dynamic Intelligent Air Interfaces

The 5G frame structure is relatively fixed with static resource allocation, whereas the 6G air interface is evolving towards a dynamic and intelligent paradigm. Subband full duplex and dynamic frame structure serve as two enablers in the time-frequency domain to flexibly address diverse requirements such as high-capacity uplink, low latency, and deterministic services. 3GPP Release 20 has designated AI-native air interface design as a 6G study item. The future air interface will evolve towards a closed loop of "real-time sensing, intelligent decision-making, and dynamic adaptation," with lightweight AI models embedded across the protocol stack to fundamentally address challenges in energy efficiency and spectrum efficiency.

Traditional base stations focus on communication connectivity, whereas in the 6G era, they will evolve into integrated platforms combining communication, sensing, computing, and intelligence.

Coverage Trend: From Ground-Based to All-Domain Coverage Across Air, Space, Land, and Sea

5G relies primarily on terrestrial base stations, with coverage constrained by ground-based infrastructure. 6G will enable integrated coverage across air, space, land, and sea. NTN phased array antennas enable direct satellite-to-mobile connectivity, while ultra-large-scale antenna arrays with thousands of elements enhance high-frequency coverage, enabling U6G coverage performance comparable to 3.5 GHz. The future coverage boundary will extend from "ground" to "sky," expand from "urban areas" to "oceans and deserts," and achieve seamless access across all domains.

Computing Trend: From Dedicated Hardware to Heterogeneous Computing Platforms

5G base station computing resources are primarily dedicated to baseband processing, relying mainly on dedicated ASICs. For 6G, wireless sites are evolving into distributed edge computing nodes. The deep integration of AI and RAN requires base stations to support AI inference while ensuring deterministic communication. Dedicated ASICs ensure real-time communication performance and energy efficiency, AI acceleration chips provide native AI capabilities, and general-purpose computing supports flexible deployment of edge AI services. Heterogeneous computing architectures enable wireless sites to achieve efficient communication while supporting diverse workloads such as AI inference, sensing, and edge computing.

Conclusion: The Intelligent Transformation of Wireless Sites

The transition from 5G to 6G represents a paradigm shift from "Internet of Everything" to "Intelligent Integration."

Commercial 5G networks have established a solid foundation for industrial digital transformation. Meanwhile, breakthroughs and validations in key technologies such as Massive MIMO, integrated sensing and communication, cellular passive SBFD, AI-RAN convergence, and NTN phased arrays are laying the technical foundation for 6G. In 2026, 3GPP officially approved the timeline for the first 6G specifications, Release 21, marking the transition from conceptual exploration to system verification and standardization. The first commercial services are expected at the end of 2029 or early 2030.

In response to this transformation, wireless site technology upgrades should take 5G-Advanced as a key evolutionary step to facilitate ecosystem integration and lay the technical groundwork. Through continuous breakthroughs in areas such as ultra-massive MIMO, integrated sensing and communication, AI-native networks, and space-air-ground integration, together with scenario-driven innovation and technology-driven applications, we can build an intelligent, ubiquitous, and continuously evolving 6G network, providing a solid connectivity foundation and computing support for the intelligent society in the 2030s. [ZTE TECHNOLOGIES](#)

Technical Evolution of Ultra-Broadband Radio for 5G and 5G-Advanced Networks



Yang Lisha

RAN Product Planning
Manager, ZTE

The transition toward 5G and 5G-Advanced (5G-A) places increasingly stringent requirements on radio access network (RAN) infrastructure, particularly in terms of site footprint, energy consumption, deployment complexity, and spectral efficiency. ZTE's Ultra-Broadband Radio (UBR) is a highly integrated RAN solution designed to address these challenges through 3D integration, AI-driven power amplification, high-density antenna arrays, and software-defined resource allocation. By supporting multi-band, multi-sector, and multi-technology deployments, UBR enables operators to modernize sites, reduce total cost of ownership (TCO), and improve network performance.

RAN Challenges and UBR

One of the primary challenges in mobile network deployment is site congestion. Legacy networks typically require separate radio units, antennas, and feeders to support 2G, 3G, 4G, and 5G services across fragmented spectrum bands. This proliferation of hardware increases tower load, constrains 5G upgrades, and raises CAPEX/OPEX. Meanwhile, operators face growing traffic demand, limited spectrum resources, multi-technology coexistence, and rising energy consumption. In dense urban and hotspot scenarios, conventional radio configurations often struggle to deliver sufficient capacity and a consistent user experience under heavy load while accommodating GSM, LTE, and 5G on the same site.

ZTE's UBR technology addresses these challenges through hardware integration, high-capacity Massive MIMO, and intelligent resource management. By consolidating multiple bands, sectors, channels, and radio access technologies into compact radio units, UBR provides a simplified and scalable UniSite RAN architecture. It enables operators to expand LTE and 5G capacity, improve spectral efficiency, maintain legacy services, and reduce lifecycle costs without further increasing site complexity.

Hardware Architecture: Multi-Band, Multi-Sector, Multi-Channel Integration

Over the past decade, ZTE has continuously advanced UBR technology, accelerating global network evolution and laying a foundation for the mobile AI era. To simplify multi-band sites, improve energy efficiency, and meet differentiated capacity requirements, the UBR portfolio includes 4TR and 8TR radio modules for external antennas, as well as Massive MIMO modules with integrated large-scale antenna arrays.

In 2014, ZTE introduced the world's first dual-band UBR, supporting the rapid expansion of 4G networks. In the Pre5G era, ZTE launched the industry's first Massive MIMO solution, helping shape the blueprint for 5G network architecture and earning the Best Mobile

Technology Breakthrough and The CTO's Choice awards at the GSMA Global Mobile Awards.

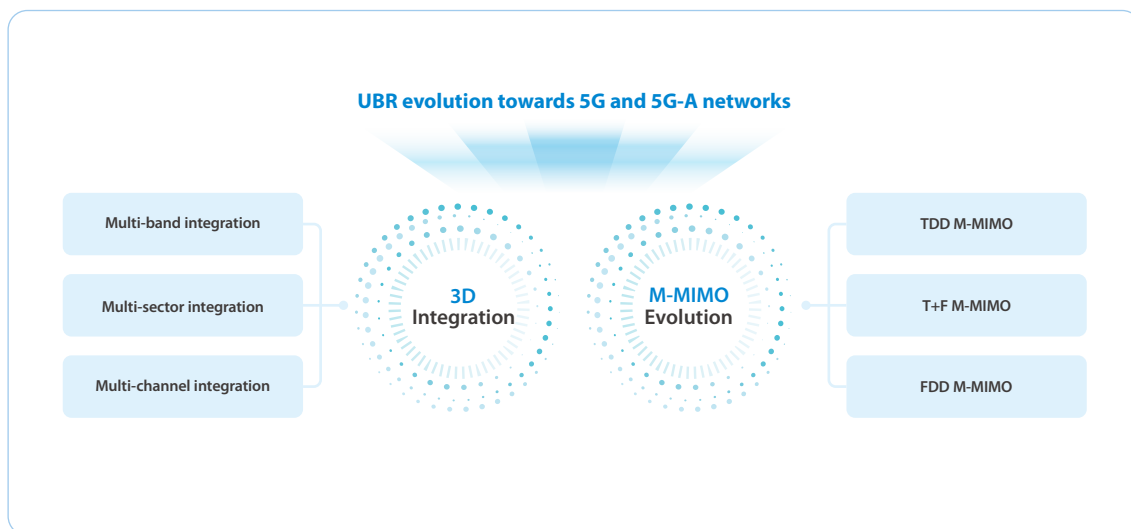
In the 5G-A and mobile AI era, ZTE offers an even broader UBR portfolio to support differentiated deployment scenarios. To enable extreme site simplification, ZTE has achieved high levels of integration across multiple bands, sectors, and channels, delivering innovative products such as 5-band and 6-band 4TR UBR, tri-sector 12T Omni UBR, and 8T UBR with the industry's highest output power for FDD tri-band deployment.

To enhance capacity and improve user experience, ZTE's Massive MIMO AAU portfolio is tailored to a wide range of scenarios. The FDD and TDD dual-mode Massive MIMO solution is the industry's first to fully utilize both FDD and TDD bands, delivering high capacity for hotspot areas while supporting dual-band and tri-band combinations. The TDD 64TR dual-band Massive MIMO solution further increases capacity for high-traffic scenarios. The industry-first 128T Massive MIMO product is designed for high-rise building coverage, while sub-1 GHz Massive MIMO supports suburban capacity enhancement and deep indoor coverage.

High-capacity Massive MIMO is therefore a key component of UBR's response to modern network challenges. By combining large-scale antenna arrays, advanced beamforming, and AI-assisted resource allocation, UBR Massive MIMO enables operators to expand LTE and 5G capacity, improve user throughput in high-traffic areas, and make more efficient use of existing spectrum.

A key advantage of the UBR Massive MIMO platform is its support for GSM co-deployment in the 1.8 GHz band, enabling simpler site configuration and lower TCO. In markets where operators must maintain GSM coverage while expanding LTE or 5G capacity, conventional deployments often require additional RRUs and antennas alongside the AAU, increasing hardware complexity, site footprint, and installation workload.

By integrating GSM capability into the same UBR unit, the solution reduces the number of active radio modules required on the tower, lowering OPEX, reducing tower load, and improving deployment feasibility in dense urban or



space-constrained sites.

The reduced module count provides sustained operational savings and improves asset utilization across multi-technology networks. GSM support within the 1.8 GHz UBR Massive MIMO deployment enables operators to maintain legacy service continuity while introducing higher-capacity LTE and 5G layers through a more compact, cost-efficient, and scalable site architecture.

Through multi-band, multi-sector and multi-channel integration, UBR can reduce the number of required radio units per site by 50% to 80%. This level of consolidation is enabled by a series of RF, structural, and thermal design innovations.

For RRU products, UBR adopts an advanced architecture with higher integration density of key components, including power amplifiers, filters, and heat dissipation fins, resulting in a 25%–30% in weight. ZTE's Massive MIMO products also adopt an ultra-simplified architecture. Through highly integrated boards, optimized PA layouts, lightweight antennas, and lighter heat sinks, the overall weight is reduced by 30% and the footprint by 40%.

In Massive MIMO products, metamaterial-enhanced beamforming is used to reduce AAU width while maintaining high RF performance. ZTE's compact array design uses smaller antenna element spacing to reduce the physical size of the array. Advanced metamaterial loading helps overcome the typical performance degradation caused by compact spacing,

and small-spacing decoupling improves beamforming accuracy and antenna pattern consistency.

Power Management: AI-Optimized Super-N PA as a Core Innovation

Energy consumption is a major component of network OPEX. Traditional remote radio units often suffer from limited power amplifier (PA) efficiency under dynamic or low-traffic conditions. UBR addresses this challenge through a three-tier energy-saving architecture, with the AI-powered Super-N PA as a core innovation.

At the equipment level, unlike conventional monolithic PA designs, UBR's Super-N PA architecture decomposes the amplification chain into multiple adaptive amplification units. With AI-optimized digital pre-distortion (DPD) and real-time load-tracking algorithms, the system dynamically activates only the required amplification components based on traffic demand, maintaining high PA efficiency across varying load conditions. In Pakistan's network, this innovation helped achieve a 42.7% reduction in overall site power consumption.

At the site level, UBR integrates "0-bit 0-watt" technology to reduce idle baseline power consumption to approximately 3 W for RRUs and 5 W for AAUs during ultra-low traffic periods. This is combined with traffic-aware channel shutdown and carrier sleep mechanisms to minimize unnecessary

idle energy consumption.

At the network level, dual-layer AI power allocation uses AI models to predict macro-level traffic patterns and dynamically coordinate power sharing across multiple radios and sectors. This network-wide optimization delivers an additional 15% reduction in energy usage.

Together, the equipment-, site-, and network-level mechanisms enable UBR to reduce energy consumption while maintaining service continuity and user experience.

Dynamic Power Sharing and Spectral Efficiency Improvement

Beyond physical integration and power efficiency, UBR further improves system capacity through software-defined power sharing and AI-enhanced Massive MIMO capabilities.

Power Sharing

In live networks, traffic load varies significantly across sectors due to differences in coverage, user distribution, service behavior, and time of day. However, in conventional RRU architectures, resources in different sectors are independent and lack physical interconnection. Even if one sector has surplus power, it cannot be transferred to another sector with higher demand.

ZTE's tri-sector UBR addresses this long-standing limitation by enabling power sharing among sectors within a single RRU. Because one RRU supports three sectors, the total output power across the three sectors forms a common resource pool, enabling dynamic inter-sector power allocation based on real-time demand.

This mechanism reduces RRU hardware requirements by approximately 20%, and lowers equipment investment costs. By increasing transmit power for high-demand sectors, the solution also improves user signal quality and boosts single-user throughput and sector capacity by 10% to 20%.

Inter-sector power allocation can be adjusted at transmission time interval (TTI) level, allowing power to be borrowed and returned without affecting burst service requirements. Through flexible scheduling by the baseband scheduler, shared power resources can

be utilized more efficiently, converting each watt of power into more bit traffic and improving overall network value.

AI-Enhanced Massive MIMO

On the algorithm side, ZTE's adaptive 1-to-6 smart cell technology dynamically activates different numbers of Massive MIMO cells within the same sector according to traffic load, maximizing spectrum efficiency. AI beamforming with coordinated SRS/PMI processing further enhances performance, improving user speeds by 15%, while AI MU-MIMO enhances UE pairing efficiency and reduces inter-user interference, increasing cell throughput by 20%.

Compared with baseline 4T4R systems, Massive MIMO configurations can double low-band capacity and quadruple mid-band capacity. In CelcomDigi's network, FDD Massive MIMO deployment increased user throughput by 1.8x, while AI-assisted load balancing increased payload capacity by 37.9%.

In addition, UBR's software-defined architecture allows remote reconfiguration of power output and radio access technologies through software upgrades. This flexibility extends hardware lifecycle, supports smooth network evolution, and helps operators adapt to changing traffic patterns and spectrum strategies.

Conclusion

Ultra-Broadband Radio represents a key evolution in RAN design, shifting network deployment from hardware proliferation to intelligent consolidation. Through RF miniaturization, multi-band and multi-sector integration, high-capacity Massive MIMO, AI-native energy management, Super-N PA architecture, dynamic power sharing, and software-defined spectral flexibility, UBR helps operators address site congestion, growing capacity demands, spectrum limitations, multi-technology coexistence, and rising OPEX.

With more than 2.4 million radio units deployed globally across over 100 projects, field data has validated UBR's ability to support high-performance network evolution while meeting the operational, economic, and environmental requirements of the 5G and 5G-Advanced eras. **ZTE TECHNOLOGIES**

AI-Powered M-MIMO: Teaching Antennas to Think

How Artificial Intelligence Is Reshaping the Performance Boundaries of Massive MIMO Systems



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The Capacity Crunch

The laws of physics are stubborn things. As mobile operators race to accommodate an ever-growing appetite for data—streaming video, video calls, connected cars, and industrial robots—they keep bumping up against a hard ceiling: the radio spectrum is finite, and there is only so much information you can squeeze through any given slice of airwaves.

The industry's answer, so far, has been Massive Multiple-Input Multiple-Output, or M-MIMO. Think of it as replacing a single loudspeaker with a wall of speakers, each steering its signal precisely toward individual listeners rather than broadcasting blindly across a crowd. A base station equipped with dozens, even hundreds, of antenna elements can serve multiple users simultaneously in the same frequency band, multiplying capacity without requiring new spectrum.

The catch? These antenna arrays are only as good as the software that controls them. Traditional M-MIMO systems rely on fixed rules and manual tuning—beam management by spreadsheet, in effect. In the real world, where traffic patterns shift by the minute, users move constantly, and buildings, vehicles, and even trees alter signal paths, rigid strategies waste enormous amounts of potential capacity.

Enter artificial intelligence. By training algorithms on the patterns that emerge from millions of radio transmissions, equipment makers are now building M-MIMO systems that learn, adapt, and optimize in real time. The results, measured in live networks from

Karachi to Jakarta, suggest the performance gains are not marginal—they are transformative.

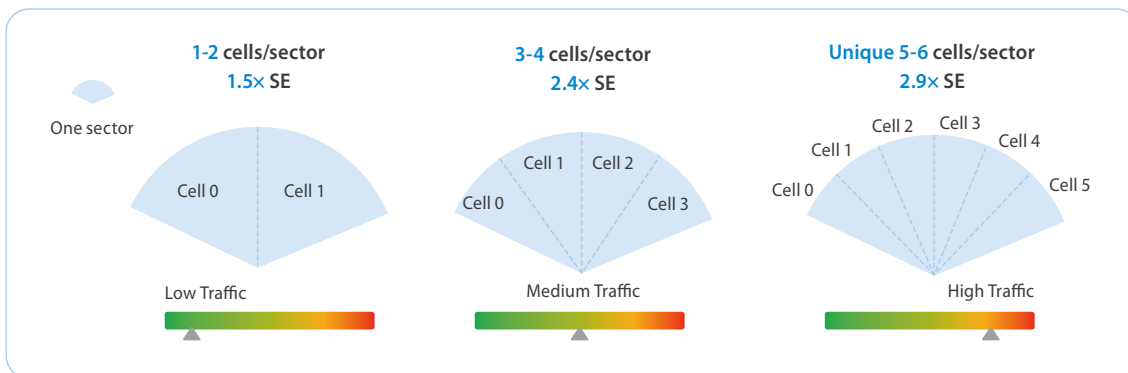
Smart Sector Splitting for FDD M-MIMO

In frequency division duplex (FDD) networks—the workhorse of modern mobile telephony—a particularly stubborn problem has long limited M-MIMO's effectiveness. Because the frequencies used for uplink and downlink are different, the base station cannot simply infer what the downlink channel looks like from what it receives on the uplink. Without accurate channel state information (CSI), beamforming becomes a guessing game.

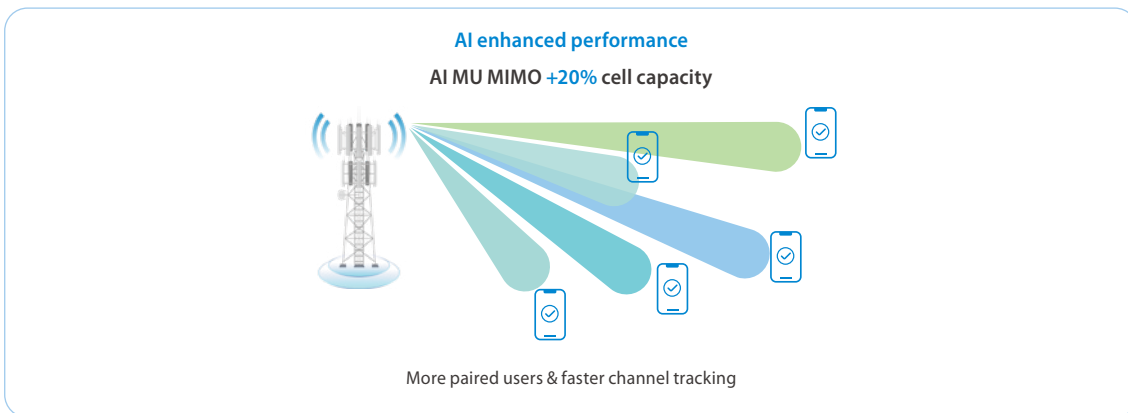
ZTE's answer is something it calls smart spatial cell group (SSCG) technology (Fig. 1). The principle is disarmingly simple: instead of treating each sector as a single, monolithic cell, the system uses artificial intelligence to divide it dynamically into smaller sub-cells, each with its own precisely tailored beam. The number of sub-cells adapts continuously to the traffic load.

The effect is striking. Under light traffic, a sector might split into just two cells, yielding a 1.5x improvement in spectral efficiency compared with a 4T4R cell. As demand builds, the system scales to three or four cells, pushing the gain to 2.4x. In dense urban hotspots, where hundreds of users cluster within a few hundred meters, the system can sustain five or six cells per sector—an industry-leading configuration that drives spectral efficiency up by a factor of 2.9.

The intelligence lies in the algorithm's ability to learn. By analyzing historical traffic data, user



◀ Fig. 1 Smart spatial cell group (SSCG) technology.



◀ Fig. 2 AI-enhanced MU-MIMO technology.

distribution, and service patterns, the system identifies the optimal cell-splitting strategy within minutes and adjusts beam weights from among tens of thousands of possible combinations. What once required teams of radio engineers with clipboards and spectrum analyzers now happens autonomously across every cell in the network.

Intelligent User Pairing of TDD M-MIMO

Time division duplex (TDD) systems, widely used in Asia and increasingly elsewhere, have a natural advantage: because uplink and downlink share the same frequency, channel reciprocity makes it far easier to acquire accurate CSI. But having good data is only half the battle. The real challenge is deciding which users to serve simultaneously—and that is where AI makes its second major contribution.

In conventional multi-user MIMO (MU-MIMO), users are grouped for simultaneous service based on crude orthogonal criteria: users with sufficiently different channel characteristics are paired together. It works, after a fashion. But in complex

environments where signals bounce off buildings, interfere with one another, and fluctuate constantly, or in a heavy-traffic cell with very large numbers of users, these simple rules leave substantial capacity on the table.

ZTE's AI-enhanced MU-MIMO (Fig. 2) takes a more sophisticated approach. Machine-learning models evaluate multiple factors simultaneously—channel correlation, interference levels, service priority, even the type of application each user is running—to identify pairings that maximize total throughput. The result is an additional 20% or more in cell capacity, extracted from the same spectrum and hardware.

Beyond smarter pairing, AI also addresses the problem of channel aging—the degradation of channel estimates that occurs when users are moving quickly, as they do on high-speed trains or in busy urban corridors. Advanced AI channel prediction algorithms analyze historical channel samples to anticipate how conditions will evolve, allowing the base station to pre-adjust beam directions before the signal quality drops. The result



is more stable connections and fewer dropped sessions in motion.

From Lab to Live Network

Promising technology is one thing. Technology that works in the messy reality of commercial networks is another. The evidence so far suggests that AI-powered M-MIMO passes this test with flying colors.

Consider Pakistan. In February 2026, ZTE and local operator Zong activated the world's first commercial deployment of AI-enhanced FDD Massive MIMO. The results after just weeks of operation: downlink throughput during busy hours rose by 39.4%, with a daily average improvement of 34.3%. Traffic loads increased 17.1% at peak times and 21.5% across the full day—evidence that better network performance encourages users to consume more. The system automatically switches between up to six splitting cells and the traditional four cells based on real-time demand, with no human intervention required.

The Chinese market offers a different kind of validation. In trials with a major domestic operator, ZTE's AI MU-MIMO solution demonstrated a 10% capacity uplift over traditional MU-MIMO on a live

network—a meaningful improvement in a market where every megahertz of spectrum is already being squeezed for maximum output.

The Road Ahead

The marriage of AI and M-MIMO is still in its early days, but the trajectory is clear. What began as an optimization layer—with algorithms fine-tuning beam weights and user pairings—is evolving into something more fundamental. The next generation of systems, already in development for 6G, will feature larger antenna arrays, more sophisticated cooperative scheduling across multiple sites, and deeper integration of communications with sensing and positioning.

For operators, the economics are compelling. AI M-MIMO extracts substantially more capacity from existing spectrum and hardware, deferring the need for expensive new infrastructure. For consumers, it means faster, more reliable connections in the places where they matter most—crowded city centers, moving vehicles, and more.

The antenna, it turns out, was only half the invention. The other half is the brain that controls it. **ZTE TECHNOLOGIES**

Indoor Networks: From Connectivity to Experience

A 4K livestream stalling at 10% upload progress during a sold-out concert. A payment QR code failing to load in an underground farmer's market. A critical video call freezing in an elevator. These moments define how users score their network. In the 5G-Advanced era, indoor areas have evolved from "signal coverage zones" to the primary battleground for user experience. Users' expectations have upgraded from "being connected" to demanding ultra-smooth and zero-wait experiences.

Three Transformations Are Reshaping Indoor Network Evolution

- Firstly, high-density hotspots are evolving from traffic delivery to experience assurance. VR spectating, HD livestreaming, and AR interactions are proliferating rapidly, challenging the traditional downlink-centric model and creating more balanced uplink-downlink, ultra-low-latency, high-concurrency traffic. The value of hotspot venues is no longer measured by data volume alone, but by the ability to guarantee that every livestream remains buffer-free and every AR interaction responds instantly. Premium indoor network capabilities are becoming a key differentiator for operators seeking to capture value in business districts, stadiums, and other strategic venues.
- Secondly, traditional coverage blind spots are creating value beyond traffic alone. In underground garages, connected vehicles consume gigabytes per OTA update and continuously upload surveillance video. In underground markets, vendors use livestreaming to expand their reach while mobile payments make reliable connectivity essential to daily

business. Emergency communications in fire escape routes and elevators, as well as smart building IoT sensing all depend on that "last meter" of indoor coverage. Blind-spot remediation has upgraded from simple signal filling to supporting traffic monetization, industry enablement, and public safety.

- Finally, the proliferation of mobile AI terminals is catalyzing a new connectivity paradigm. With AI glasses, commercial service robots, and other intelligent become more common, the traditional human-centric connectivity model is being disrupted. A new pattern prioritizing both humans and machines is emerging, increasing connection density and service types. With manual configuration and static management becoming costly and inefficient, intelligence has become a critical requirement for reducing network costs and improving efficiency.

These three transformations lead to a common imperative: indoor networks must achieve breakthroughs in experience, coverage, and intelligence—leveraging ultra-wideband aggregation to deliver premium experience, full-scenario tiered coverage to eliminate blind zones, and AI-powered operations to simplify network management.

Ultra-Wideband Spectrum Aggregation: Enabling Premium Experience

Bandwidth is the most direct factor in ensuring user experience. High-frequency bands offer abundant resources but limited coverage; mid- and low-frequency bands provide good coverage but scarce bandwidth. The challenge lies in efficiently coordinating fragmented spectrum.

Leveraging an ultra-wideband digital architecture,



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Wu Jun

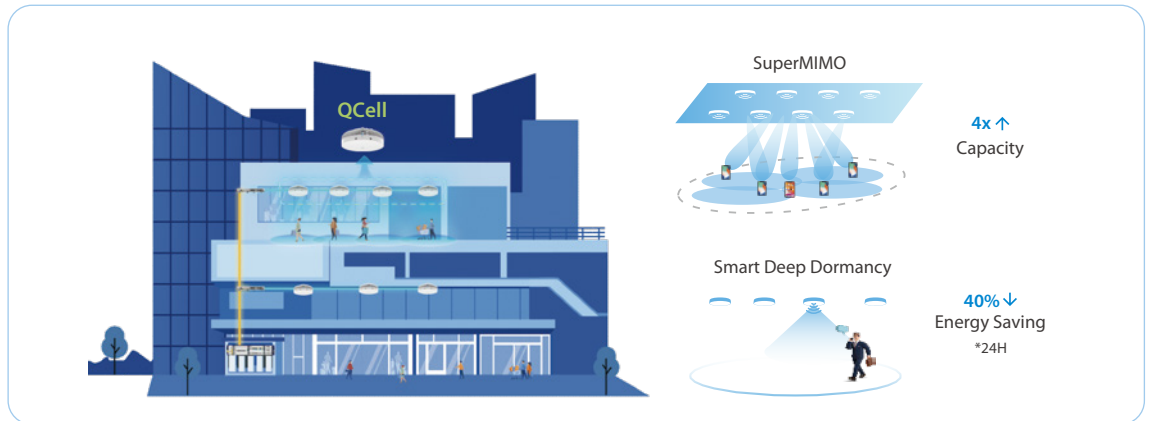
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Fig. 1 QCell: Superior experience for high-value scenarios.



ZTE's QCell (Fig. 1) integrates four frequency bands and 12 transceiver channels into a single remote radio head. Combined with multi-carrier aggregation, it consolidates fragmented spectrum resources into a continuous, high-capacity pipeline to deliver peak single-user throughput of over 5 Gbps, supporting bandwidth-hungry applications such as HD live streaming or AR/VR.

Furthermore, Distributed SuperMIMO technology significantly boosts spectrum efficiency. Through intelligent joint scheduling, distributed radio heads are coordinated to operate as a massive MIMO cell, leveraging beamforming and multi-user MIMO to serve more terminals on the same time-frequency resources. It increases network capacity by three to four times over conventional 4T4R solutions, helping operators meet traffic growth while reducing spectrum and capacity expansion costs.

Notably, this architecture is future-proof. It meets the long-term evolution needs of 5G-A without any hardware modifications. Through simple software configuration or upgrades, operators can split cells, add new carrier configurations, or introduce new services such as sub-meter-level high-precision indoor positioning, thereby safeguarding the long-term sustainability of infrastructure investments.

Full-Scenario Tiered Coverage: Balancing Deployment Cost and Service Value

Indoor scenarios are complex, with varying demands. The traditional one-size-fits-all approach often leads to insufficient capacity in hotspots and wasted resources in low-demand areas. The

essence of full-scenario coverage is matching each space with the optimal solution, striking the right balance between network performance and deployment cost.

Based on the 3GPP R18 specifications, ZTE's network-controlled repeater, qNCR (Fig. 2), provides a lightweight, cost-effective solution to achieve deep coverage. Adopting a wireless backhaul architecture, the device requires no fiber deployment or additional baseband units, and can be rapidly deployed with access to mains power. A single unit can cover an underground garage ranging from 5,000 to 8,000 square meters or elevator shafts in 35-story high-rise buildings. Compared to traditional solutions, it reduces construction costs by 40% and power consumption by 50%, making it a precise fit for wide-coverage, low-traffic blind areas.

Crucially, qNCR solves the long-standing pain points of traditional repeaters, including poor manageability, interference issues, and lack of KPI monitoring. The device establishes a stable control link with the host base station and uses intelligent interference suppression algorithms to adapt to macro-network scheduling in real-time, avoiding interference at the source. Relying on unique RF identification technology, the network management system can accurately distinguish between macro-cell users and qNCR users, enabling independent monitoring of core KPIs such as coverage, capacity, and interference. Fault troubleshooting efficiency is dramatically improved, bringing coverage blind spots into the standardized O&M system.



◀ Fig. 2 qNCR: Budget-friendly blind spot eliminator.

Together, QCell and qNCR form a complementary architecture that precisely matches diverse scenario requirements, optimizes deployment and operational costs, and ensures every investment translates into improved user experience and business returns.

AI-Powered Intelligent Operations: Sustaining Long-Term Network Value

The ultra-wideband and full-scenario coverage solution provides a solid foundation, while intelligent operations unlock long-term network value. Leveraging AI technologies, operators can dynamically balance between user experience, energy consumption, and maintenance efficiency.

For energy saving, AI-based intelligent deep sleep predicts user distribution and service load to enable precise on/off control for individual QCell radio heads. Equipment automatically enters deep sleep during idle periods and wakes up within milliseconds when a user accesses the network, reducing overall site energy consumption by 30%–40% and supporting operators' green and low-carbon goals.

Regarding operations, QCell's all-digital architecture shifts operations from experience-based practices to data-driven intelligence. Full-link visualization enables one-click fault tracing, replacing the traditional point-by-point investigation. Meanwhile, qNCR's intelligent algorithms perceive environmental changes in real time and dynamically optimize parameters, ensuring network stability in complex scenarios and significantly shortening fault resolution times.

In terms of user experience, AI endows the network with proactive adaptation capabilities. The system perceives user density, service type, and traffic requirements in real time, enables intelligent system-level coordination, and optimizes beam scheduling strategies to dynamically allocate resources. In high-capacity scenarios, this ensures transmission quality for both users and intelligent terminals, transforming the network from a passive pipe into an intelligent service platform capable of active adaptation.

Conclusion

Empowered by 5G-A and AI, indoor networks are transitioning from basic connectivity infrastructure to user experience platforms. Ultra-wideband technology unleashes the value of spectrum assets, full-scenario hierarchical coverage balances between cost and performance, and AI-driven intelligent operations continuously improve quality and efficiency. Together, they provide a mature, actionable path for global operators to evolve their indoor networks.

The technical synergy between ZTE's QCell and qNCR represents not just a product upgrade, but a revolution in network deployment philosophy. Through scenario-specific deployment and intelligent operations, operators can simultaneously meet the demand for premium experience in key scenarios and basic coverage in blind spots. This helps unlock the value of indoor scenarios, build differentiated service advantages, and realize the commercial and social value of 5G-A indoor networks. **ZTE TECHNOLOGIES**

RuralPilot Solution: Connecting the Unconnected



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As global digital transformation accelerates, over 300 million people remain excluded from mobile broadband coverage, and 3.1 billion more live within network coverage but do not use these services—held back by weak infrastructure, high costs, and low digital awareness. Rural areas face lasting connectivity gaps, limiting access to education, healthcare, financial services, and economic opportunities.

To tackle these challenges, ZTE launches the RuralPilot solution—a full-stack, intelligent, and green network deployment solution built exclusively for rural coverage. Combining innovative hardware, efficient green power systems, flexible wireless backhaul, and compact infrastructure, it helps operators connect the unconnected, significantly reduce CAPEX and OPEX, and build sustainable digital ecosystems for underserved communities.

Rural Connectivity Challenges: Limitations of Traditional Solutions

Deploying mobile networks in rural regions presents unique difficulties:

- **High construction costs:** Building rural sites costs over 35% more than urban sites, due to complex civil works, remote site locations, and challenging terrains.
- **Unstable grid power:** Most sites rely on diesel generators, leading to high OPEX, frequent maintenance, and increased carbon emissions.
- **Backhaul limitations:** Fiber is costly and difficult to deploy in remote areas.
- **Complex logistics and installation:** Transporting heavy equipment through mountainous areas increases lead times and labor costs.

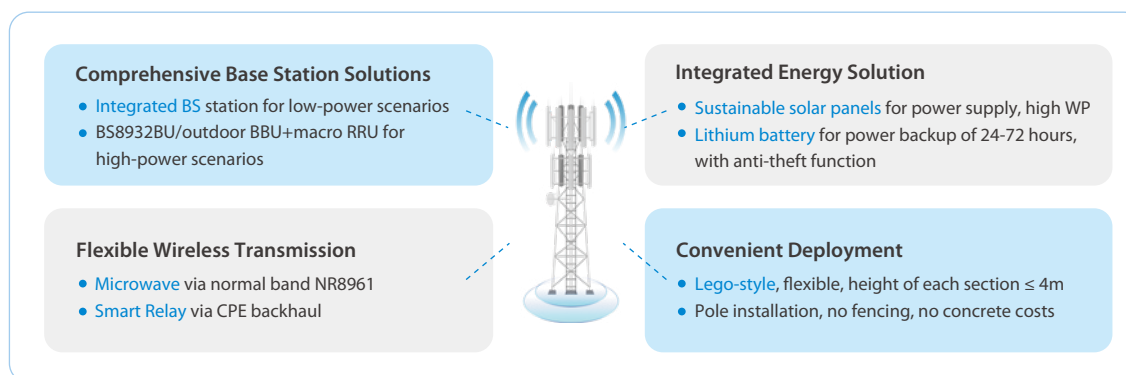
Traditional macro-site solutions are too costly,

slow, and inefficient for these scenarios. A simpler, smarter, and more sustainable deployment paradigm is needed.

ZTE RuralPilot Solution: Redefining Rural Network Coverage

ZTE RuralPilot breaks down traditional barriers in rural connectivity through four core innovations:

- **Comprehensive base station solutions:** A range of RAN equipment meets diverse rural deployment requirements, featuring a lightweight, highly integrated design with low-power devices. While maintaining network performance and coverage, it significantly reduces site power consumption. All equipment supports standard pole-mounted installation. With minimal space requirements and low construction difficulty, it enables rapid site deployment and service activation, greatly improving network construction and O&M efficiency.
- **Flexible wireless transmission:** Leveraging microwave backhaul technology, the RuralPilot solution enables single-site transmission over distances of up to 50 kilometers, effectively overcoming transmission bottlenecks in remote areas. It features an all-outdoor, zero-footprint architecture with integrated routing capabilities and high transmit power, removing the need for dedicated equipment rooms and complex on-site configuration.
- **Integrated energy solution:** The RuralPilot solution enables 100% solar-powered site operation, eliminating diesel generators and recurring fuel costs while providing a stable, reliable green energy supply across remote regions. Its iEnergy management software further optimizes energy utilization, reducing operating expenses and



Four innovations of the RuralPilot solution.

enhancing system sustainability. The all-in-one power cabinet integrates power modules and high-performance lithium batteries in a compact design that supports pole-mounted installation, flexible deployment, and simplified O&M.

- Convenient deployment:** The RuralPilot solution features a modular, Lego-style pole design that eliminates the need for concrete foundations or fencing. The solution adopts an optimized self-supporting tubular tower structure made of high-strength steel, delivering enhanced wind resistance and seismic performance while maintaining a slim profile to reduce overall steel consumption. With all equipment mounted on the pole and no equipment room required, RAN equipment, power systems, and cabinets can be deployed within a minimal site footprint, reducing theft risks.

Empowering Digital Inclusion, Lighting up a Shared Future

The RuralPilot solution has rapidly demonstrated its commercial value through efficient deployment and lifecycle cost advantages. Its proven delivery capabilities have been validated across multiple projects. **In Liberia**, the project team completed the deployment of 128 base stations in just three months, bringing stable mobile communication services to over 580,000 rural users. **In Ethiopia**, 152 rural base stations have been rolled out across the country's remote regions, delivering comprehensive 2G, 3G, and 4G network coverage and benefiting more than one million users in underserved areas.

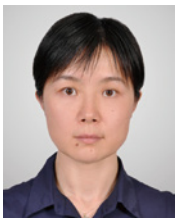
In Cameroon, a 360-kilometer backbone microwave network traversing mountains and forests provides reliable connectivity along a route of more than 2,000 km, serving over 13 million users.

The solution's solar power system slashes diesel consumption and carbon emissions, and is paired with intelligent energy management software to optimize energy efficiency and ease long-term O&M pressure at remote sites. Overall, the solution cuts network coverage costs by 70% and improves network expansion efficiency by 60%, laying a robust foundation for seamless network scaling and long-term technology evolution.

The RuralPilot solution has earned authoritative international recognition, with its Signal Reach Program clinching top-tier honors at leading global industry awards. In 2025, the program stood out from a vast pool of global submissions to receive the WSIS Champion Award. Building on this milestone, the solution secured two further prestigious Digital with Purpose (DWP) distinctions at the 2026 DWP Global Summit: the Smart Cities Award and the Global Award.

Beyond extending signal coverage, the solution provides otherwise isolated rural communities with access to educational resources, telemedicine services, market insights and business opportunities. The solution empowers telecom operators to fulfill universal service obligations, narrow the urban-rural digital divide, and unleash the economic potential of rural areas. Through this continued expansion, network connectivity generates profound and far-reaching socio-economic value. **ZTE TECHNOLOGIES**

GigaMIMO: Advancing Ultra-Massive Arrays as a Cornerstone of 6G Evolution



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In the mobile AI era, innovative services such as holographic communication, XR, AIGC real-time generation, and digital twins are rapidly emerging. Their diverse requirements—high bandwidth, low latency, and ultra-reliability—are pushing 5G-A networks to evolve continuously from “connecting everything” to “intelligent connectivity.”

At the pivotal stage of the evolution from 5G to 6G, the industry faces a dual mission: maximizing the potential of 5G-A for emerging services and accelerating the research and development of 6G core technologies to build a solid foundation for the future intelligent world. Whether it is enhancing 5G-A capabilities or preparing 6G for the future, the generational leap of wireless networks always follows one core logic—breakthroughs in capacity are the starting point of evolution. Only by approaching the Shannon limit can we create the fundamental impetus for new services, scenarios, and ecosystems.

Capacity Breakthroughs Underpin the Evolution of Mobile Technology

The evolution of mobile technology has always been a process of continuously pushing performance boundaries. Shannon’s theorem defines the theoretical ceiling of communication system capacity, and each generation’s evolution essentially achieves capacity breakthroughs by pushing the limits of the key variables in this theorem. For example, from 2G to 4G, the focus was on expanding bandwidth, improving spectral efficiency, and effectively mitigating interference.

In the Pre5G era, to further increase system

capacity under limited spectrum resources, ZTE, with forward-looking technological insight, pioneered Massive MIMO technology, opening up the spatial dimension—much like adding multiple lanes to a communication highway—and dramatically boosting data transmission capacity, making it a cornerstone of 5G networks.

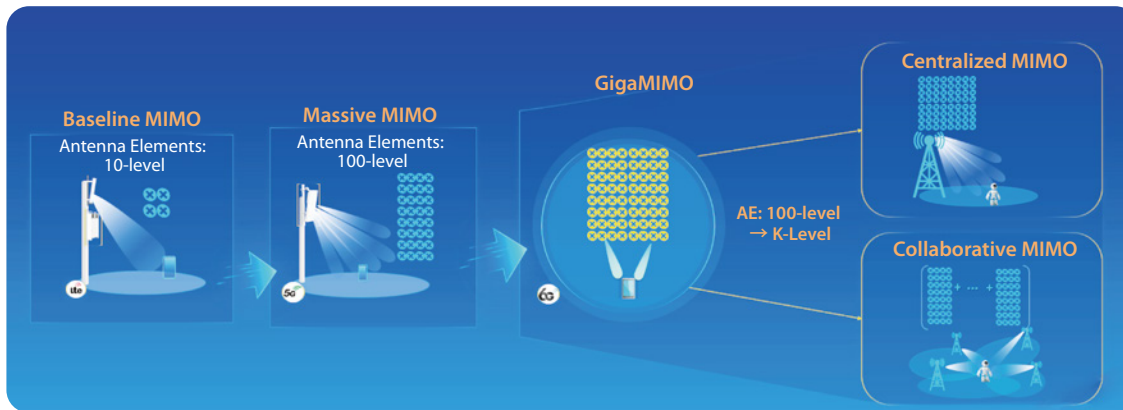
Continuing this technological trajectory, ZTE has introduced the GigaMIMO solution as the industry evolves from 5G-A to 6G. Based on ultra-massive antenna arrays, GigaMIMO further unleashes the potential of the spatial dimension, helping break through network capacity bottlenecks, and providing higher-speed, more stable, and more reliable network support for cutting-edge applications such as immersive communications, connected vehicles, and embodied AI.

GigaMIMO Redefining Cellular Boundaries Toward 6G Evolution

GigaMIMO represents the next evolution of Massive MIMO. It expands the capabilities of ultra-massive antenna arrays, fully exploits spatial degrees of freedom, and evolves the data transmission architecture from two-dimensional to three-dimensional, marking another leap in transmission capacity and serving as a cornerstone for 6G.

The GigaMIMO solution comprises two core technologies: centralized MIMO and collaborative MIMO, which work together to deliver consistently high performance from the cell center to the edge (Fig. 1).

- Centralized MIMO focuses on the cell center, using



◀ Fig. 1 From Massive MIMO to GigaMIMO: Scaling the spatial domain for a capacity leap.

ultra-massive antenna arrays to achieve a tenfold increase in capacity, providing ample resources for massive connections and data floods in future higher-frequency, wider-bandwidth scenarios.

- **Collaborative MIMO** focuses on the cell edge, forming a virtual ultra-massive antenna array through intelligent collaboration among multiple sites, bridging the traditional experience gap at the cell edge and delivering seamless, stable, high-bandwidth experiences for users in high-mobility and cell-edge scenarios.

GigaMIMO drives the continuous evolution of massive antenna array technology, both enhancing 5G-A network capabilities and laying a solid technical foundation for the smooth evolution to 6G, achieving a balance between current network value enhancement with future technology readiness.

GigaMIMO Conquering Challenges in Efficiency, Computation, and Collaboration

To fully unlock the potential of the spatial dimension, GigaMIMO must overcome three major challenges.

- **Efficiency:** As antenna scale grows, insertion loss and power consumption rise exponentially, not linearly—controlling energy consumption while multiplying performance is a prerequisite for large-scale deployment.
- **Computation:** The drastic increase in the number of channels leads to a rapid increase in MIMO matrix dimensions, causing computational complexity to grow quadratically and making

traditional brute-force computing unsustainable.

- **Collaboration:** Cross-site collaboration requires picosecond-level synchronization accuracy and massive real-time information exchange; achieving such precise coordination among nodes is far from trivial.

To address these challenges, GigaMIMO achieves key technological breakthroughs in architecture, computational structure, and collaborative algorithms.

Architectural Innovation

GigaMIMO adopts a new hybrid analog-digital fully connected architecture. On top of traditional digital beamforming, it adds analog beamforming in the vertical dimension, enabling adaptive wide and narrow beams and adjustable directions, making spatial resource scheduling more flexible and precise. The distributed PA architecture places PAs close to the antenna elements, greatly reducing insertion loss and routing loss, significantly improving antenna gain, and laying a foundation for the efficient deployment of large-scale arrays. Additionally, the AI DPD chip with an embedded neural network deeply integrates RF device characteristics to automatically calibrate signal distortion in real time, greatly enhancing nonlinearity compensation and translating it into PA efficiency gains, achieving a dynamic balance between efficiency and linearity.

These three innovations work together, enabling GigaMIMO to achieve a tenfold increase in capacity while sharing coverage with existing commercial 5G networks and improving energy efficiency by over 30% in the U6G band.

“From Massive MIMO to GigaMIMO, ZTE continues to push the boundaries by “deeply exploiting the spatial dimension,” laying a cornerstone for next-generation communication networks.”

Computing Capability

GigaMIMO faces the same fundamental challenge as large-scale computing systems—the scaling law: when the number of antennas or channels doubles, the matrix dimension also doubles, and computational complexity increases quadratically. GigaMIMO overcomes this challenge with a novel “1 master node + N collaborative nodes” architecture. It decomposes large matrix operations into multiple parallel subtasks, with each collaborative node processing a portion independently, reducing computational complexity from quadratic to approximately linear scaling. This means GigaMIMO can be implemented on existing commercial networks without requiring additional computing resources.

Collaborative Scheduling

Traditional schemes rely on GPS to maintain synchronization accuracy, achieving only nanosecond-level precision, which is insufficient for ultra-massive collaboration. GigaMIMO achieves two breakthroughs. First, it enables AI-predicted synchronization by combining inter-base-station calibration and UE-assisted calibration with AI prediction. Nodes can anticipate channel variation trends and complete synchronization in advance, boosting synchronization precision from the nanosecond level to the picosecond level—a thousandfold improvement. Second, it enables projection matrix compression: it applies an innovative channel matrix projection compression algorithm to reduce dimensionality, allowing the receiving side to fully recover channel information without affecting joint beamforming performance, while drastically cutting inter-site data

exchange—from about 64 Gbps to just 4 Gbps for a single 64TR cell, a reduction of over 93%.

GigaMIMO Delivers Remarkable Trial Results

The technical potential of GigaMIMO has been fully verified in live networks. Collaborative MIMO was field-tested at a university in Wuhan. Through an innovative high-precision cross-site clock synchronization and calibration mechanism, synchronization accuracy between sites was improved from the nanosecond level to the picosecond level, with phase error controlled within $\pm 10^\circ$, laying a solid foundation for joint beamforming. Multiple distributed sites form a virtual ultra-massive array, enabling more precise joint beamforming and effectively improving network performance in overlapping coverage areas. Field test results show that this technology boosts user-experienced rates in overlapping areas by 2–6 times and increases the average capacity by 26.5%, fully demonstrating potential for practical deployment. Meanwhile, field verification of centralized MIMO in the U6G band shows that single-user rates can exceed 9.6 Gbps, and single-cell throughput can surpass 192 Gbps.

Through its innovative exploration of 6G technologies and products, GigaMIMO not only enhances existing 5G-A network capabilities and substantially elevates user experience, but also provides a critical technical foundation for the smooth evolution from 5G-A to 6G. From Massive MIMO to GigaMIMO, ZTE continues to push the boundaries by “deeply exploiting the spatial dimension,” laying a cornerstone for next-generation communication networks. **ZTE TECHNOLOGIES**

Five Key Antenna Platforms for 5G Networks

In the construction and optimization of mobile communication networks, base station antennas serve as fundamental hardware for ensuring comprehensive cellular coverage, owing to their high reliability, low power consumption, and ease of deployment.

With the rapid rollout of 5G networks, challenges such as multi-band co-site deployment, limited antenna mounting space, and escalating manual operation and maintenance costs have become increasingly prominent. Consequently, antenna requirements are evolving toward higher integration, ultra-wide bandwidth, ultra-high capacity, green and sustainable operation, and greater intelligence.

The evolution from 4G to 5G has placed increasingly complex requirements on antennas, particularly in terms of multi-band, multi-mode coordination. Traditional narrowband, fixed-beam antennas are no longer adequate, and antennas are evolving from standalone RF components into system-level network nodes.

Currently, mainstream 5G base station antennas fall into five major categories: FDD multi-band antennas, FDD+TDD converged antennas, digital intelligent antennas (DIA), active+passive (A+P) integrated antennas, and AI-driven smart adaptive antennas (SAA). These five antenna platforms are widely applicable to various networking and optimization scenarios. The following sections describe the key features of each platform based on specific application requirements.

FDD Multi-Band Antenna: Core Infrastructure for Wide-Area Coverage

Moving beyond traditional single-band designs, this antenna integrates multiple FDD bands including 700 MHz, 900 MHz, 1800 MHz,

and 2100 MHz into a single unit, supporting multi-mode co-site operation from 2G to 5G. It effectively alleviates tower resource constraints and reduces multi-device interference. With low insertion loss, long-range coverage, and maintenance-free operation, this antenna is primarily deployed in suburban, rural, and along major roads to ensure continuous wide-area coverage. Mainstream products are 8- to 12-port ultra-wideband antennas with remote electrical tilt, represented by the ZTE 2L4H (two low bands and four high bands) 12-port multi-band antenna. It supports remote tilt adjustment for fine-grained network optimization.

FDD+TDD Converged Antenna: Key Enabler for 5G Capacity Expansion and Multi-Band Coordinated Networking

This antenna combines FDD's wide-area coverage capabilities with TDD's large-bandwidth characteristic, addressing the requirements of both continuous coverage and high capacity. It enables coordinated networking of high- and low-frequency FDD and TDD bands without requiring additional mounting poles. It is primarily deployed in medium- and high-traffic scenarios such as general urban areas, industrial parks, and core areas of county-level cities, balancing coverage quality and user throughput while significantly reducing base station retrofitting costs. The mainstream product is the FDD 2L4H + TDD 8TR 20-port converged antenna.

Digital Intelligent Antenna: A Dedicated Solution for High-Density Traffic Scenarios

Digital intelligent antennas employ sector splitting. The core principle involves splitting a



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conventional 120° sector into two 60° sub-sectors or multiple narrow-beam sub-sectors, thereby doubling cell capacity while substantially reducing inter-cell interference. This offers a low-cost, high-efficiency passive network expansion solution. Such antennas are widely deployed in dense urban areas, university campuses, commercial districts, and other high-traffic scenarios. Mainstream products include 6-sector hard-split and soft-split antennas. ZTE's soft-split antenna leverages digital weighting to enable flexible 4T6S and 8T3S configurations, effectively overcoming the high sidelobe levels and severe inter-cell interference inherent in conventional 8TR soft-split solutions. It is particularly suitable for 4G and 5G coexistence scenarios where high 4G traffic loads necessitate sector splitting for capacity relief.

A+P Integrated Antenna: Highly Integrated All-in-One Networking Equipment

This antenna integrates passive wide-coverage radiating elements with lightweight active RF modules. The low-band FDD passive unit provides basic wide-area coverage, while the high-band TDD (or FDD) active units handle high-capacity traffic in hotspot areas, achieving both broad coverage and localized hotspot capacity expansion. With a streamlined structure and simplified installation, it is well-suited for dense urban areas, general urban zones, and small- to medium-sized hotspot scenarios, representing a mainstream solution for coordinated coverage and capacity optimization in 5G networks. The representative product is ZTE's integrated A+P transparent antenna.

AI-Driven Smart Adaptive Antenna: Enabling "Last-Mile" Network Intelligence

Leveraging innovative technologies including topology visualization, attitude sensing, beam shaping, array adjustability, and intelligent optimization, this antenna delivers significant network performance gains. It is primarily applied in priority service areas, areas with tidal traffic patterns such as CBDs and campuses, and

emergency scenarios such as typhoon relief. The representative product is ZTE's intelligent adaptive 4+4+4+8-port electrically tiltable antenna, covering the 700 MHz, 900 MHz, 1800 MHz, and F/A bands.

Overall Deployment Strategy

In actual deployment, the five antenna types are flexibly combined based on coverage objectives, capacity needs, and site conditions. FDD multi-band antennas are mainly used in suburban areas, FDD+TDD converged antennas in urban expansion scenarios, digital intelligent antennas in high-traffic hotspots, A+P integrated antennas in new or space-constrained sites, and smart adaptive antennas in priority service areas. This tiered deployment strategy optimizes return on investment.

Together, these five antenna platforms form a comprehensive networking framework featuring wide coverage, high capacity, and intelligent optimization, fully addressing diverse 5G network requirements across coverage enhancement, capacity expansion, and optimization scenarios. They provide a hardware foundation for improving quality and efficiency while simplifying network architecture.

In addition, ZTE's antenna platforms incorporate transmission maximum (Tmax) technology, which highly integrates conventional power dividers, cables, and phase shifters. The resulting reduction in interconnection nodes improves impedance matching and radiation efficiency, enabling greener antenna products.

In summary, simplification, sustainability, and intelligence represent the overarching trends in antenna development. ZTE will continue its dedicated efforts across these three dimensions. Looking ahead, 6G research will drive the convergence of antennas with new technologies such as reconfigurable intelligent surfaces (RIS), enabling a shift from passive channel adaptation to active channel shaping. The integration of green, low-carbon principles with AI-driven autonomous networks will give rise to more efficient and flexible antenna architectures. **ZTE TECHNOLOGIES**

How 5G Ultra-Long-Range Coverage Is Reshaping Maritime Connectivity

Global marine economic activity is entering an unprecedented period of growth. The precision operations of deep-sea fishing, the large-scale O&M of offshore wind farms, the digital upgrade of marine tourism, and the intelligent transformation of maritime law enforcement—all these trends share a common underlying enabler: a reliable maritime communication network. Yet it is precisely in the vast and harsh maritime environment that traditional terrestrial communications fall short. For vessels far offshore or platforms operating in remote marine areas, a communication breakdown is not merely an efficiency loss—it can mean a safety risk. Achieving wide-area, high-reliability maritime connectivity at a reasonable cost has become a key challenge for coastal nations and regions worldwide.

Layered Collaboration: A 3D Network Architecture for Maritime Coverage

The difficulty of maritime communications lies in

the gradient effect of distance—the closer to shore, the higher the traffic density and the more stringent the throughput requirements; the farther offshore, the greater the coverage challenge, yet business demands do not necessarily diminish accordingly. A "three-network-in-one" architecture enables three-dimensional coverage on demand through layered collaboration (Fig. 1):

- Nearshore Network (0-10 km) leverages existing coastal base stations as anchors to provide high-capacity access. This zone supports high-density scenarios such as aquaculture rafts, port logistics, and coastal tourism, with demanding requirements for downlink throughput and network capacity. The solution deploys industry-specific private networks using sub-3 GHz and C-band frequencies, delivering 100 Mbps downlink and 5 Mbps uplink access capabilities to meet the real-time connectivity requirements of smart ports and aquaculture monitoring.
- Offshore Network (10-50 km) is the primary coverage zone for maritime operations.



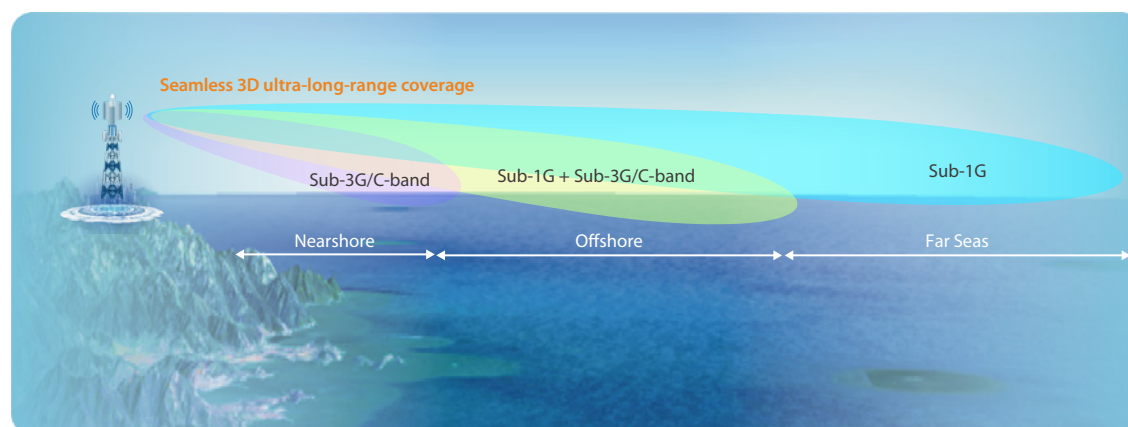
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◀ Fig. 1 3D network architecture for maritime coverage.

Ultra-long-range base stations are deployed at key locations such as coastal towers, hilltops, and platforms, combining low- and mid-band networking with high-gain directional antennas to provide stable signal coverage up to 50 km offshore. This layer supports core services including fishing vessel communications, video backhaul for maritime law enforcement, and marine ranch monitoring—making it the critical infrastructure for the digital transformation of the marine economy.

- Far-Sea Network (50-120 km) targets far-offshore operational scenarios. Sub-1 GHz low-band frequencies provide wide-area coverage, with shipborne CPE terminals serving as mobile relays and supporting seamless handover between 5G and satellite links. This ensures communication continuity at the network edge while dramatically reducing the costs of satellite-only communications.

The three-layer architecture is not solely distance-driven; each layer addresses specific coverage ranges and service requirements, forming an integrated and collaborative solution from nearshore to far offshore.

Technical Depth: From Signal Enhancement to Network Self-Intelligence

In the ultra-long-range coverage domain, challenges center on two key directions: how to make signals travel farther and how to keep the network stable and efficient in complex maritime environments. Achieving ultra-long-range coverage depends on systematic breakthroughs across multiple key technologies.

- At the RF layer, the combined application of three technologies significantly improves signal propagation efficiency. Dual-PA power superposition technology delivers approximately 2.5 dB of combining gain in transmit power; tower-top RRU deployment reduces feeder loss by 2–3 dB; and 65° narrow-beamwidth high-gain antennas precisely focus signal energy toward target sea areas.
- A further breakthrough comes from intelligent

O&M. Maritime networks face far more complex interference sources than terrestrial networks—atmospheric ducts, sea-surface reflections, and meteorological changes all cause signal quality fluctuations. Traditional manual optimization methods cannot respond in real time. By deploying intelligent computing boards at base stations, the network leverages AI computing capabilities to identify service types (such as video backhaul, voice calls, and IoT reporting) in milliseconds, dynamically allocate network resources, and proactively avoid interference sources. Field test data shows that in the 15–20 km maritime zone, uplink throughput improves by over 30%, latency drops by 7%, and service stuttering is reduced by 50%. This "self-optimizing" capability is particularly vital for maritime scenarios where O&M teams cannot be permanently stationed.

- Terminal-side innovation is equally critical. The marine environment imposes stringent reliability requirements on equipment—salt spray corrosion, extreme temperature differentials, and continuous vibration are the norm. Terminals designed for shipborne scenarios must operate stably across a wide temperature range of –35°C to 75°C, with transmit power reaching four times the industry conventional level to overcome long-distance transmission loss, while supporting dual-mode switching between 5G and satellite networks to ensure uninterrupted communications in far off-shore regions.

Commercial Validation: From Benchmark Projects to Global Deployment

The value of technology is ultimately tested in the market. In recent years, ZTE's ultra-long-range coverage solution has been deployed across multiple coastal regions globally, gradually forming differentiated commercial pathways.

- The Rizhao project in Shandong is a typical case of large-scale deployment. In 2026, 24 ultra-long-range base stations were deployed along the Yellow Sea coast, covering 50 km of coastline. The project integrates the 700 MHz low-band coverage with the 2.6 GHz capacity layer



through coordinated networking, achieving downlink throughput exceeding 100 Mbps in nearshore waters and maintaining uplink throughput above 10 Mbps in mid-to-far offshore areas. The service supports more than 1,200 fishing vessels and over 50 offshore platforms, enabling diverse applications ranging from fisher livestreaming to fisheries law enforcement.

- The Qingdao "Hanhaitong" project explores a commercialization pathway for far-offshore operations. Targeting fishing operations 80–120 km offshore, operators launched a "CPE terminal + satellite backup" service model. Equipped with Hanhaitong terminals, vessels use low-cost 5G connectivity in nearshore waters and automatically switch to satellite links within milliseconds when entering open seas, ensuring seamless communication continuity. Compared with traditional maritime satellite services, this model significantly reduces per-vessel communication costs. The terminal supports extreme temperatures from -35°C to 75°C and has been validated under harsh winter conditions in the Yellow Sea.
- In overseas markets, a 5G ultra-long-range maritime coverage test was completed in Indonesia's Sulawesi Sea using the 2.3 GHz band,

achieving a coverage distance of 60 km and providing a digital foundation for local fisheries and marine tourism. In South Africa's Mossel Bay, Africa's first 5G ultra-long-range maritime network was deployed, delivering throughput exceeding 210 Mbps at 22 km offshore.

Outlook: From Ultra-Long-Range Coverage to the Smart Deep Blue

The coverage bottleneck of maritime communications is, in essence, an adaptability challenge for terrestrial mobile networks in an entirely new spatial dimension. ZTE has proposed a network architecture centered on layered collaboration, validating a solution path that balances technical feasibility and economic viability through systematic RF hardware enhancement, dynamic optimization through intelligent algorithms, and scenario-specific terminal adaptation. For the marine industry, this means that communication connectivity is evolving from a "nearshore privilege" to "universal access across all waters"—livestreaming without stuttering, law enforcement without blind spots, rescue operations without disconnection, and data without silos. As technological boundaries continue to expand, the wave of digital transformation is advancing from land to the deep blue. **ZTE TECHNOLOGIES**

Green PA Evolution: Energy Efficiency Innovations for a Low-Carbon Future



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Radio access networks (RANs) consist of three core subsystems: passive supporting infrastructure (e.g., power distribution and cooling systems), digital baseband units (BBUs), and radio units (RUs, namely RRUs/AAUs). Among them, RUs account for approximately 40% of total mobile network energy consumption and up to 78% of power consumption at individual base stations.

Within each RU, power amplifiers (PAs) serve as the dominant power-consuming devices. As a key part of the digital front-end, they amplify signals prior to over-the-air transmission. Under heavy cell load, their power share increases significantly. For a conventional 4T4R dual-band 5G radio operating at full load, PAs may account for as much as 90% of the total power consumption.

Current mainstream energy-saving solutions mainly reduce PA power consumption through semiconductor process optimization and intelligent power management, including low-power idle modes and radio sleep/shutdown mechanisms during low-traffic periods. However, these incremental improvements are insufficient to satisfy the growing energy-efficiency requirements of next-generation RUs, calling for disruptive architectural innovations.

Integrated Hardware Optimization for High-Efficiency Green PAs

An integrated hardware paradigm moves beyond incremental improvements in traditional PA designs by integrating architectural performance, material reliability, and packaging compactness.

Super-N Architecture

At the core of the scheme is the Super-N architecture (Fig. 1), which replaces two bulky Doherty PAs with dozens of smaller PAs optimized in real time. Through multi-channel parallel arrays and adaptive load-sensing modules, the architecture dynamically adjusts operating transistor stages, bias current, and output power in response to real-time network traffic fluctuations. This adaptive operation effectively eliminates excessive static power loss under light- and medium-load conditions, a major source of energy waste in traditional PAs. In typical 4T4R dual-band 5G scenarios, Super-N reduces average PA power consumption by 25%–35% across the service cycle.

Diamond-Based Materials

To sustain the high-efficiency operation of the Super-N architecture and mitigate efficiency degradation at high temperatures, diamond-based materials can be adopted as the primary heat dissipation medium for high-power PAs in 5G and 6G scenarios. Conventional silicon and alumina ceramic substrates feature limited thermal conductivity. Even with high-power GaN transistors, high-density integration readily creates localized hotspots, resulting in degraded device performance and reduced reliability. In contrast, diamond-based materials offer an ultra-high thermal conductivity of 1,500–2,200 W/(m·K), approximately 5 to 10 times that of traditional substrate materials, together with a low thermal expansion coefficient, superior insulation, and high mechanical stability.

3D Heterogeneous Integration Packaging

3D heterogeneous integration packaging is a key



◀ Fig. 1 Super-N architecture.

enabler of miniaturized, low-loss, and highly stable PAs. Conventional 2D planar packaging suffers from lengthy interconnection traces, large parasitic parameters, and low integration density. In contrast, 3D vertical stacking technology enables high-density integration of PA core chips, passive components, and diamond thermal management modules. This structure drastically shortens signal interconnection routes, reduces parasitic resistance, capacitance, and inductance, cuts power losses during signal transmission, and raises device integration density by more than 60%. Meanwhile, the vertical stacking architecture creates a three-dimensional heat conduction path to further boost the overall device heat dissipation performance.

The combination of Super-N architecture, diamond-based thermal materials, and 3D heterogeneous packaging forms an integrated hardware system for green PA optimization. The architecture improves power, reducing heat generation at its source; diamond-based thermal materials enable long-term reliable operation through highly efficient heat dissipation; and advanced 3D packaging enables low-loss transmission, compact integration, and improved thermal management. This solution addresses key limitations of traditional PAs, including low light-load efficiency, severe thermal accumulation, and bulky form factors, providing a solid hardware foundation for the large-scale, low-carbon deployment of next-generation RU systems.

AI-Driven Energy Optimization

New-generation power amplifiers must also improve linearity to achieve higher energy efficiency. Linearity refers to a PA's ability to amplify signals

without distorting their waveforms, ensuring high consistency between the input and output signals.

Digital pre-distortion (DPD) is a technique used to improve PA linearity, enabling higher signal quality and improved power efficiency. Incorporating AI into DPD algorithms can further improve performance and adaptability.

Replacing or enhancing conventional DPD algorithms with machine learning models enables dynamic adaptation to diverse input signals and environmental variations. Deep neural networks (DNNs) can be trained to learn the nonlinear properties of PAs and modify the input signal in real time, while reinforcement learning or online learning enables DPD to self-adjust under real-world operating conditions.

AI-driven DPD requires substantial data for training and enhancement, collected from diverse real-world scenarios covering different frequency bands, output power levels, and environmental conditions. Simulations are conducted in controlled settings, and models are optimized using actual device data to ensure robustness. PA input and output signals are labeled to train models to identify and mitigate nonlinear distortion. Meanwhile, AI-based DPD systems accelerate radio design by optimizing the match between the PA and specific radio products for optimal performance, reducing development time from months to weeks.

Innovations in both PA hardware and software will be essential for reducing total power consumption and improving power efficiency, making a significant contribution to MNOs' energy reduction goals and accelerating the transition toward net-zero RANs. **ZTE TECHNOLOGIES**



ZTE and Zong Collaborate to Explore and Deploy UBR Solution in Pakistan

Over the years, ZTE and Zong (CMPak Ltd.) have been committed to driving technological innovation, exploring new solutions to enhance network capabilities and elevate user experience, and accelerating the commercial deployment of innovative wireless technologies in Pakistan.

ZTE UBR solution is one of the successful cases that has been deployed on a large scale commercially. It meets evolving requirements as the network develops while delivering a better user experience and higher revenue.

UBR Solution Meets Zong's Network Requirements

The successful deployment of the UBR solution not only meets the requirements of Zong's network development and evolution, but also addresses the specific needs of Pakistan's wireless market. Key characteristics of Pakistan's wireless market include:

- New site deployment results in a higher TCO due to substantial CAPEX and OPEX associated with

site acquisition, civil works, batteries, and diesel generators (DGs).

- Mobile subscriptions and smartphone adoption continue to increase. According to data from the Pakistan Telecommunication Authority (PTA), Pakistan's teledensity reached 83.35% as of July 2026. Smartphones account for 71.8% of active devices on Pakistan's mobile networks, while 2G-only devices account for around 28%.

These two factors lead to a lower ROI for new site investment. As a result, the sector-level expansion on existing sites become the preferred option. ZTE, together with Zong, introduced the sector split solution (ZTE X-Site solution) into the existing network, using 2T2R or 4T4R sector splitting. The sector split solution not only improves existing 4G performance but also brings additional benefits. First, it enables sector-level capacity expansion based on actual traffic load. Second, as it can be deployed on existing sites, it offers greater deployment flexibility and speed than new site deployment.

The sector split solution was first commercially deployed at scale on Zong's network by the end of

2018. In January 2019, ZTE together with Zong announced the commercial launch of X-Site+4T4R sector split solution in Pakistan.

With the large-scale deployment of the 4T4R sector split solution, new deployment challenges emerged. The growing number of single-band RRUs, including both reused and newly added units, increased site complexity, required additional tower space, and raised power consumption, resulting in additional OPEX.

Starting in 2019, ZTE and Zong pioneered the UBR solution (ZTE UniSite solution). The solution supports 4T4R on both the 1.8 GHz and 2.1 GHz bands, integrates filters to mitigate interference from the 1900 MHz band, and simplifies site deployment with fewer RRUs and lower power consumption.

Commercial deployment results show that, the UBR solution offers significant advantages in 4T4R sector-split scenarios (Fig. 1). For example, a traditional single-band solution requires five RRUs, two combiners, and two additional filters, whereas the UBR solution requires only two 4T4R UBRs. Additionally, the UBR solution enhances 4G capacity by upgrading LTE 2100 MHz from 1T2R to 4T4R. As a result, the UBR solution while reducing OPEX.

UBR Solution Expanded to More Scenarios with a Diversified Portfolio

With continuous network development and

evolving requirements, the UBR solution has been extended to a broader range of application scenarios, with new products and solutions introduced to meet diverse network requirements.

- **New site scenarios:** Three dual-band 4T4R UBRs can replace six traditional single-band RRUs, reducing the number of RRUs per site by up to 50% and helping reduce tower rental costs.
- **Hotspot and coverage blind spot scenarios:** In 2024, ZTE and Zong commercially launched the ZTE PAD site solution, integrating antennas, BBU, and UBR into a single unit, significantly reducing the site footprint and enabling more flexible and rapid deployment.
- **High-power UBR requirements:** Driven by LTE refarming and spectrum evolution, UBR power requirements have increased from the initial 4×80 W to 4×120 W to meet enhanced coverage requirements and deliver a better user experience.
- **Capacity expansion scenarios:** FDD Massive MIMO is a key 5G technology that can be introduced into 4G networks to enhance network capacity. As network requirements continued to evolve, ZTE and Zong further extended dual-band integration to 1.8 GHz + 2.1 GHz FDD Massive MIMO (FMM). In September 2021, Zong, together with ZTE, successfully completed the first commercial trial deployment of a dual-band FDD Massive MIMO site supporting both 1.8 GHz and 2.1 GHz in



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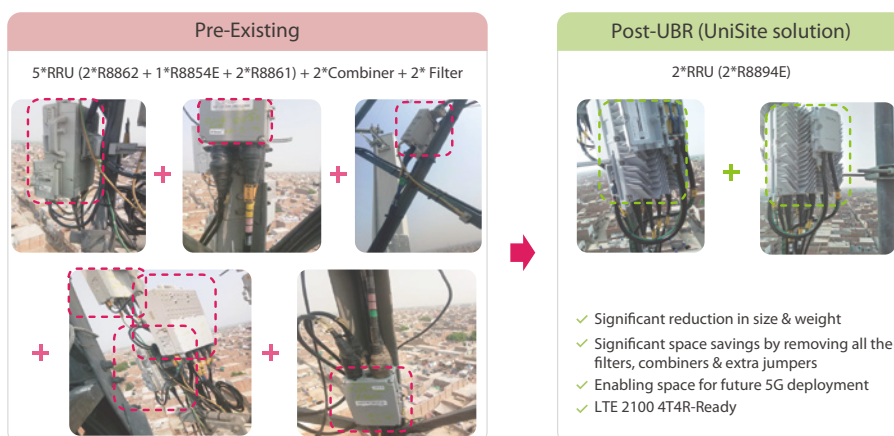
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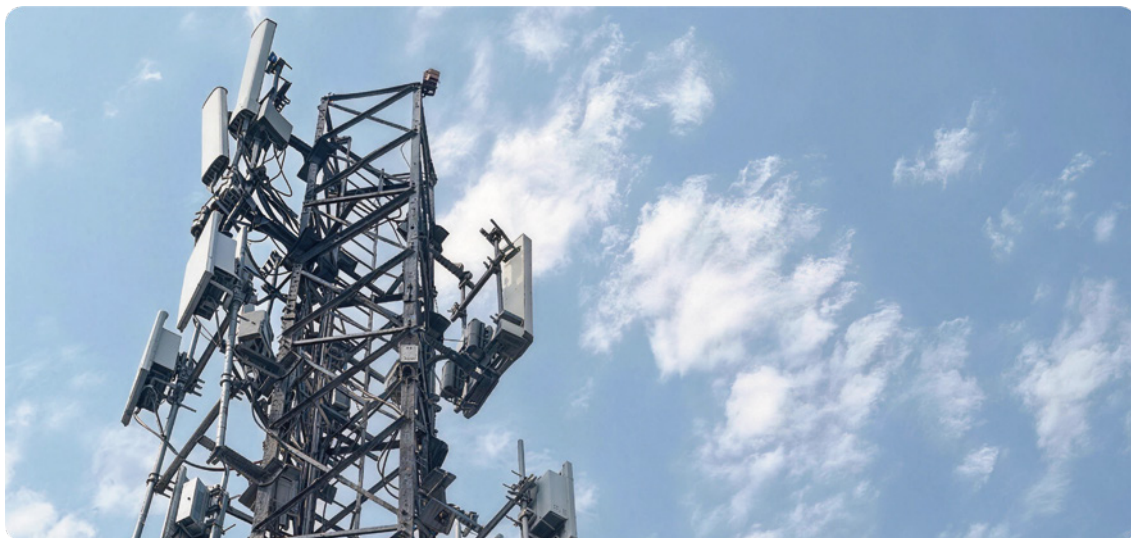


Liu Wutao

E2E Deputy Director
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◀ Fig. 1 UBR solution offers significant advantages over the traditional RRU solution.



Peshawar. Since then, FDD Massive MIMO has become a new capacity expansion solution and has been deployed at scale.

UBR Innovation Driving Enhanced Network Quality and User Experience

Since 2024, ZTE and Zong have accelerated UBR innovation, translating new technologies into improved network quality and user experience.

In 2024, ZTE and Zong introduced the innovative Omni 12T12R UBR Site, featuring ZTE's industry-unique Omni 12T12R UBR. Supporting both the 1.8 GHz and 2.1 GHz dual bands, the solution can be flexibly configured as either a 4T3S site (3 sectors with 4T4R per sector) or a 2T6S site (6 sectors with 2T2R per sector), accommodating 2G, 3G, and 4G while also being ready for the 5G evolution. Compared with the traditional 4T4R UBR, the Omni 12T12R UBR site reduces the number of RRUs by 67%, resulting in a corresponding 67% decrease in RRU-related tower rental costs and a 26% reduction in RRU weight.

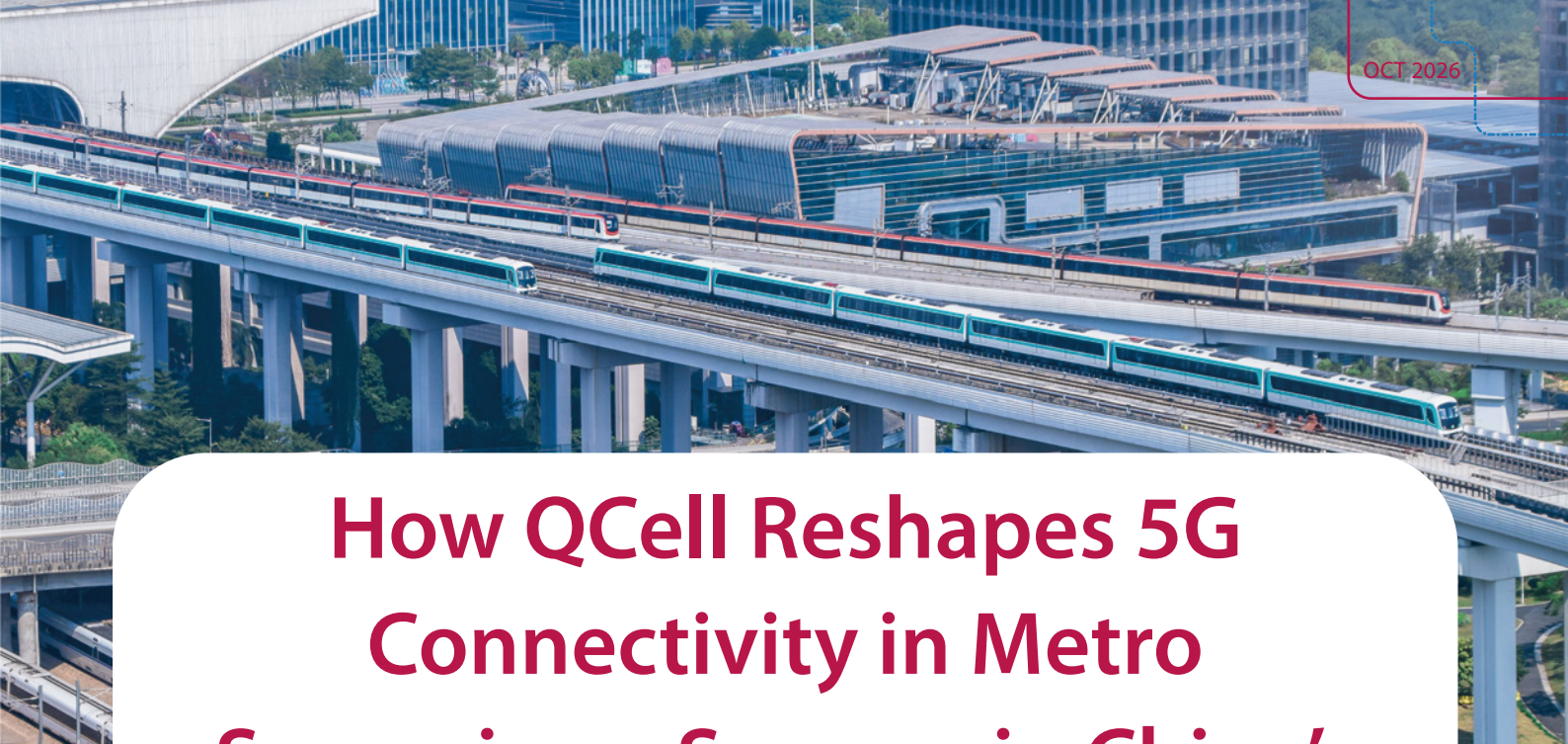
In 2025, ZTE and Zong further strengthened their collaboration with the commercial launch of the industry's first high-power 8T8R UBR solution coupled with ZTE digital intelligent antenna (DIA) solution, marking another significant milestone for both companies. ZTE's high-power 8T8R UBR solution delivers the industry's highest power

of 8×120 W for 1.8 GHz and 2.1 GHz dual bands. Coupled with ZTE's DIA antenna solution, the system supports software-defined beamforming function, which enables two 4T4R cells for current network or one 8T8R cell for the coming 5G NR deployment.

Accelerating AI-RAN and 5G Solutions for Future Network Leadership

Today, AI and 5G have emerged as key drivers of network evolution in Pakistan. Drawing on their successful collaboration and experience with UBR solutions, ZTE and Zong have continued to jointly explore evolving UBR requirements and AI-RAN solutions to support 5G network development. In February 2026, Zong and ZTE achieved the first commercial deployment of AI-based FDD Massive MIMO in Pakistan. By introducing the AIREngine board, the FDD Massive MIMO can automatically switch to multiple beams (up to six beams) based on traffic load, enabling efficient resource allocation, further boosting cell capacity, and optimizing user experiences.

Going forward, ZTE and Zong will continue to collaborate on innovative UBR solutions for new 5G spectrum bands, addressing new challenges as 5G deployment accelerates and supporting Zong in building a leading 5G network in Pakistan. [ZTE TECHNOLOGIES](#)



How QCell Reshapes 5G Connectivity in Metro Scenarios—Success in China's Metros and Beyond

If you have ever taken the metro during morning rush hour, you are familiar with the scene: platforms packed with hundreds of commuters, many using their phones to stream videos, make video calls, or scroll through social media. Then, almost simultaneously, the dreaded buffering spinner appears, rotating endlessly, or the signal bar simply vanishes.

ZTE has helped Chinese operators overcome this challenge with an innovative in-building solution. Today, metro stations, high-speed railway stations, and large shopping malls across China—places beyond the reach of outdoor macro base station signals—enjoy seamless 5G coverage, thanks to a small white “box”: QCell (i.e. pico RRU). Typically mounted on or concealed within the ceiling of station halls, it goes unnoticed by most passengers. Yet it has quietly transformed the daily underground commuting experience for millions.

Beijing Metro Line 12: China's First 5G-A 4CC-Enabled Metro Line

Shortly after the National Day holiday in 2025, passengers on Beijing Metro Line 12 noticed a subtle

change—a “5G-A” indicator appeared on their phones. Video loaded faster; scanning QR codes for entry and exit became smoother; high-definition streams played almost as smoothly as if connected to home Wi-Fi.

Behind this improvement, China Mobile and ZTE deployed 4-band QCell across all stations on Line 12 and enabled 5G-Advanced 320 MHz four-carrier aggregation (4CC) through software upgrades. Four-carrier aggregation combines spectrum resources across multiple frequency bands into a larger broadband pipe. ZTE's QCell aggregates four carriers—2.6 GHz (100 + 60 MHz) and 4.9 GHz (100 + 60 MHz)—and, combined with multi-antenna cooperative enhancement algorithms, significantly improves network throughput.

Field tests delivered remarkable results: average downlink throughput exceeded 4.4 Gbps, with peak rates reaching 4.6 Gbps. Line 12 thus became the country's first metro line to offer a 4CC ultra-fast experience, and the technology now covers all platform areas along the line. The significance of Beijing Metro Line 12 lies in demonstrating the continuous evolution capabilities of the QCell-based digital indoor distribution solution in the 5G-A



Lv Pei

RAN Product Planning
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era—the same hardware infrastructure, through innovations such as carrier aggregation, can evolve from gigabit-level to multi-gigabit (over 4 Gbps) performance.

Shenzhen Gangxia North Station: The “Eye of Shenzhen” Gigabit Experience

Gangxia North Station, an interchange for Shenzhen Metro Lines 2, 10, 11, and 14, is currently the largest metro station in China, with an average daily passenger flow of nearly 300,000. Its main hall ceiling, resembling a giant eye, has earned it the nickname “Eye of Shenzhen.” This landmark station also presents a typical high-capacity, ultra-dense networking scenario—vast open space, extremely high pedestrian density, and complex network topology.

In 2024, Guangdong Telecom and ZTE completed the first commercial deployment of a QCell-based 5G-A SuperMIMO + CA (3CC aggregation) solution operating across the 3.3–3.6 GHz band with 300 MHz of bandwidth. It achieved a new peak downlink throughput of nearly 5 Gbps, demonstrating that 5G-A technology in transport hubs has reached commercial viability.

The elegance of the SuperMIMO scheme lies in its software-based approach: leveraging the existing QCell active digital indoor distribution system, it

coordinates spatially distributed pRRUs to form a virtual large-scale antenna array akin to outdoor macro-cell systems. On the one hand, joint beamforming converts interfering signals into useful ones, enhancing the single-user experience; on the other hand, MU-MIMO efficiently enables spatial multiplexing among multiple users, significantly boosting cell capacity.

“Given how enormous Gangxia North Station is, I didn’t expect China Unicom’s network to be this fast—even when the train carriages are crowded, the connection remains smooth,” remarked a daily commuter on Line 11.

The experience at Gangxia North Station confirms a key insight: in high-density, high-value indoor scenarios such as transport hubs, the QCell digital indoor solution, coupled with software innovations like SuperMIMO, can deliver a quantum leap in performance without hardware replacement.

From Metro to Broader Scenarios

The deployment expertise accumulated in metro environments is equally transferable to other high-density indoor settings.

Large Sports Venues

In 2021, the “Big Lotus” main stadium of the



Shenzhen Gangxia North Station



Hangzhou Olympic Sports Expo Center—the venue for the opening and closing ceremonies and track-and-field events of the 2022 Asian Games—required reliable wireless connectivity for up to 80,000 spectators. Hangzhou Telecom and ZTE completed the world's first test and verification of a 300 MHz 5G QCell at this site. In a live test, FTP downlink throughput reached 1.2 Gbps, with uplink rate sustained at 331 Mbps. With the 1D3U (DSUUU) large-uplink frame structure, peak uplink rates exceeded 730 Mbps. Key areas—including spectator stands, the field, and VIP lounges—were fully covered by 4G/5G signals using ZTE's QCell equipment. At the Chengdu Phoenix Mountain Ice Basketball Arena, Sichuan Telecom and ZTE commercially deployed a QCell system with the 1D3U large-uplink feature enabled, effectively ensuring a reliable user experience during events.

Large Shopping Malls and Commercial Centers

In a major shopping mall in Chengdu, Sichuan Telecom and ZTE deployed QCell products featuring SuperMIMO in the 3.5 GHz band. Live test results showed 5G user rates of around 1.2 Gbps, with peak single-user rates reaching 1.5 Gbps—approaching

the theoretical limit for a single user.

Airports and Other High-Density Indoor Scenarios

QCell series products have been extensively deployed in airports, large hotels, commercial shopping centers, and high-traffic office buildings. The QCell supports NR OBW meeting the full bandwidth requirements of major operators in China. It can also connect to power dividers and ceiling-mounted antennas for flexible multi-point deployment—particularly suitable for underground parking garages with numerous obstructions and irregular layouts.

Concluding Remarks

While these deployments originate from China, the challenge of delivering stable, reliable 5G experiences in high-density scenarios is a common concern for operators worldwide. ZTE is committed to sharing the deployment insights it has gained from complex scenarios—including metros, high-speed railways, sports stadiums, and more—with global operators, offering customized solutions tailored to diverse needs. **ZTE TECHNOLOGIES**

ZTE

To lead in connectivity and intelligent computing, enabling
communication and trust everywhere