



# BOUNDLESS XR WITH PHOTOREALISTIC VISUALS



## ENABLING REVOLUTIONARY MOBILE EXPERIENCES IN THE 5G FUTURE

Extended Reality (XR) describes the wide spectrum of real-world to virtual-world interactions between humans and machines, generated by computer technology and wearables. It's an umbrella term that encompasses Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR)—and everything in between. XR is already transforming everyday consumer experiences and many market verticals, from industrial manufacturing and health care to education and retail—but it's a long way from reaching its full potential.

Taking XR to the next level of immersion within the power and thermal constraints of mobile devices is the key challenge. Today's XR business opportunity is to make it possible for people to walk around anywhere, any time, and enjoy a mobile XR experience—but how can we deliver the next level of photorealistic experiences on sleek mobile XR glasses? That future reality is closer than you might think, as 5G begins to introduce its revolutionary wireless advances: far faster data transfer speeds, much lower latency, and higher quality of service.

This boundless XR experience needs to work anywhere and be truly mobile while offering a mesmerizing photorealistic experience when its on-device capabilities can be augmented by additional processing over 5G. But how will it happen?

In this nascent market of boundless XR, the coming wireless edge transformation—which introduces a new era in distributed computing powered by 5G, on-device processing, and edge cloud processing—could offer a solution. But making this vision a reality will require the entire XR and 5G ecosystem to come together.

## MOBILE XR AND THE NEXT LEVEL OF IMMERSION

Imagine combining the power-efficient, latency-sensitive, on-device rendering and tracking of today's mobile XR headset with the partial rendering capabilities of the edge cloud over a 5G link with low latency and high quality of service (QoS). That is the next revolutionary step in XR—boundless mobile XR experiences characterized by photorealistic visuals. How will we get there, and what are the building blocks toward it?

**PC-tethered XR.** The advantage of today's PC-tethered VR/AR solutions are clear: They offer realistic visuals because they aren't limited by power and thermal constraints. But the primary disadvantage is also apparent: Tethered connectivity imposes hobbling limitations regarding freedom of movement and location. In short, wired XR solutions are a non-starter for future mass-market adoption. The next generation has no patience for cables. As we move toward our increasingly mobile future, PC-tethered XR—exemplified by today's gamut of wired solutions—will fade into the past and be a niche opportunity. The next step in this evolution will be leveraging the best of both worlds by combining the greatest qualities of PC-tethered solutions with the benefits of today's mobile XR.

**Mobile XR.** Mobile XR is here today, rising from today's slot-in and standalone VR/AR glasses, gathering strength in a young market, and leveraging the widening scale of the mobile ecosystem. Technologies such as Qualcomm's Snapdragon XR1 platform (with its efficient on-device processing) combine immersive XR features to support lifelike visuals, audio, and interactive experiences on a wide array of mobile XR devices—



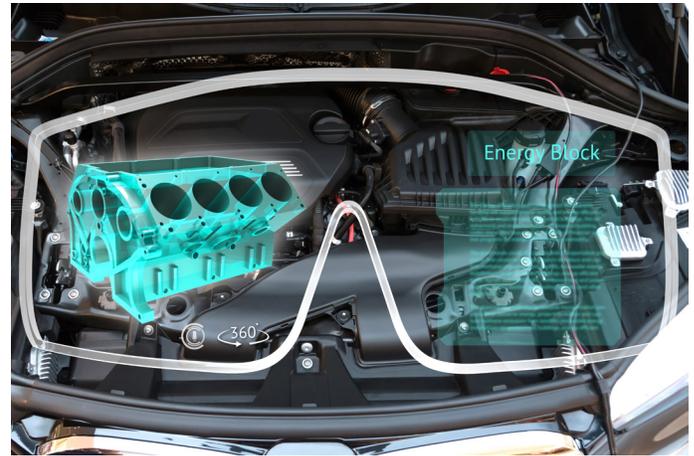
enabling vivid VR experiences in 3D games and seamless AR as humans interact in new ways with the real world. These mobile XR wearables offer users the ability to enjoy reliable, anywhere/anytime usage—with a simple setup and no wires—as an everyday aspect of their lives. And the future looks bright, as mobile XR is poised to rapidly evolve.

The future will see a convergence of the smartphone, the mobile VR headset, and AR glasses into a single, comfortable XR wearable. Not only will the new wearables provide immersive, intelligent, and always-connected experiences that truly enhance and enrich our lives—they will also be sleek and even fashionable. Transcending today's thick, bulky headsets, tomorrow's lightweight wearables will be common and ubiquitous, conveying lifelike audiovisual information to humans worldwide.

What will power these futuristic mobile XR scenarios? The coming 5G revolution—already widely heralded for its higher bandwidth, lower latency, and greater quality of service—will take mobile XR to the next level.

***The wireless edge transformation with 5G.*** In the 5G era, operators are pushing compute resources further out from the central cloud toward the edge of their networks. By investing in this architectural shift, these operators are setting the stage for a wireless edge transformation: Intelligence will no longer be confined to the central cloud but rather distributed to the devices that form the wireless edge. The edge cloud will then complement on-device processing, sensing, intelligence, and security. This transformation at the wireless edge opens up a world of new experiences characterized by stronger immersion, immediacy, personalization, and privacy, and a new class of services with distributed functionality between the device and the edge cloud over 5G

This wireless edge transformation is already taking place and delivering its expected benefits—but it, too, is about to become far more consequential. The onset of 5G as a unifying connectivity fabric will



introduce new capabilities that further enhance services as real-time interactive collaboration and transform industries like smart vehicles, robotics, health care, and the industrial Internet of Things (IoT).

Distributed intelligence at the wireless edge will merge seamlessly, on the fly, with the on-device capabilities of smartphones, IoT sensors, and other connected things. These devices will be capable of perception, reasoning, and independent action, processing low entropy data and transmitting relevant content back to the cloud.

***Boundless XR with split-rendering.*** The convergence of mobile XR and the wireless edge will give way to heretofore unachievable mobile boundless XR experiences such as multi-player gaming with photorealistic graphics, and next-generation six-degrees-of-freedom (6-DoF) video—made possible by a technology called *split-rendering*. Split-rendering will solve the challenge of overcoming the compute-intensive, latency-sensitive nature of the XR visual processing pipeline in a distributed system.

Imagine a lightweight mobile XR headset that performs power-efficient, on-device rendering and tracking and is augmented by rendering at the edge-cloud over 5G's low-latency, high-capacity, high-QoS link. This integrated system approach would involve close coordination between the XR device and the edge cloud, the result of which would be a new level of distributed computing, making

boundless mobile XR with immersive, photorealistic visuals possible.

Realizing this idyllic boundless XR experience will require not only the revolutionary leap of 5G but also the cooperation of the XR and 5G industry players—from original equipment manufacturers (OEMs) and content developers to telecom providers and the mobile operators. Investments and standardizations must coalesce into an ecosystem that supports the necessary market cooperation: On-device processing will remain essential in all use cases and be augmented by edge cloud processing contributions from mobile operators’ services. When the entire XR and 5G ecosystems work together, a great synergy and mutual incentive will result: Everyone benefits from increased consumer adoption.

### THE XR EXPERIENCE OF THE FUTURE

The future will be here before you know it! The 5G dream will become the 5G mainstream—commonplace and blazing fast. Operators will have

invested in the necessary compute infrastructure, successfully combining on-device processing with edge-cloud offloading, and consumers will be enjoying mobile XR with photorealistic visuals. What will the boundless XR experience look like?

Visuals will have vastly improved, and form factors will be sleeker and more comfortable, as close to normal glasses as you can imagine. Consumers will wear their XR glasses for everyday AR, interacting with their surroundings in entirely new and innovative ways, and occasionally entering VR mode by turning their sleek glasses opaque and enjoying artificial digital environments and experiences. These users will enjoy anywhere/anytime access to enhanced realities involving gaming, sports, driving, traveling, shopping, real-time collaboration, education, health care, and more.

*Sleek and stylish XR glasses.* It’s difficult to understate the importance of style, sleekness, and comfort in discussions about XR wearables. For consumers, the “cool” aspect will make a huge impact on



market acceptance. The XR glasses of tomorrow have the potential to replace all the other screens in consumers' lives—yes, even those large HDTVs in their living rooms. Like today's smartphone, tomorrow's mobile XR wearable could become one of the world's most revolutionary computing devices—not only sleek and durable but also highly capable, enabling a wide field-of-view, high frame rates, vivid screen color and brightness, and both transparency and opaqueness for myriad use cases.

**Increased immersion and believability.** Truly immersive XR essentially requires tricking the brain. Boundless XR will be characterized by rich sensory experiences, photorealistic content, and natural interactivity, supported by true-to-life visuals and deep, pervasive sound fields. As a result, consumers will find that the boundaries between their physical and virtual worlds will mostly vanish. At any given moment, they will be able to transition seamlessly between the real world, a digitally augmented mindscape, and a computer-generated world.

**Premium XR anywhere.** In the near future, 5G coverage will become widespread, and the areas where 5G doesn't reach will become smaller and smaller. But even in those areas, consumers will still crave reliable anywhere/anytime mobile XR experiences—and that's why the answer to boundless mobile XR is to keep increasing the on-device processing capabilities during this new era of distributed computing. In that way, mobile XR will bring immersive experiences to any location at any time.

## UNIQUELY POSITIONED

Today, Qualcomm's leadership in on-device processing and 5G at the wireless edge is helping drive the industry toward photorealistic, boundless XR. Qualcomm has designed a split-rendering architecture to provide an efficient end-to-end solution. The company is also developing the foundational technology required for boundless XR, such as immersive 3D graphics, computer vision, machine learning, intuitive security, and 5G technologies.

In the [Snapdragon XR1 Platform](#), Qualcomm offers users high-quality mobile XR experiences while enabling OEMs to develop mainstream devices. The XR1 platform features special optimizations for XR experiences, ensuring strong interactivity, power consumption, and thermal efficiency. The company's [Snapdragon 845 Mobile Platform](#) integrates a visual processing architecture that introduces outstanding graphics, video, and display processing technologies with cutting-edge XR performance. And the [Snapdragon X50 5G modem](#) will usher in the next generation of cellular services.

Boundless mobile XR provides the best of both worlds—premium XR experiences through on-device processing and photorealistic visuals through split-rendering—to achieve a new paradigm of interactive use cases, transforming industries and offering unprecedented augmented experiences. In many ways, the future potential of boundless XR epitomizes the full potential of 5G. ●



At Qualcomm, our inventions are the foundation for life-changing products, experiences, and even industries. When Qualcomm connected the phone to the internet, the mobile revolution was born. Today, as we lead the world to 5G, we're making it possible for literally billions of objects to seamlessly connect and intelligently communicate with each other. And our history of sharing our foundational inventions will continue, allowing our customers to build the products that will change the lives of people everywhere.