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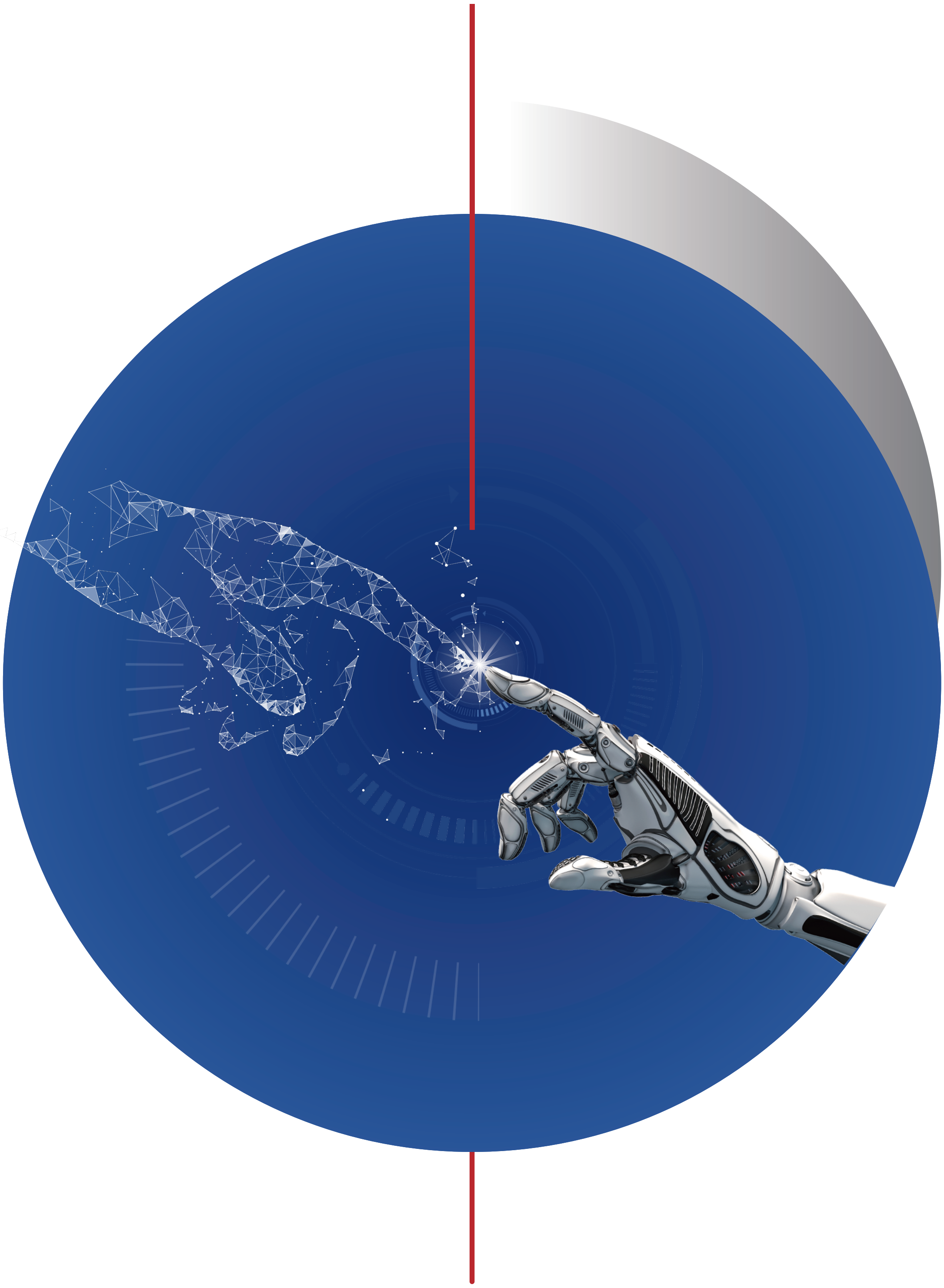

Roads to Mobile 2030
10 Wireless Industry Trends

Building a Fully Connected, Intelligent World

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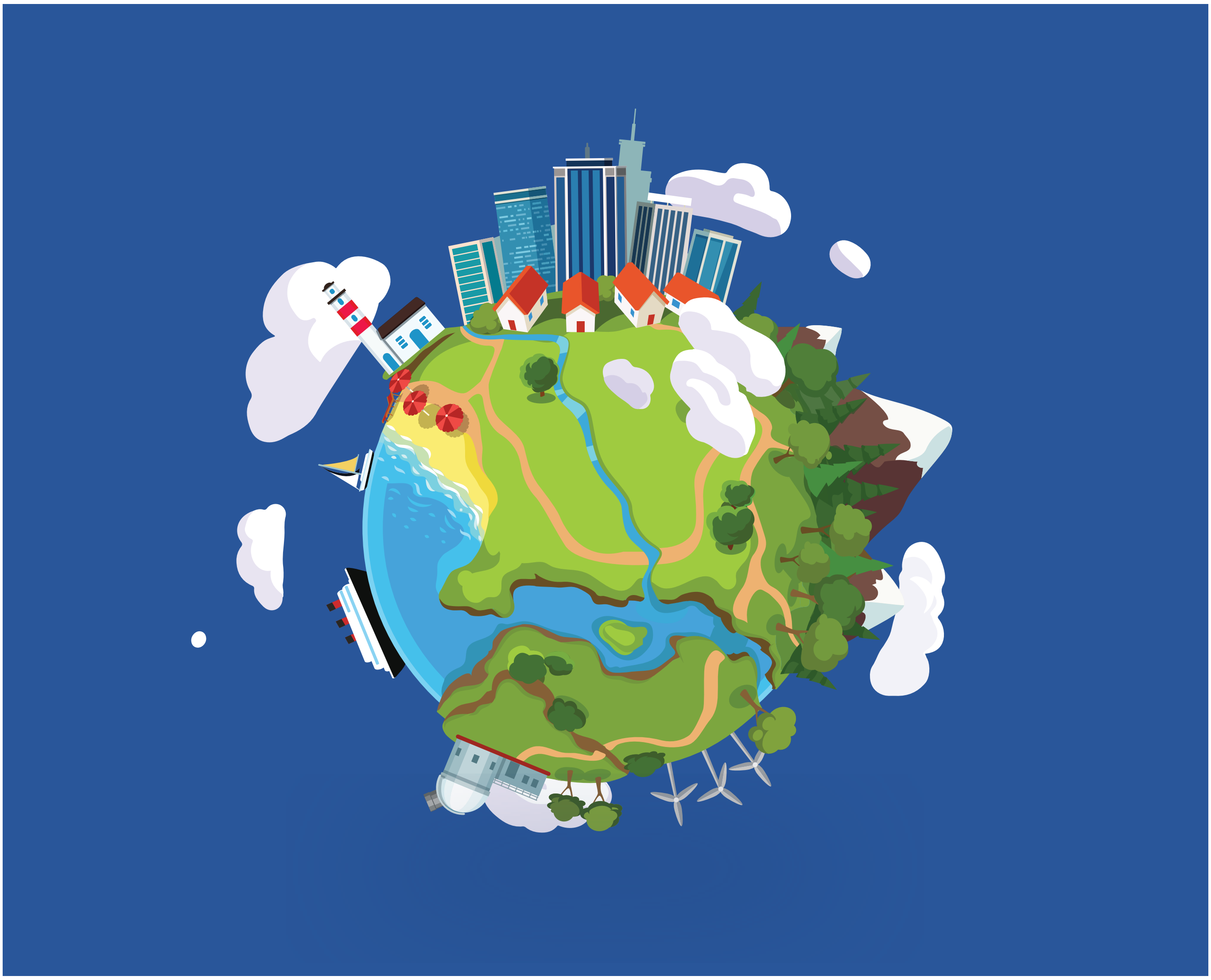
Wireless Network Connect Intelligent World 2030

5G is developing rapidly worldwide. By September 2021, 176 commercial 5G networks have been deployed, involving over 1.5 million 5G sites. Global 5G users have reached 520 million, enjoying a brand-new cross-generational experience. At the same time, the proportion of HD video duration has increased to 80%, and popular short video apps tend to stream high-quality video, such as 1080p and HDR. Further, the resolution of mainstream VR content doubles compared to 2020.

Industry IoT is also scaling up. Over 10,000 projects will be completed in 2021, integrating over 250 modules and terminals into steel, port, manufacturing, and many other key industries, through more than 1,500 commercial contracts. This shows that more and more enterprises are using 5G to improve efficiency, quality, and security at reduced costs.

5G is changing industries and everyday lives, but this change is just the beginning. At the turn of a new decade, the Intelligent World 2030 is already taking shape.



Society: Physical-Digital Integration

Over the past two years, the ongoing outbreak has rapidly pushed digitalization forward. Teleworking, teleconferencing, and online learning are commonly adopted. As 5G continues to develop alongside new Internet technologies, a "digital new continent" is flourishing. By 2030, more than 50% of individual activities will take place in a digital space that is integrated with the physical world to an unprecedented extent. Digital life will be more convenient and diverse than the physical one, becoming quite close to our physical reality.

With physical and digital convergence will come a full-real and full-sensing mobile Internet. XR will bring holographic and immersive experiences, with full interaction through hearing, sight, touch, and smell as a major part of communicating in the digital space. Always-on AI and cloud computing services will diversify work and lifestyle applications. 5G connected vehicles along with multi-sensory communications and autonomous driving will become a third mobile space beyond homes and offices.

Business: Age of Digital Economy

The digital economy has shown a strong resilience during the global health crisis. 5G increases the convergence of digital technologies with the real economy to improve production efficiency, injecting new momentum into economic growth. From production to consumption, diverse demands have caused sharp changes to production models, with the decision-making points gradually moving upstream, which requires enterprises to innovate.

Towards 2030, 5G and other technologies like AI will trigger a new wave of technological transformation, taking the digital economy to new heights. 5G connections will enable a massive number of sensors, robots, and production devices to interact in real time. Advanced intelligent algorithms will facilitate production simulation, verification, prediction, and control, improving both tool and decision-making efficiency as well as promoting smart manufacturing, human-machine collaboration, and flexible production.

High-speed networks with higher reliability will emerge to deliver AI-as-a-service (AIaaS), security-as-a-service (SaaS), and computing-as-a-service (CaaS) on demand, making AI and computing resources more available and accessible to the enterprises looking for intelligent growth at drastically reduced costs.

Environment: Green Growth and Intrinsic Security

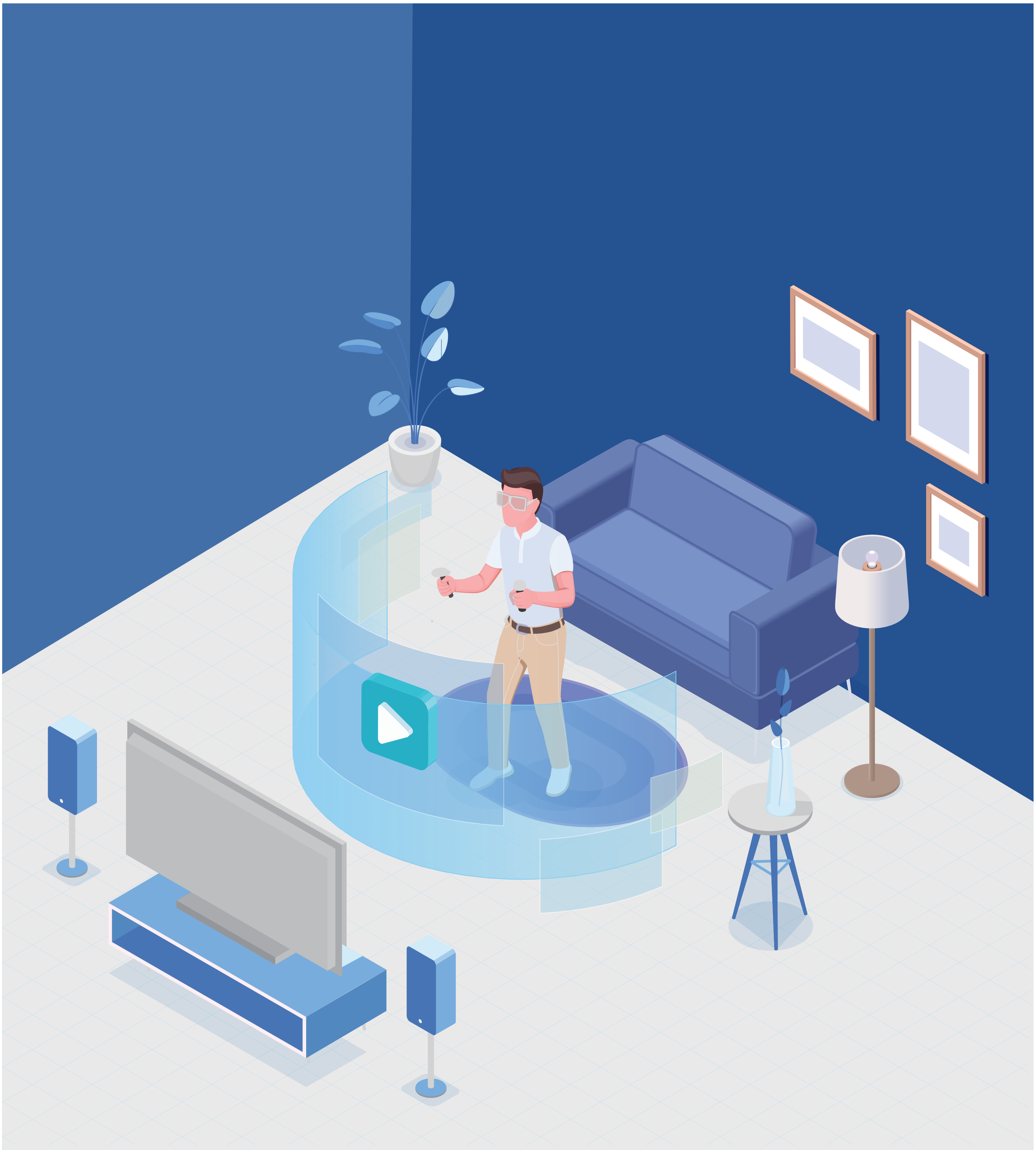
To date, more than 120 countries and regions have announced their carbon neutrality targets. The International Telecommunication Union (ITU) has proposed a 45% reduction in ICT carbon emissions by 2030. This goal requires industry-wide efforts to cut the energy consumption of ICT products and increase the share of renewable energy in networks.

Moreover, mobile networks need to accelerate digitalization in various industries to help them improve energy efficiency and reduce carbon emissions. For example, smart operations and status monitoring help improve the efficiency of power grids; production automation and precise decision-making help industrial enterprises reduce resource waste. Furthermore, 5G networks must provide connectivity and sensing capabilities across even remote areas, including mountains, rainforests, and oceans, to help tackle extreme weather and epidemic outbreaks.

Constant social progress relies on collaboration where trust is crucial. Therefore, trust and security will be essential for mobile networks to catalyze industrial transformation and act as the new anchor for a digital society. Mobile communications cannot safeguard the operations of various industries unless they are visible, manageable, controllable, and secure. In 2030 and beyond, new services, architectures, and technologies will create security challenges, requiring mobile networks to adapt their security capabilities to given contexts.

10 Wireless Industry Trends in This Decade

Trend 1: 10 Gbps for Physical-Digital Integration



5G brings cross-generational user experience. 360 ° free-viewpoint videos have been gradually applied in live broadcasting services. New applications, such as AR and VR, are creating a better simulated experience. The world is stepping into a future where the virtual experience is becoming more real, more interactive, and more immersive.

Real-time interaction requires a lower latency in addition to higher speeds. For example, 360 ° VR and AR Pro featuring virtual and physical convergence will use 8K, 16K, or even 64K resolution as well as up to 60 to 120 fps frame rate. This requires networks to provide 1 to 10 Gbps in the downlink and over 100 Mbps in the uplink while ensuring an E2E delay of 1–5 ms.

These requirements will exert enormous pressure on mobile networks in terms of capacity, stability, and uplink capabilities. A cell now providing 4K XR video services of 60 fps to 5–10 users will only be able to support one user once the video configuration is enhanced to 16K and 120 fps. This means that capacity will need to expand. The interactive video experience of high-resolution multi-angle AR will also require networks to provide a lower latency and higher robustness to combat signal fluctuation, ensuring the experience of cell-edge users. Real-time video upload for interactive immersive services further necessitates higher uplink speed from current xMbps to up to 100 Mbps.

The following technologies will play a crucial role in providing 10 Gbps connectivity with low latency for ubiquitous, immersive, and interactive video experience.

- Flexible duplex: Some subframes of a TDD downlink slot are used for uplink transmission to help reduce latency and increase uplink speed. By breaking the hard division between FDD uplink and downlink spectrum, some uplink spectrum is used for downlink transmission, increasing downlink speed. As such, uplink and downlink resources can be used more efficiently in specific contexts. Interference issues can be resolved through spatial isolation and mutual aid between transmission and reception, while breakthroughs can be made in engineering implementation.

- Service QoS guarantee: Key technologies, such as network coding and interaction with layer 2 HARQ, ensure low latency and cope with signal fading. The joint coding design between signal sources and channels improves reliability and maximizes efficiency while delivering the minimum guaranteed bandwidth.

Trend 2: One Network for 100-Billion All-Scenario IoT

People-to-people mobile connections have improved our communication and lives, while thing-to-thing connections will reshape the digital society. By 2030, cellular networks will see universally more diverse and complicated IoT connections. Mobile IoT networks need to evolve to cover various use cases over a single network.

NB-IoT has had nearly 300 million connections, but its maximum connection capacity is still limited to several thousand. NR can provide large bandwidth, but it is still often too expensive. Furthermore, different IoT types require different speed levels, so we need to define more IoT types. Now, IoT is available not only in low-speed use cases like water meters and smoke sensors, but also in high-speed ones such as XR services and smart wearables. And as we diversify connections from low-speed kbps to high-speed Gbps, we can also deliver the precise speed required by each IoT scenario.

In addition to various speeds, IoT requires new capabilities. For example, uplink and deterministic latency are a key demand for IoT in healthcare, steel, manufacturing, and other industries. Let's look at manufacturing: we need to build uplink-centric networks to deliver xGbps capabilities required for machine vision applications. Another example is industrial control. With low latency and high reliability, deterministic experience can be guaranteed for process control and machine collaboration. Industrial control requires deterministic latency to drop from 20 ms to just 1 ms and also provide a 99.9999% latency reliability. Key technologies include:

- Flexible configuration, which enables seamless transmission between uplink and downlink. Antennas having a high isolation and filters having a high roll-off can ensure proper downlink-uplink configuration on adjacent carriers.

- Interference control and reliable transmission, which ensure latency reliability, including high-reliability robust weight algorithms and fast closed-loop interference control in the time, frequency, and space domains.

Another key area of improvement is passive IoT. There are many devices that do not use batteries, either due to limitations or to save costs (such as some fast-moving products, logistics packages, and product packaging). These form the end of the hundreds of billions of passive IoT connections and are based on battery-free passive label technology. Network technologies offer a new way to improve passive IoT in identification precision, coverage, positioning accuracy, recognition efficiency, and cost effectiveness. This requires the industry to jointly define relevant standards and build a support ecosystem.

Currently, passive IoT applications are limited to entrance and exit areas. Scaled deployment depends on whether coverage can be significantly improved to support an NLOS transmission of more than 100 m outdoors and more than 30 m indoors. It further requires enhanced regional networking to support interference coordination among readers, ensuring a 99.9% read success rate. The labeling technology supports energy harvesting and can work with an extremely low power usage of below 10 µW at a very low cost. Key technologies include:

- Centralized multi-antenna sweeping, narrowband transmission, and reverse amplification, which are used to improve the coverage of passive IoT.

- Excitation signals are orthogonal to NR/LTE subcarriers to ensure their coexistence. Interference coordination and suppression based on base station scheduling supports adaptive networking. Digital-analog hybrid technology enables self-interference cancellation.

- Simplified protocol stack, lightweight strong security protection mechanism, and lightweight access/management sessions help reduce TCO.

Trend 3: Satellite-Ground Collaboration for 3D Coverage

Today, three billion people around the world still have no access to the Internet. About 700 million of them live in remote areas. In addition, most geographic areas around the world, such as forests, mountains, deserts, oceans, and skies, are not covered by networks. Mobile networks have more capabilities and operate at a higher efficiency in densely populated areas, while satellites provide more economical coverage in areas with a population density less than 10/km2. The combination of both can achieve 100% global coverage and further bridge the world's digital divide. Importantly, this will also create 3D coverage for near-ground space, making communications and control possible for aerial vehicles like drones and planes.

Continuous breakthroughs in core technologies concerning wireless communications, integrated circuits, satellites and carrier rockets, have occurred over the past two decades. The technology that supports satellite launches and processing capability of satellites have improved a lot. Therefore, the combination of mobile and satellite communications becomes increasingly mature.

With mobile networks, advanced cellular technologies can be used for satellite communications. This solves the capacity, deployment, and mobility problems of satellites. For example, multi-antenna and radio multiplexing technologies can improve satellite coverage and spectrum efficiency; high equivalent isotropically radiated power (EIRP), high-density interconnection, and large phased array antenna technologies can provide multi-point beam coverage and high-gain adjustable beams to solve problems caused by high speeds of satellites, such as large propagation path loss, ionospheric scattering, and Doppler shift; and ultra-high-speed mobility can solve the constant changes of access locations between devices and satellites, ensuring network service quality.

What's more, satellite communications can share the mobile industry chain and thrive on the huge installed base of the mobile market. To collaborate satellites with ground communications, the network protocols, spectrum, and devices must be integrated. First, satellite and mobile network protocols must be mutually inclusive to provide access on demand. Second, the spectrum resources of satellite and mobile networks must be combined to ensure co-existence. And last, satellite and mobile communications must share the same device industry chain. This means devices should be able to directly access satellite networks. The IMT industry chain will quickly bring down the cost of satellite devices.

Trend 4: Integrated Sensing and Communications for True Digital Replica

Integrated sensing and communications will bring applications beyond those of traditional mobile networks. A digital replica of the real world can be created by using wireless communications signals for real-time sensing that obtains actual environment information and also using advanced algorithms, edge computing, and AI to generate ultra-high-resolution images. Integrating real and virtual worlds delivers a more realistic experience.

Sensing is required in various industries, such as vehicle, person, and object sensing in the Internet of Vehicles (IoV), intrusion detection in security protection, drone detection in aviation regulation, detection of falling, breathing, and heartbeat in medical rehabilitation, and wind speed and rainfall sensing in meteorological detection. Meeting these requirements usually requires new spectrum resources to construct sensing networks, which is time-consuming and costly. However, through software and hardware upgrades, sensing capabilities can be provided using widely deployed 5G networks, which have inherent networking advantages, strong coverage, and large-scale antenna arrays. In this way, 5G networks become capable of both communications and sensing.

Integration is the basis for the wireless sensing. Multi-type target sensing capabilities are built on existing 5G networks to provide 24/7 wide coverage without having to change network architecture and increase site deployment density. Communications and sensing resources can be multiplexed through time, space, and code division, so that sensing functions can be added to base stations as required at lower deployment costs. High-isolation antennas are full-duplex and have 5G TDD enabled, that is, supporting a co-frequency co-time full duplex (CCFD) sensing mode while ensuring optimum communications performance. Architecture integration can help standardize the processes and interfaces of sensing control and data flows, making it possible to rapidly provide E2E sensing services in different industries and ensure data security.

Increasing sensing resolution is the key to expanding sensing applications. Ultra-wideband Massive MIMO can achieve centimeter-level sensing. Multi-site collaboration of cellular systems can add 3D multi-angle sensing with no blind spots to single-site sensing. In addition, the machine learning-based target recognition algorithm can improve the recognition resolution with rich multi-dimensional (time, frequency, space, and code domains) 5G NR information.

Trend 5: Intelligence in Every Industry and Connection

Networks have become increasingly complex with the development of communications technologies and the expansion of 5G applications. Traditional O&M modes can no longer meet the requirements of diversified networks. Multi-band and multimode cellular networks complicate networking and network collaboration, which brings challenges in multi-band and cross-domain collaboration, fault locating in complex networking, and unified resource scheduling and experience management in the context of dynamic user changes. 5G networks, as an enabler of various industries, need to provide various types of services and meet personalized experience requirements. Therefore, user experience management is complex and O&M is difficult.

By 2030, high-level autonomous driving networks featuring with "full automation, zero wait, and zero touch" will be built to promote comprehensive evolution toward intelligent radio interface, network, and O&M. This constitutes one of the important capabilities that support the digitalization of various industries. The intent-driven and AI-powered wireless networks will keep moving up in level of automation, from highly autonomous level 4 to fully autonomous level 5.

Future networks will be capable of autonomous thinking and decision-making so as to deal with the different business intents of different industries. They can automatically, accurately, and efficiently identify the service objectives in telecommunication, agriculture, public utilities, oil and gas, logistics, and finance fields, convert them into network configuration languages, and orchestrate them. This enables efficient adjustment and allocation of network resources as well as fast adaptation to service changes and requirements.

In addition, level 5 autonomous driving networks will be capable of self-evolution and zero-touch automated O&M. After the network receives an intent-driven adjustment policy, the base station reports information it detects about itself and its surrounding environment in real time and generates a digital twin model. Based on the environment and hardware information reported by the base station, the network automatically adapts parameters and possible scenarios. Intelligent fault monitoring supports fault detection and cross-layer collaborative diagnosis. And the spatiotemporal dynamic correlation algorithm can issue fault alarms in advance to enable self-recovery. Network performance self-optimization will gradually replace manual, experience-based optimization. Machine learning and performance simulation can find the optimal network parameters and collaborate multiple targets across sites automatically.

The radio interface is the most complex part of a wireless network, but by 2030, we can expect radios with native intelligence. Intelligent radio reconstruction algorithms, including the neural model algorithm, can provide more flexible modes for channel, spectrum, and codeword scheduling. This can improve performance and energy efficiency by 50%, approaching the theoretical limits.

Trend 6: Full-Link and Full-Lifecycle Green Networks

In this decade, the mobile industry is expected to deliver a good network experience anytime and anywhere. In a fully-connected digital world, network traffic is expected to grow by 100 times. With industries moving towards green growth, mobile communications is no exception. To prevent the energy consumption of mobile networks from increasing linearly with traffic, full-link and full-lifecycle green networks must be built to improve energy efficiency per bit by 100 times.

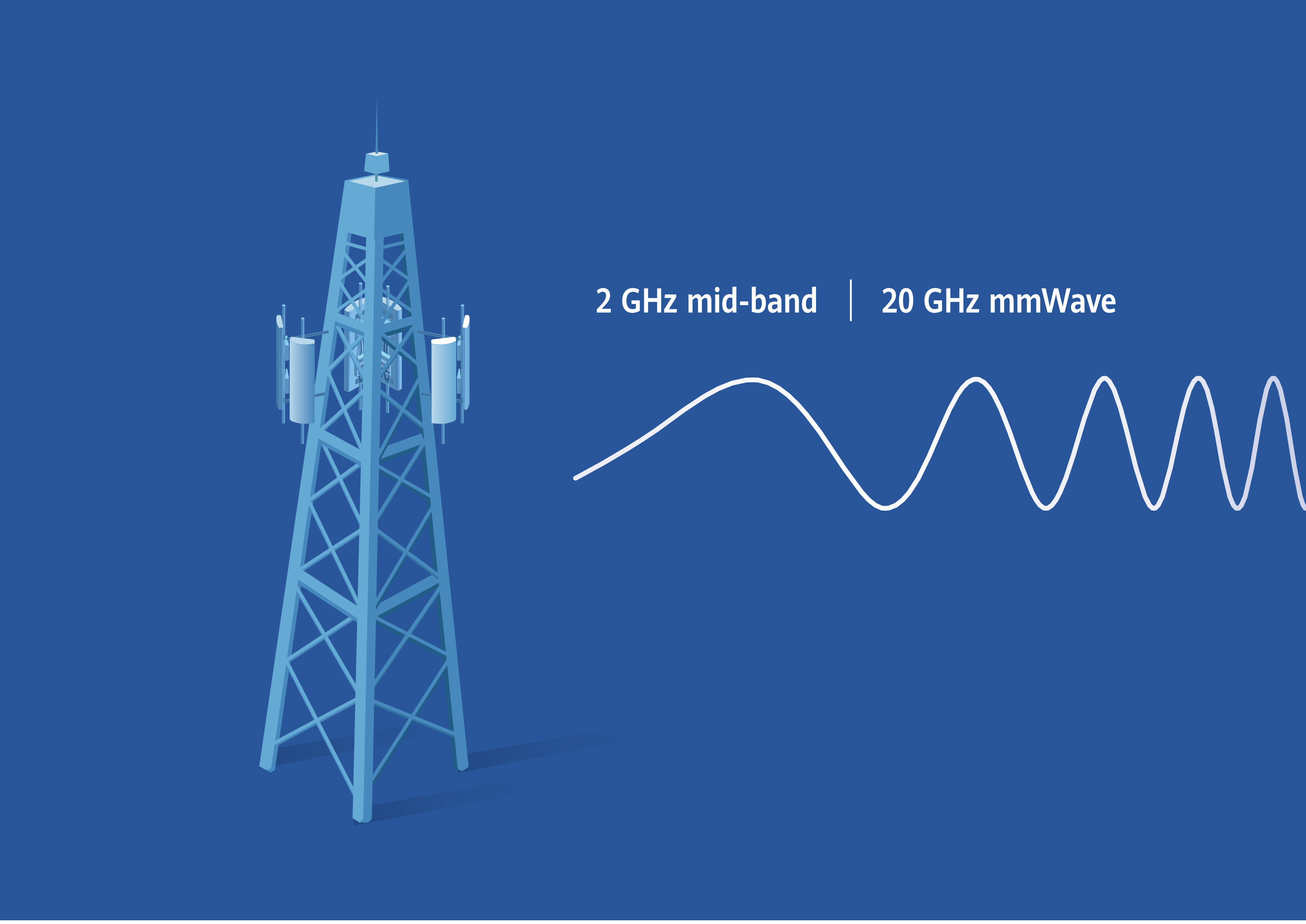
For base stations, high performance used to be the focus. In the future, energy efficiency must be considered as a fundamental factor. Key green and energy-saving technologies throughout the energy transmission link must be transformed, such as auxiliary equipment on the energy supply side, base station main equipment on the energy use side, and green radio interface technologies for device energy saving.

Networks will become intelligent. Intelligent networks can shut down physical components based on scenario-specific network KPIs and user QoS requirements as well as the time, space, or frequency domains of services to reduce the energy consumption of base stations. This guarantees a good network experience while saving energy, achieving network-level intelligent energy saving. In addition, a decoupled architecture will be applied to deploy uplink-only or downlink-only sites for different scenarios. And near-field networks will allow sites to be deployed close to users, reducing network transmit power.

Sites will be simplified. Systematic site design will improve the energy efficiency of power supply links by taking into consideration the energy conversion efficiency of every node, line loss of the links, and power consumption optimization of auxiliary devices such as air conditioners. Site architecture innovations, such as centralized BBUs and full-outdoor air-condition-free sites, will reduce non-functional devices such as air conditioners.

Future equipment will be inherently efficient. Energy saving in power, time, frequency, space, and code resources will be explored by studying modules, architectures, processes, materials, and algorithms to continuously improve equipment energy efficiency. Future AAU power consumption reduction will change, from active antenna unit (AAU) power increase to comprehensive im-

provement of AAU power and passive antenna diameter. With larger antenna diameters, the same cell coverage can be achieved with a smaller RF transmit power, greatly reducing the energy consumption of base stations. Moreover, the dynamic capability of equipment will be improved so that maximum energy efficiency per bit can be achieved, no matter whether they are busy or idle.



Trend 7: Flexible Full-Band Sub-100 GHz

User DOU is growing exponentially — expected to reach 600 GB by 2030 — as UHD video and XR Pro become more popular, and hologram and sensory technologies mature. Cellular networks will carry more than half of the world's traffic, while WTTx will carry 20% of home broadband traffic.

More spectrum resources are required to fulfill these demands.

In terms of sub-10 GHz, each country requires an average bandwidth of 2 GHz. In addition, over 20 GHz of bandwidths are available on the millimeter wave. Therefore, with sub-100 GHz spectrum, the industry can evolve sub-100 GHz spectrum to NR, by further developing incumbent spectrums as well as defining and allocating new spectrums.

Different spectrums have different characteristics. The low band provides wide coverage but insufficient bandwidth, while the

high band is ideal for traffic hotspots because of its high bandwidth. In contrast, the mid-band combines their advantages to provide both wider coverage and better experience. Therefore, sub-10 GHz spectrum resources are valuable. To maximize the value of this golden spectrum, multi-band combination is required to achieve continuous and wide coverage. As traffic increases, by 2025, high-capacity sites need to be expanded using mmWave base stations, which are then expected to gradually deploy on a large scale. Therefore, sub-10 GHz and mmWave spectrums are required to build a cellular network with continuous coverage.

Despite its advantages, operators also have certain challenges, such as band combination on sub-100 GHz and discrete spectrum. Hence, operators need to reconstruct the way they use multiple spectrums to maximize value to achieve ten-fold spectral efficiency. With multi-band convergence that significantly improves system resource utilization, operators can flexibly use different bands, choose duplex modes, allocate uplink and downlink time, frequency, and space resources, as well as distributing services and controlling channels based on service types, user locations, moving speeds, and network loads. Moreover, control channel overhead can be reduced by having multiple bands to share common control channels. For this, control-plane connections are carried over low-band and high-reliability networks while user-plane data is carried over high-band and large-bandwidth networks. By modifying the TDD system, some resources in the downlink subframe will be also used for uplink transmission. This will help addresses challenges on low latency and uplink coverage, ultimately achieving optimal performance.

Trend 8: Generalized Multi-Antenna for Reduced Per-Bit Cost

Reducing the per-bit cost is not only the unremitting pursuit of researchers and engineering experts, but also the economic basis for the rapid development of next-generation communication systems. It is hard to predict the future of mobile networks over this decade, but mobile traffic will certainly grow exponentially. Lower per-bit cost is therefore critical for the ICT industry to build sustainable and healthy wireless networks. Innovation in coding technologies from 2G to 5G has already prompted unbounded growth in mobile communications, and this continued progress is pushing the limits of Shannon's Law. In 5G, we've witnessed the wide use of multi-antenna technologies, which extends the limit of Shannon's Law and significantly reduces per-bit cost. For example, the 5G TDD C-band quintuples the bandwidth per carrier compared with 4G FDD (100 MHz vs. 20 MHz). Massive MIMO also improves spectral efficiency by three to five times. Continuous innovation in engineering can slash the cost per bit by 15 to 25 times at the same cost of network construction.

To achieve a hundred times less cost per bit by 2030, we need to think outside the box, exploring new dimensions and spaces of wireless communications. This means improving and breaking through assumptions based on Maxwell and Shannon formulas in real-life scenarios, that is, finding the best way to combine electromagnetic field and information theories to ultimately add new value. In addition, spectral effi-

ciency can be improved with non-orthogonal multiple access (NOMA) and non-linear coding technologies.

Applying multi-antenna technologies to every band and every scenario is an important way to reduce costs and increase efficiency. In the future, massive MIMO will be supported on all bands, significantly improving the spectral efficiency and easing the deployment of bands below sub-100 GHz. Hence, architecture innovation in Massive MIMO, multi-band/broadband highly-integrated antennas based on metamaterials, and technological innovation such as super-resolution multi-antenna, high isolation of transmit and receive signals, and digital analog cancellation, are critical for the wide deployment of Massive MIMO.

Moreover, services and sites are no longer bound together via the User Centric No Cell (UCNC) networking. Multiple site links are available for user services, improving useful signals while reducing signal fading and interference. In this way, resources are allocated based on users, and user-centric networks can be built to provide non-disruptive services at cell edges. Multiple technologies are required to build UCNC networks, including duplex-enabled integrated access and backhaul (IAB), macro-macro and macro-micro network coordination, high-performance clock synchronization network and channel calibration, and high-precision channel estimation algorithm for time, frequency, and space dimensions.

Trend 9: Security as Cornerstone for a Digital Future

Security is the cornerstone of industry transformation. It requires continuous innovation and industry cooperation. In the future, simplified service security will be necessary for integrated protection, one-click threat handling, and one-stop services.

Traditionally, network security assurance for cellular communications mainly focuses on boundary defense. For example, the core network in the core equipment room and the RAN system at the edge are defined as different trust domains based on the positions of different NEs, and security gateways are deployed at the network boundary to protect the core network. Today, there are more and more attack surfaces and vectors, due to the growing popularity of 5G industry applications, diversified service types, MEC deployment, massive IoT device access, and network convergence. As a result, network boundaries become more complex and dynamic. The system is exposed to broader, more complex, and stronger cyber attacks. In 5GtoB scenarios, multiple communication standards need to be converged, resulting in more nodes being exposed to attacks. Deploying different types and security levels of networks may cause cross-network horizontal penetration. In the future, we cannot avoid all risks by overlaying or adding external security devices. Therefore, to effectively ensure secure networks for customers, we need to build intrinsic system security, combine security architecture with wireless system architecture, and develop a resilient, visible, manageable, controllable, and comprehensive secure system.

Intrinsic device security lays the foundation for stronger, efficient protection. Integrated protection, which includes full-stack hardening, check, and detection, can also boost protection and efficiency while reducing the number of nodes.

Intelligent security O&M is required at the network layer to improve efficiency with the same number of O&M personnel. Security situational awareness can detect attack events in real time, analyze and evaluate threats, and implement one-stop threat handling, including automatic recognition, detection, orchestration, and response.

A resilient system capable of proactive defense can minimize the impact of attacks on service systems. Networks can withstand attacks with trusted computing technologies such as high-intensity cryptography, security isolation, and software-hardware combination. In addition, graceful degradation ensures uninterrupted mission-critical services and fault recovery in minutes.

New technologies, such as AI and quantum computing, also signal new risks and opportunities in security. For example, it is essential to prevent AI from being misled by malicious data; this requires improved integrity of AI training data and enhanced model robustness through adversarial training. On the other hand, AI modeling can improve detection accuracy by identifying the risks of possible new, unknown threats in advance. At the same time, quantum computing has an important impact on traditional cryptographic algorithms because of its powerful computing capability. Therefore, it is important to find a secure way to evolve traditional algorithms to quantum security algorithms. Moreover, the end-to-end intrinsic security of future wireless networks can be enhanced by using quantum computing and analyzing quantum true random numbers and quantum key distribution technologies.

Trend 10: Mobile Computing Network for Device-Pipe-Cloud Collaboration

Currently, distributed MEC is mainly used for XR, cloud gaming, and certain 5GtoB use cases. It helps us improve experience and deployment. In this phase, cloud and networks are still loosely coupled, with resource and management synergy mainly based on telecom cloud. By 2025, XR will become more interactive, and industrial operational technology (OT), will be more digitalized. By then, networks and computing must use APIs for QoS, location, video compression, and service provisioning to achieve real-time collaboration. By 2030, tactile Internet, metaverse, and high-speed mobile IoV will have become far more popular. Therefore, a single service model will be insufficient to build a new digital platform. Hence, networks and computing need to be seamlessly connected to provide uninterrupted and high-quality services on demand. This is where the mobile computing network (MCN) comes into play.

MCN needs to introduce several new technologies for cloud-network collaboration across data, operation, information, communication technology (DOICT) domains. First of all, the run-time of cloud and networks is integrated to support the Web 3.0 computing architecture represented by WebAssembly. Then, their architectures are integrated to enhance cloud scheduling based on the mobile network's control plane. The network deployment architecture uses MECs as anchors to build serverless local computing. At the cross-domain coordination layer, cloud-network loose coupling will be replaced with strong collaboration, that is, TPC collaboration. In particular, the types of terminals will change significantly, needing to support new terminal applications such as vUEs. Finally, ecosystems and businesses are integrated. As such, distributed ledgers and smart contracts are required to enhance data transaction security across networks and systems.

Ultimately, MCN will help operators enhance service experience while exploring business models that integrate computing and network services as well as helping industries become more efficient.