



Exploring the metaverse and the digital future

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GSMA™ Intelligence

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Executive summary

The metaverse: melding physical and virtual worlds

Despite being one of the latest buzzwords in tech, the metaverse can trace its roots back to a 1990s sci-fi novel. Although it lacks a universal definition, it is typically conceptualised as a network of immersive digital environments where people can interact, game, work and shop, often through virtual reality (VR) headsets connected to mobile broadband. There is significant hype and investment among tech and financial communities, which has led to massive market value projections. It has also resulted in some consensus around the principles on which the metaverse should operate: decentralised; interconnected and interoperable; and safe and trustworthy.

Various companies have made the metaverse a strategic priority

Hints of the metaverse are already reflected in some existing applications such as Minecraft, Roblox and Fortnite, which could provide a springboard for the scaled fusion of virtual experiences that has been envisaged. Some parties have displayed a degree of uncertainty and scepticism, but Meta, Microsoft, Qualcomm and other firms in the tech ecosystem are betting big on the metaverse and its potential to characterise the next chapter of the internet. Grand ambitions and long-term funding commitments highlight the desire of companies to lead the charge.

Future digital experiences present opportunities for mobile operators

An increasing number of mobile operators have set out on their metaverse journeys, including AT&T, Verizon, KDDI and SKT (which has developed its own platform called Ifland). There are several ways that operators can participate in the metaverse's development and capture value, such as by leveraging the advanced capabilities of 5G networks (plus edge compute and slicing technologies) or non-infrastructure opportunities such as utilising current digital identity efforts to generate incremental revenue from new services. However, additional demands on mobile networks could be significant, especially in the case of mainstream adoption.

Tech enablers will underpin sectoral metaverse applications

In addition to high-speed, low-latency mobile connectivity, certain technologies are likely to be central to the metaverse and the fusion of our physical and digital worlds. These include wearables, avatars, artificial intelligence (AI) and blockchain-based non-fungible tokens (NFTs). Combined with 5G (and future 6G) networks, this suite of enablers is poised to disrupt a swathe of industries, such as gaming, entertainment, retail and even architecture and manufacturing. Meanwhile, Seoul has become the first major global city to develop a metaverse platform for public services and cultural events, committing \$3.3 million to fund the initiative.

Issues that have troubled the internet era only set to escalate

While opportunities abound, there are multiple barriers to the development of a thriving metaverse that works for everyone. First and foremost, ensuring trust and safety online is a major challenge, with issues such as abuse, bullying and harassment particularly problematic when they impact the wellbeing of children and other vulnerable groups. Challenges relating to cybersecurity, data privacy and false information are also likely to intensify, which will need digital regulation and oversight mechanisms fit for purpose. Even if supply-side issues can be negotiated, action will be required to stimulate user awareness of and engagement with metaverse experiences.

Creating a fully fledged metaverse requires stakeholders to act

As the race to the metaverse heats up, appropriate policymaking will be needed to help turn ambitions into reality while protecting users from harm. Regulatory frameworks will need to facilitate mobile operators' continued investments in 5G network deployments, ensure fair competition and mitigate concerns pertaining to data privacy, safety and security. As well as planning for the impact of the metaverse on their networks, operators should move now to identify potential opportunities, collaborate with content creators and partner with hardware companies to develop compelling propositions for consumer and enterprise markets.

1. Web 3.0 and the metaverse: what, how and when

1.1 A brief introduction

The internet, in its earliest form, was the physical connection of wires and governing protocols that allowed users to communicate on a single network. Web 1.0 brought the internet to the masses, allowing people to consume static, read-only content. Web 2.0 ushered in a new era of dynamic, interactive pages, enabling communication between users. Web 3.0 is currently developing around us, connecting users, content and programs directly to each other, bypassing intermediary applications. It is this Web 3.0 framework that could create “massively multi-user economically strong applications”,¹ including the metaverse.

The metaverse was introduced as a fictional concept by Neal Stephenson in his 1992 novel *Snow Crash* and referred to a permanent virtual world, a successor to the internet, where people spent large parts of their lives in digital environments. These places would be accessible via special goggles and allow people to meet, interact, play games, buy and sell things, and more.

Arguably the internet’s first attempt at replicating such a world was Second Life, a place to socialise online without storylines or challenges. Digital realms such as Second Life and MindArk’s Entropia Universe quickly became popular, with the former boasting millions of users at the end of the 2000s. Though Second Life’s user numbers have since waned drastically, there is a loyal (and potentially growing) community of ‘residents’ still active on the platform.

Today, the metaverse – the kind that many tech companies are racing to build – refers to a scaled, virtual fusion of video games, social networking and entertainment that creates new, immersive experiences, such as swimming while listening to music at an online concert. For some, the metaverse is just the latest technology buzzword and may appear to be an enhanced version of VR. But advocates view it as transformative. Meta (formerly Facebook), for example, seeks to capitalise on the fledgling opportunity. Meanwhile, over 550 mobile apps include the term in their description or names.² Though it remains unclear what a fully fledged metaverse will look like, there appears to be a consensus that people will engage and interact in interconnected 3D worlds via on-screen representations of themselves known as avatars.

Table 1: Core technologies in the metaverse

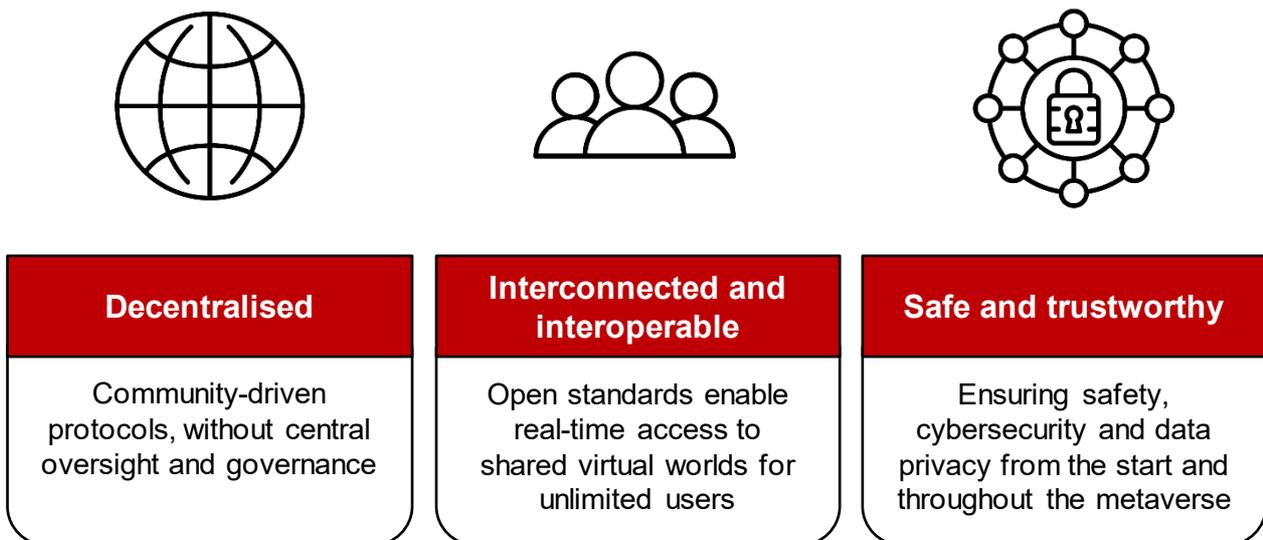
Augmented reality (AR)	A presentation method wherein objects in the real world are supplemented with artificial digital objects, which can be either constructive (i.e. adding to real world objects) or destructive (i.e. masking real world objects).
Virtual reality (VR)	An artificial rendering of an environment making use of audio and visual fields, possibly supplemented with other sensory devices.
Mixed reality (MR)	A blend of elements of physical and digital worlds into a single immersive experience.
Extended reality (XR)	An umbrella term encompassing AR, VR and MR, which refers to the spectrum of technologies that combine computer-generated virtual elements into the real environment.
Artificial intelligence (AI)	AI is the ability of a computer or machine to emulate human tasks through learning and automation, generally understood to be the simulation of the higher-order functions of intelligent beings in areas such as visual processing, speech processing and analytics.

Source: GSMA³

Key principles that make up the metaverse

As the concept is largely embryonic, there is no single definition of the metaverse – and one may never emerge. Nevertheless, there is some uniformity on certain foundational pillars on which the development of the metaverse should be based in order for it to function effectively and for everyone (see Figure 1).

Figure 1: Key principles in the metaverse



Source: GSMA Intelligence

Decentralised

Web 3.0, and the companies working to build it, are “aiming to make the web and the internet more decentralised, verifiable, and secure”.⁴ The metaverse will incorporate some of these Web 3.0 principles. Some parties are steadfast in their view that decentralisation needs to be at the core of a successful metaverse. Building decentralisation into the foundation of the metaverse could mitigate the risk of a central entity that can act freely as a gatekeeper to user interactions, play the role of an oversight authority and impose the standards and policies to which developers must adhere.

To deliver this kind of decentralisation, attention has turned to blockchain technology as a means of ensuring the metaverse landscape is secure and avoids being controlled by a select group of large corporations. From a blockchain standpoint, decentralisation refers to the transfer of control and decision-making from a centralised entity to a distributed network, which can have benefits for reconciling data, reducing points of weakness and optimising resources.⁵ It has been pointed out, however, that a heavily decentralised platform leveraging community-based standards and protocols (like the open web) would not necessarily prevent the existence of dominant closed platforms in the metaverse.⁶

Interconnected and interoperable

For a fully fledged metaverse to come to fruition, it will need to interconnect the many different devices and platforms being used for interaction. In October 2021, Meta’s Founder’s Letter stressed the need for interoperability to “unlock a massively larger creative economy than the one constrained by today’s platforms and their policies”. Ecosystem lock-ins are a popular, tried-and-tested way to force continued engagement while isolating the competition – especially when it comes to technology and operating systems. However, with interoperability likely being the driving force of the metaverse, layered standards are required – as they are with the internet – to allow different and diverse networks and subnetworks to clearly interact with each other.⁷

The idea of the metaverse often refers to shared virtual worlds that people can access and navigate seamlessly and in real time through different, typically XR devices. Hence, the interconnected nature of these digital environments could be paramount, as it will allow these environments to be experienced synchronously and persistently by an effectively unlimited number of users. Interconnecting standards are already starting to take hold: Disney Pixar’s Universal Scene Description (USD) is an open-source software that allows transmission of 3D data, a key factor in developing the immersive 3D worlds that could make up the metaverse. Similarly, standards around verifiability that provide a user with portable unique credentials that can be used across virtual world boundaries could prove useful.

Safe and trustworthy

A third principle of the metaverse is the related notions of safety and trustworthiness. As with any online interactive platform, there are user safety concerns (such as online abuse, trolling, inappropriate contact, grooming and mis/disinformation). And given the size and immersive nature of a fully fledged metaverse, these issues could be exacerbated. As there are many different forms of threats to online safety, there is no one way to address all of the issues. Nevertheless, according to technology and human rights expert Brittan Heller, “VR and AR platforms need specific terms of service for immersive environments...because platform governance in digital worlds must regulate behaviour, in addition to content”.⁸ Cybersecurity, a key tenet of this pillar in relation to both the hardware and software components of the metaverse, will become more challenging, as vulnerability will increase due to the broader attack surface for online criminals.

Regulatory frameworks can often struggle to keep pace with technological change; as such, user education, awareness and prevention will be vital to security and resilience in the metaverse.⁹

Personal data privacy issues may also come to the fore as new in-depth virtual experiences take shape and digital devices and platforms connect. Beyond cross-industry collaboration, Meta's Founder's Letter stated that privacy and safety should be embedded into the metaverse from the outset, as well as new forms of governance. However, it is reasonable to assume that concerns over the mishandling of sensitive user data, for example those that plagued Second Life's creator Linden Lab,¹⁰ will remain. Protecting such data and analysing the large number of transactions could be an important feature in securing the metaverse and stimulating adoption.¹¹

1.2 Market size and time frame

Market size

Some proponents believe the metaverse could be the future of the internet, with its series of virtual worlds establishing the most important new technology platform since the arrival of the worldwide web itself. In June 2021, Roundhill Investments created an exchange-traded fund (ETF) to track and profit from the work of metaverse enablers. Meta's hope is that the metaverse will reach a billion people within the next decade and support jobs for millions of creators and developers, in addition to hosting hundreds of billions of dollars of digital commerce.

To that end, valuations attributed to early incarnations of the metaverse suggest a clear commercial reason for the strong desire from the big names in tech to be at the forefront of this nascent phenomenon and to shape the design of a future digital reality. One estimate put the economic value of Second Life in 2005 at \$64 million, while Project Entropia saw \$1.6 billion pass through its online world in the same year.¹² Yet, the potential value of the modern, in-progress metaverse far eclipses these figures. Epic Games – which owns Fortnite, one of the most popular games globally – believes that the metaverse could become “a multitrillion-dollar part of the world economy”.¹³

Forecasts from multiple sources appear to validate that belief. PWC expects the value of the metaverse market to exceed \$1.5 trillion by the end of 2030 (see Figure 2). Morgan Stanley goes further, seeing the metaverse as an \$8 trillion addressable market, which is likely to become the “next generation social media, streaming and gaming platform”. Reports also suggest that the gadgets and wearables opportunity in the metaverse could be worth \$100 billion in 2030 and subsequently grow another fivefold by 2040.¹⁴

Figure 2: Metaverse market size, 2021–2030

Source: PWC¹⁵

Time frame

The projected market size may reflect a growing consensus around the profound impact that the metaverse could have. Though investment bank Jefferies believes a fully realised version of the metaverse may be more than a decade away, it thinks the metaverse has the potential to disrupt “almost everything in human life”.¹⁶ Despite the time – and effort – that will be required to build the metaverse, work has already been undertaken to sow the seeds for developing the metaverse and expanding its ecosystem.

At Web Summit 2021, Roblox stated that it has been working on its vision of the metaverse for about 15 years and that “it needs to be a place that everyone can access, a place where people can express themselves and connect together”.¹⁷ The promise shown by games such as Roblox, Fortnite and Minecraft implies that they could all be stepping stones to an emerging new medium. Alongside such momentum and focus on the content and software fronts, there is also hardware under development to facilitate access to the metaverse and future virtual experiences. Firms such as Google, Meta, Qualcomm and Snap are working on new AR wearables for the metaverse, some of which are expected to launch in 2022.

It could take a decade, if not longer, to build a fully fledged metaverse in which people could live and work across interconnected physical and virtual environments. Nevertheless, with interests piquing, visions forming, and technologies and capabilities improving, it seems that important pieces to the metaverse puzzle are beginning to come together. Peggy Johnson, CEO of Magic Leap, considers that we are already in the early stages of the metaverse “in some way”.¹⁸ In addition, Microsoft co-founder Bill Gates has said that while the technologies powering the metaverse are still undergoing intensive research and experimentation, he believes that virtual work meetings will increasingly be done via personal avatars by 2024.¹⁹

2. Key players and implications for telcos

2.1 Central players in the building of the metaverse

Whether or not the metaverse becomes as ubiquitous as the smartphone is today, several firms have already identified it as part of their future endeavours (see Table 2). Though Apple, the largest tech company in the world, is reported to be somewhat circumspect,²⁰ there is clear momentum from other quarters – specifically the gaming industry, which is expected to account for most of the metaverse market value over the medium term. Tim Sweeney, founder of **Epic Games** (which is 40% owned by Chinese conglomerate Tencent) has said that firms like his are in a race to get to a billion users in order to set the metaverse’s standards for the future, with the next three years a critical time period. **Tencent** itself has yet to fully outline its ambitions, possibly due to China’s increased scrutiny of leading domestic tech firms, but it has identified three main pathways to the metaverse: gaming; social networking; and AR/VR-based experiences.²¹ In January 2022, it was reported that Tencent had opened talks to acquire Black Shark, a gaming devices and accessories manufacturer.

Moreover, **Roblox**, the world’s largest user-generated gaming platform, has its own metaverse plans. The company saw its value rocket during the pandemic, leading to a flotation on the New York Stock Exchange in 2021. Roblox sees the metaverse as becoming a “human co-experience utility” that is “arguably as big a shift in online communication as the telephone or the internet”.²² It aims to give users and developers ways to create digital worlds, thereby providing opportunities to game, learn, work, socialise and attend events, with the platform’s virtual economy powered by its Robux currency.

Table 2: Examples of metaverse activities

Baidu	In November 2021, Baidu’s Xirang (Land of Hope) metaverse app went live, offering a virtual exhibition environment and workplace for users, which is accessible via smartphones, PCs or VR goggles. Baidu has also made hardware investments through subsidiaries such as iQiyi.
ByteDance	TikTok owner ByteDance is beta testing a metaverse social media app after investing in multiple companies, including VR headset maker Pico and chip designers Stream Computing. The app, called Party Island, allows invited users to create avatars, join virtual events (e.g. concerts) and message other participants.
Mawari	Mawari’s 3D rendering solution moves rendering into the cloud, allowing for real-time XR interactive experiences. Mawari has worked with several mobile operators, including NTT Docomo and KDDI, to enable its new digital offerings.
Nonvoice	By working with app developers, Global agency Nonvoice has launched its Metaverse 5G Portal, which aggregates around 15 consumer AR apps, spanning education, games and sports. The platform operates on a revenue-sharing model with telco partners.

Nvidia	Graphics company Nvidia has built its Omniverse platform to be the 'plumbing' that can connect rich, shared virtual worlds within the metaverse. The platform is being used across a growing number of industries for projects such as design collaboration and creating simulations of real-world buildings and factories.
Qualcomm	Qualcomm hopes that its flagship Snapdragon chips will be users' ticket to the metaverse. At CES 2022, Qualcomm announced a collaboration with Microsoft to expand and accelerate the adoption of AR in the consumer and enterprise sectors, with initiatives focused on chips and glasses.
Snap	Snap, owner of Snapchat, has long been building custom avatars and AR filters to overlay digital features onto the real world. In 2021, it unveiled the fourth generation of its smart glasses, known as Spectacles, making them available for developers to experiment with creating experiences.

Source: GSMA Intelligence (based on research and company interviews)

In October 2021, Mark Zuckerberg changed the name of Facebook's parent company to **Meta**, subsequently claiming in a personal post in February 2022 that the firm is now "a metaverse company, building the future of social connection". Meta has earmarked \$10 billion to develop the AR/VR headsets and glasses that many predict will provide a dominant access point to the metaverse. Using this funding, Meta will also hire 10,000 people, some of whom will be "highly specialised engineers". The company is actively building VR apps for social meeting places and for the workplace, including ones that interact with the real world.

Another member of 'big tech', **Microsoft** is also seen as a central player to the metaverse. The firm revealed at its annual Ignite conference that 90 new services will be launched in three areas, one of them being the metaverse. Microsoft is working to make virtual gatherings as natural as possible using VR goggles and motion-capture gloves that will accurately replicate human gestures online and capture body language. It is also making progress in spatial audio, so that communications and application sounds are real and immersive, and building the "identity systems of the future" that will enable computing solutions to be embedded in the real world while bringing real presence to any digital space.²³ In addition, Microsoft has announced its intention to acquire leading games developer Activision Blizzard,²⁴ which could support its metaverse strategy – although the transaction will require approval from the Federal Trade Commission (FTC).

2.2 The role of operators

Infrastructure

The successful running of sophisticated digital worlds and XR will require similarly advanced – and consistent – mobile broadband services. While the networks that carry data traffic are often overlooked, they are one of the main reasons why tech firms, investors and other stakeholders are so enthusiastic about the prospects of the metaverse. 5G networks have the ability to provide the high-capacity, low-latency transmissions needed for immersive experiences, as well as allow the user to experience extended realities (offered by the metaverse) in the real world. Moreover, by the end of the decade, the arrival of 6G technologies could enable further advances in digital worlds and scenarios, and the melding of virtual and physical realities.

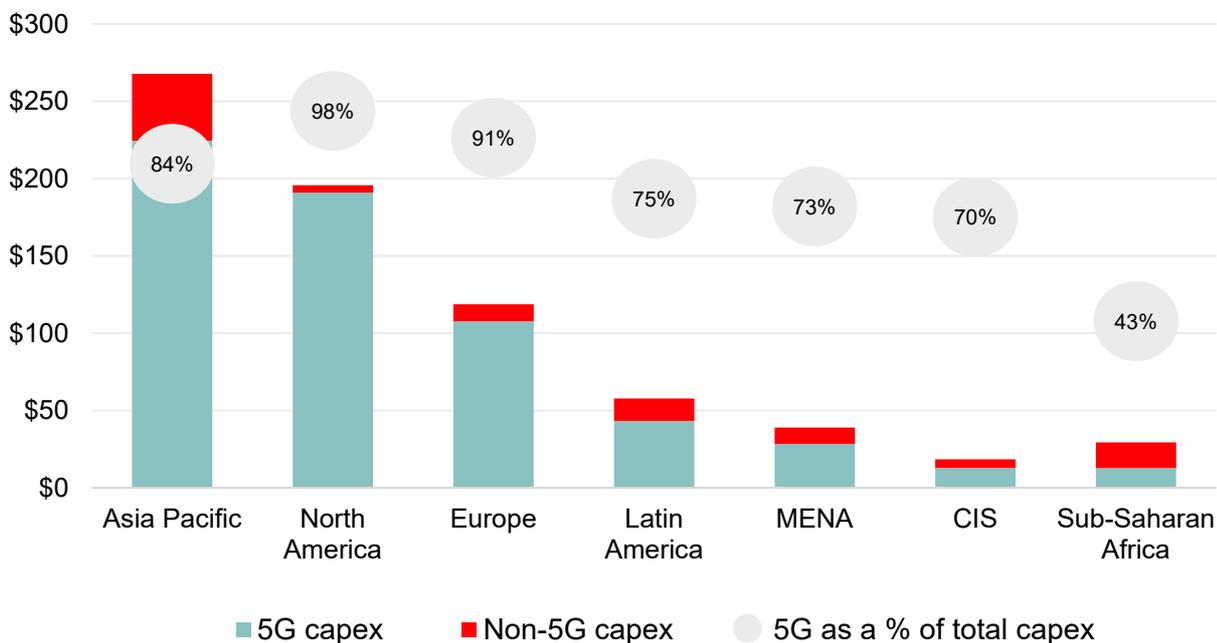
As the primary suppliers of connectivity, mobile operators are naturally interested in exploring potential opportunities in the metaverse, especially given the significant 5G infrastructure and spectrum capex commitments they have already made and will make over the coming years (Figure 3). Verizon sees 5G, particularly mmWave spectrum, as being fundamental to the ultra-

fast, low-latency connectivity that will “start to open up possibilities like VR experiences that include the sense of touch, and AR experiences that let visitors have in-depth conversations with AI hosts”.²⁵

However, the growth of data triggered by the metaverse could put additional strain on mobile networks. According to Credit Suisse, even modest metaverse usage could cause current data consumption to increase 20× by 2032.²⁶ The economics of mobile networks are evolving, adding pressure onto operators as the demand for advanced network capabilities increases rapidly. Flexible regulatory frameworks, harmonised and affordable spectrum, and other supportive policy initiatives have the potential to ease this pressure and help to facilitate a fully fledged metaverse.

Figure 3: Mobile operators will invest \$620 billion in their networks over the 2022–2025 period, of which 85% will be dedicated to 5G

Capex (billion)



Source: GSMA Intelligence

The rollout of high-quality, reliable 5G (and future 6G) networks is therefore the main pathway for operators to carve out a position in the metaverse ecosystem. With advanced mobile connectivity providing the platform, there are network innovations – such as edge computing and slicing – that operators could use to capture new value from metaverse growth areas.

Multi-access edge computing

Amid huge excitement about the metaverse from wealthy investors and big tech firms, one opportunity for the telecoms industry is 5G multi-access edge computing (MEC), a technology that serves as both a resource computing platform and a mobile network capability platform. Immersive experiences such as those offered by the metaverse require networks that provide “low-latency communication for imperceptible response time and significant server resources to run the virtual 3D world”.²⁷ Work has started to test and develop the optimal 5G Telco Edge Cloud network infrastructure that could enable interoperable services in the metaverse.²⁸

Localised content, efficient real-time data processing and management, and ultra-low latency connectivity are some of the features made possible by MEC, enabling innovative consumer and enterprise services. MEC can be both a technical and commercial solution for operators that allows them to establish new business models and provide more than enhanced mobile broadband. It can facilitate opportunities for operators to expand into other new sector-specific markets, and unearth revenue streams through MEC-enabled connectivity offerings and hosting edge application servers for third parties. Operators are also collaborating with partners such as AWS, using revenue-sharing models to offer public and private cloud services in areas to support ecosystem development.²⁹

Network slicing

Hype around AR/VR and digital worlds resurfaces every few years but usually fades away. However, there is a view that for the first time the technology is almost in place, with connectivity moving close to what might be needed to underpin the metaverse. Network slicing may be another opportunity for operators to monetise 5G, as it offers the capability to isolate and tailor portions (or 'slices') of the network to cater to the differing needs of customers or future virtual applications.

For instance, Deutsche Telekom has successfully completed an end-to-end 5G network slicing trial with Ericsson and Samsung, which siphoned off one slice for mobile broadband and another that was optimised with higher throughput and low latency to support VR gaming. Trials such as this demonstrate how network slicing could be used to customise user uplink/downlink rates and latency requirements to guarantee on demand the level of service quality needed to support metaverse use cases, such as cloud gaming.

Leveraging core competences

While 5G networks can unlock the metaverse, mobile operators have the potential to generate other revenue streams in support of these new types of service offerings. Given their wealth of experience and expertise, operators are well positioned to provide services such as data traffic analysis and management, which allow for seamless application automation, along with a collection of usage data and billing for platform providers.

Tech opportunities for operators

Besides providing the digital 'nuts and bolts' of the metaverse, there may also be scope for operators to share in its spoils, such as through revenue-sharing agreements, strategic investments (e.g. SoftBank's Vision Fund 2 into NFT-related startups) or the successful development and marketing of new services, applications or plans. Verizon is already exploring metaverse opportunities, utilising its six 5G research labs to test and trial imaginative enterprise and consumer use cases for 5G, such as holographic medical imaging. Verizon made an initial foray into the metaverse at the 2021 Super Bowl, offering a virtual 5G stadium in Fortnite Creative. The experience let fans come together and interact with their favourite NFL players via games. Verizon believes that the metaverse might be the best opportunity for 5G's so-called killer applications to flourish.³⁰

Case study: SKT

SKT is arguably one of those leading the mobile industry’s charge into the metaverse. The South Korean operator has even moved to reorganise its business in order to capture future growth from sources outside of core telecoms services. Finalising this corporate restructuring in November 2021, SKT will house Iland, the metaverse platform the operator launched earlier that year, in its new AI Service Unit.

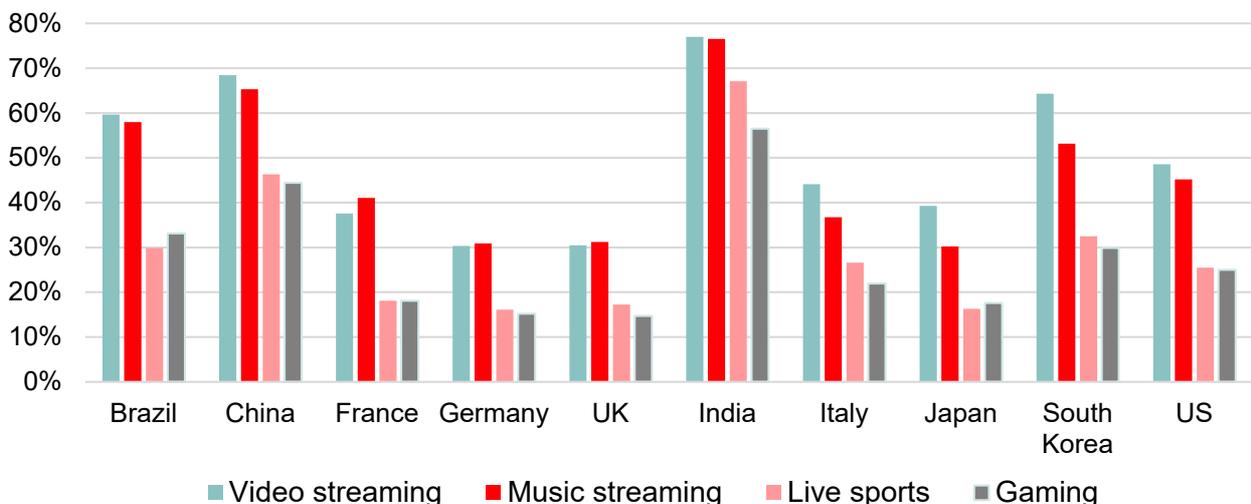
Iland has been designed “to maximise user experience through diverse virtual spaces and avatars”,¹ with an initial focus on meetings and presentations. However, SKT has pledged to expand this to holding large-scale events such as lectures, festivals and concerts. With several companies launching their own metaverse platforms, success may depend on attracting as many users as possible through themed events and customised services. Accordingly, SKT plans to offer special programmes and content, such as fan meetings with K-pop stars and social media influencers.

Gaming

In light of a growing trend towards subscription-based cloud gaming services, mobile operators are increasingly pursuing opportunities in this sector. All three mobile operators in South Korea offer cloud gaming services to their customers, while A1 Telekom, China Mobile, Orange, Telefónica and Vodafone have launched propositions in collaboration with third parties. Reflecting the global dimension of this theme, several telcos – including Deutsche Telekom, EE, Globe, Orange, SoftBank, SKT, Telstra, Telus and Verizon – are participating in the Niantic Planet-Scale AR Alliance, which is leveraging 5G’s performance capabilities to develop and distribute AR-based content and game titles.³¹ These types of gaming environments have the potential to evolve into a world that makes up the fully fledged metaverse.

Figure 4: Consumers are most interested in music and video streaming; gaming will benefit from rising 5G adoption

Which of the following do you already have as part of your mobile subscription/contract or would you be interested in adding to your mobile subscription/contract if it was available?
(Percentage of respondents)



Source: GSMA Intelligence Consumers in Focus Survey 2021

Digital identity

In the fully fledged metaverse, users could have the ability to travel between worlds or other metaverses while keeping their digital identities and possessions intact. This interoperability between metaverses will be supported, in part, by the verifiability of the users. An operator's ability to verify identity at the connection and then continue to verify without divulging sensitive data would enable users to create avatars, purchase NFTs and bring all of it across digital world borders. Additionally, a mobile network identity verification at connection would allow users to experience the metaverse on multiple devices, depending on the desired experience, switching between headset, smart glasses or smartphone while either inside or outside the home.

AR/VR solutions

As mobile connectivity advances, an increasing number of telcos are recognising the business potential of the metaverse. Operators in leading markets such as China, South Korea and the US are exploring how to blend the digital and real worlds through AR/VR as a way of making back money spent on superfast 5G networks. SKT has described the metaverse as both its "future business model" and its "core business platform", while several operators (including LG Uplus, Bell, KDDI, China Telecom and Orange) and chipmaker Qualcomm are part of the Global XR Content Telco Alliance, which is helping to finance the creation of high-quality AR/VR content.³² In Thailand, TrueMove has partnered with Nonvoice to launch a cloud AR application platform, subsequently incorporating NFTs/digital collectibles as part of the service.

The scaling of 5G standalone network deployments could strengthen the AR/VR opportunity, with greatly improved speeds, latency and reliability supporting operators to better identify and develop new experiences (and revenue streams). Similarly, planning for the 3GPP's Release 18 begins the process to make 5G-Advanced a reality, which incorporates plenty of metaverse-friendly features and capabilities, including boundless XR.

Partnerships

Leveraging new and existing relationships creates the potential for telcos to establish partnerships to capitalise on the metaverse. AT&T is one operator already thinking in this direction. According to AT&T, connectivity is "the glue that will bind everyone and everything, together".³³ Its Ecosystem Innovation Team is already working with businesses to help build technologies and solutions for the future metaverse. Leveraging the superior capabilities of mobile operators' 5G networks, partnerships could therefore be key to discovering the killer application(s) in the metaverse. AT&T and e-sports organisation 100 Thieves have collaborated on the AT&T Station, an immersive VR space located within the VRChat platform. The experience is AT&T's first push into the metaverse and 100 Thieves' first experiment in digitising apparel items as the lines between the real and online worlds continue to blur.

3. Opportunities and applications

In 2020, the Covid-19 pandemic accelerated a digital evolution for many citizens, firms and industries. It is no surprise, then, that use of the term ‘metaverse’ surged in 2021. Precisely what the metaverse will become remains to be seen. It may be an all-encompassing futuristic world of VR and avatars, or alternatively just a richer, more immersive version of today’s online platforms and networks. In any case, myriad potential use cases are foreseen as the metaverse unlocks access to new creative, social and economic opportunities.

3.1 Key enabling factors

5G networks and beyond

As described previously, 5G networks provide the high-bandwidth, low-latency services that a fully fledged metaverse needs to succeed. Advanced capabilities such as MEC and network slicing enable remote rendering and support the frame rate needed for an immersive experience.³⁴ Mobile 5G (and future network generations) will serve as the foundation for the metaverse, underpinning user engagement and helping the content and app ecosystems to flourish.

Wearable technology

Full 3D telepresence via AR or VR hardware is seen by many as a critical enabler to delivering a genuine metaverse experience. Instead of being on a computer, in the metaverse you might use a headset to enter a virtual world that connects all types of digital environments. In this scenario, an individual would be able to sense the other users occupying that same shared location rather than looking at faces on a flat screen display. AR and VR could therefore reflect the logical step beyond the smartphone and the current mobile internet era.

The market is quickly maturing and seeing major investments, with AR (digital 3D objects layered on top of the real world) seen as suiting outdoor experiences and VR (interacting in an immersive, simulated world) better placed for indoor environments, such as the home. However, with advancements in AR/VR technology still progressing, the first iterations of the metaverse may continue to be powered by smartphones over the coming years. Over the longer term, a shift to AR/VR as a central platform for digital and telecoms services could have far-reaching implications for the tech ecosystem and handset vendors in particular.

Avatars

While visions for the metaverse vary, there seems to be broad agreement that a foundational element of future digital worlds will be customisable avatars that can move, speak and/or perform animated actions. This is in sharp contrast to existing websites or social media networks, where individuals are typically represented by a username or thumbnail picture. Avatars have been common in online platforms since the 1990s (e.g. in Habbo Hotel), but recent advances in VR are enabling users to truly embody their digital manifestations, for example by using hand-tracking controllers to gesture and interact with virtual items.

Utilising its Mesh platform, Microsoft is adding 3D virtual avatars and environments to its Teams business communication system as part of its push towards the metaverse. Within immersive meetings, an avatar will represent a person and use AI to imitate movements and gestures – without the need for an AR or VR wearable. Besides providing respite from video conferencing, millions of avatars (acting on behalf of their human counterparts) may also shape how the IMVU

metaverse, a 3D avatar social media app, develops by exercising voting rights in exchange for a fungible token.³⁵

AI

More than running synthetic versions of ourselves, AI will help enable, support and populate the metaverse – while dramatically reducing power consumption and improving the performance of 5G networks. AI algorithms can quickly parse huge volumes of data to derive insights and drive action, and are already commonplace within consumer and enterprise situations. Across the metaverse landscape, AI could be leveraged for ‘digital humans’ (i.e. 3D chatbots), creative writing, language processing and interface optimisation. Regarding the last point, AI could play a vital role in accessibility to the metaverse, such as through image recognition for people with visual disabilities, automatic translation, intelligent exoskeletons to interact with the digital world and brain computer interfaces for the most vulnerable.³⁶

Non-fungible tokens

Non-fungible tokens (NFTs) are non-interchangeable assets that represent ownership of a unique digital item.³⁷ NFTs have one owner, which is recorded on a blockchain (most commonly Ethereum) to secure ownership. A blockchain is a shared, immutable ledger for recording transactions and tracking assets.³⁸ Virtual property (e.g. land or buildings), which links to a user and does not disappear between sessions, is widely expected to be a core feature of metaverse environments, as is the ability to exchange and/or sell that property. NFTs have seen an explosion of interest, which could provide a signal as to how virtual economies would work. They have gained popularity as a decentralised and reliable way to track and establish ownership of digital goods, without any controlling authority or corporate server.

NFTs could enable virtual assets to be moved freely between metaverses controlled by different companies, with a certificate of ownership or authenticity proven on an autonomous database. Decentraland, for example, is based on the Ethereum blockchain and uses ERC-20-based tokens (via the MANA cryptocurrency) to facilitate trading plots of virtual land. Similarly, The Sandbox, a Hong Kong-based gaming platform, is allowing users to build up its virtual world and monetise their creations using NFTs.³⁹ In practice, a high degree of standard-setting and cross-industry cooperation is necessary for full portability; however, NFT sales from metaverses are growing fast and are now the third largest category of transactions, behind digital collectibles and artwork.

3.2 Sectors potentially impacted by the metaverse

By leveraging the capabilities of 5G, AI, AR and VR, the disruptions and applications that may emerge in the development of the metaverse have the potential to be wide-ranging, from interactive entertainment to traditional industries such as construction and manufacturing. Bernstein, a wealth management firm, considers that markets with potential annual revenue of at least \$2 trillion could be disrupted by the metaverse.

Gaming

Due to its immersive nature gaming is expected to be a foundational use case for the metaverse. Research suggests that gaming – including AR/VR hardware, software, service and ads – will account for over half of the metaverse’s market value in 2024.⁴⁰ Anticipation of this has resulted in a spike in investor interest in firms capable of building such experiences. In November 2021, for example, The Sandbox raised \$93 million from investors led by SoftBank’s Vision Fund 2. Meanwhile, Microsoft announced an agreement to buy Activision Blizzard in a \$68.7 billion all-cash deal; the transaction would be Microsoft’s largest acquisition to date and reflects its long-term aim

to be a leading player in the emerging metaverse space, with gaming a key component of that ambition.

Tech firms have already implemented metaverse elements in popular games such as Animal Crossing, Fortnite and Roblox, the last of which reported over 49 million daily active users in November 2021, many playing via mobile devices. Platforms and creation systems that allow users to build, own, and monetise (via NFTs) their virtual gaming experiences – such as Epic Games' Unreal Engine – may become central to the gaming sector's role in the metaverse. An NFT-based 'play-to-earn' model incentivises engagement by rewarding players with in-game items. Further, Bionic and The Forgotten Runes Wizard's Cult are developing a 'create-to-earn' model, in which the community will generate game lore and custom NFTs in exchange for land and resources.

Live entertainment and events

Unlike current VR, which is mostly used for gaming, the future digital universe could be used for practically anything, including work, play, cinema trips or just socialising. One opportunity lies in the planning of live virtual events such as concerts, in which millions of individuals from around the world can interact. Following Travis Scott's virtual performance, millions of people watched Ariana Grande virtually perform in Fortnite in September 2021, while BTS – the most popular K-pop boyband – has released a new album within the game.

Epic Games has moved beyond video games and into social experiences, such as dance parties and virtual gigs, where users can pay to dress their avatars in different costumes. Likewise, SoftBank's investment will help fuel the growth of The Sandbox creators' economy as it expands into fashion, architecture and virtual concerts. Given the considerable impact from Covid-19 on the live events industry, a sustainable future will depend on more than live-streaming performances, which provided a stop-gap solution during lockdowns. Metaverse platforms could represent a paradigm shift for the sector, enabling musicians to establish a sense of presence and a deeper connection between themselves and their fans.

Retail

As an open, interconnected landscape of platforms, products and tools, the metaverse could eventually become home to all the brands and services consumers interact with on a day-to-day basis. Rather than visiting a website to browse 2D versions of products, users could see those items in 3D before deciding whether or not to make a purchase. Immersive virtual shopping experiences could allow users to 'try on' clothes via their avatars, which may have a positive environmental impact by reducing levels of returns and waste from online orders.

Many fashion companies have experimented with making virtual clothing, which people's avatars can wear in digital environments. Through Roblox, Nike has created Nikeland, which is modelled on its headquarters and allows users to play and design games, and outfit their avatars. Well-known luxury names such as Dior and Gucci, as well as some local and regional brands, are intending to release virtual products on platforms such as Zepeto, which launched three years ago and has around a quarter of a billion users across Asia. Digital retail could therefore be a new frontier in the metaverse, which is also giving rise to virtual influencers. These could be real people who design and sell items in the metaverse to other users in exchange for in-game currency or computer-generated avatars created and controlled by brands for marketing purposes.

Enterprise/work

Despite the strong social communication/interaction element to many metaverse ambitions, the metaverse is more than just games and entertainment. As part of its development of an "infinite office", Meta has been experimenting with a VR meetings app called Workplace, which – like the

company's social space, Horizon Worlds – uses virtual avatar systems. Microsoft, too, sees a role for the metaverse in the world of work, showcasing in 2021 its Azure-powered platform Mesh, which uses MR to “enable geographically distributed teams to have more collaborative meetings”.⁴¹

In addition to office environments, there could be opportunities for the metaverse in industrial settings. Nvidia is focused on its NVIDIA Omniverse, a real-time virtual world simulation and collaboration platform, which is being used across a growing number of industries, including architecture, automotive and engineering. The platform allows for the creation of digital twins (synthetic versions of real places) and the training of robots in virtual spaces before they are put into use on the factory floor.

Education

While Covid-19 and the associated restrictions on movement limited in-person education, technology has allowed people to continue learning remotely. The metaverse has the potential to have positive socioeconomic impacts by further enabling digital education opportunities, such as by delivering rich, immersive experiences that could enhance classroom environments. Roblox has created a \$10 million fund to support the development of online education applications in its virtual world.⁴² In addition, mobile operators such as AT&T are also collaborating to develop metaverse-enabled learning platforms and programmes.⁴³

Case study: metaverse for public services

Seoul has become the first major global city to develop its own metaverse platform for public services and cultural events, committing \$3.3 million to fund the initiative. The platform is expected to be fully operational by 2026 and will feature a virtual mayor's office and fintech incubator, and allow citizens to file a civil complaint or visit historic sites via VR technology. The programme reflects South Korea's aim to use digital and AI tools to improve healthcare, central infrastructure and the economy, and follows the formation of a 'metaverse alliance' of 500 firms, which is backed by \$26 million of state financing.

In addition, several Chinese cities are incorporating the metaverse into their official economic plans. In December 2021, the Shanghai Municipal Commission of Economy and Information Technology released its five-year development plan, which calls for the promotion of the metaverse's use across public services, business offices, industrial manufacturing and more.

4. Challenges

Though opportunities for individuals and industries abound, there are multiple barriers to developing and, in turn, thriving in the metaverse. Everything envisioned and/or possible does not necessarily translate into viability, and there are some concerns about the dystopian nature the direction the metaverse conversation may be taking – especially as upholding appropriate governance frameworks could be as complex as the digital reality itself. Consequently, demand- and supply-side challenges may come to hinder the creation and builders of the metaverse.

4.1 Interoperability

Many experts believe that there will not be one dominant metaverse and that instead ‘bridges’ will gradually be created to allow users to keep their avatars and possessions, and to easily migrate or port them between different online spaces.⁴⁴ To that end, a primary challenge to the effective functioning of the metaverse is guaranteeing interoperability between different virtual worlds to provide a seamless user experience. This includes the issue of accessibility: will users be able to enter the metaverse via a browser, an app, a games console or all of the above? Collaborative work to develop the optimal 5G Telco Edge Cloud standards has already started and should facilitate interoperable services in the metaverse.

Additional interoperability challenges relate to the integration of avatars and the importing of other 3D creations developed in modelling software different to that of the digital world the user is seeking to access. Further, several firms vying for metaverse leadership operate in interdependent worlds and have endured some common experiences, from antitrust battles to ad tracking disputes. As tech giants all look to swoop into new territory, promoting interoperability may require the architects of future digital operating systems to work closely together to safeguard against closed systems and to implement common standards.

4.2 Trust and safety

In the past, Second Life attracted negative headlines after high-profile virtual riots, Ponzi schemes based on its own currency (called the Linden dollar) and issues around child grooming. Habbo (formerly Habbo Hotel) faced issues such as scams, lapses in content moderation and online raids by Anonymous.⁴⁵ Such challenges could be amplified if the metaverse goes mainstream, presenting tech firms with implications that span cybersecurity, privacy, false information and safety.

Online safety and wellbeing

Today, people face a number of issues (e.g. abuse, bullying, misogyny) that may prevent a safe and trustworthy online experience. According to an Anti-Defamation League report, 83% of adults and 60% of children surveyed had experienced harassment in online multiplayer games.⁴⁶ As Covid-19 has driven populations online, more children than ever are connected. These issues have the potential to worsen as the metaverse blurs the real and digital worlds. Moreover, there are clues that the kind of dangers that pervade the internet may carry through to emerging virtual environments.⁴⁷ For instance, in November 2021 a beta tester for Horizon Worlds was sexually harassed (though Meta’s internal review of the incident concluded that the individual should have activated a safety feature).⁴⁸ Meta has since introduced a four-foot "Personal Boundary" feature for its social VR platform.

Many internet companies have developed advertising-based business models, focused on encouraging users into viewing more adverts. An immersive metaverse has the potential be a much more potent tool in manipulation than mobile apps, exposing users to significantly more effective forms of digital advertising than ever before. The wellbeing of users is a multi-faceted issue, which may require standards and protocols along with public discourse about how to keep the metaverse safe. The Information Commissioner's Office Age Appropriate Design Code (or Children's Code) is made up of 15 standards that ensure compliance with children's online data protection obligations.⁴⁹ Likewise, digital literacy programmes may prove vital to ensuring young people sufficiently understand the workings of the metaverse and can access appropriate content within it.

Cybersecurity

Generally speaking, security may be a step behind when it comes to new technology. However, the funding and development of a (largely unregulated) metaverse into a legitimate marketplace could be "extremely attractive" to cybercriminals by offering a "huge potential for scams".⁵⁰ Current cybersecurity challenges, including phishing, malware and hacking, will persist and could expose vulnerabilities of VR headsets or avatars to misrepresentation or theft of sensitive information. Further, criminals may buy and sell fake NFTs and malicious smart contracts. A Chainalysis report has found a small but growing portion of activity on NFT marketplaces that could be attributed to money laundering practices.⁵¹ Integrating security measures will be required so that brands and users are empowered to engage without fear of being susceptible to nefarious agents.

Data privacy

Related to the challenge of security is that of data privacy and protection, with possible implications for legislation such as the GDPR. At a time when some people are reducing their usage of social media (and even deleting apps from their smartphones), whistleblower Frances Haugen has warned that the metaverse could give Facebook another monopoly online, in addition to being addictive and extracting more personal information from users.⁵² In fact, the granularity of interaction data available, including where someone goes, how long they look at something and how they react to certain stimuli, is a major reason why tech firms, data brokers, website providers and more are so interested in this space. Individuals and regulators will demand transparency to trust that behavioural data is being used and protected appropriately, though both may face enforcement and governance challenges. The rise of the metaverse may therefore require new considerations of privacy, particularly regarding data portability between digital platforms and the collection of personal information, such as physiological responses.

Mis/disinformation

The arrival of the internet has proved an accelerating factor for false information, with online channels efficient instruments for circulating 'fake news' for various reasons, including convenience, instantaneity and scale. Social media platforms and governments are already struggling with the issue, which is set to grow further and see delivery mechanisms change as technology evolves.⁵³ The metaverse could risk exacerbating the spread of mis/disinformation on a variety of themes, such as politics and democracy, climate change, religion and health. For example, social media networks have been weaponised to spread inaccurate or misleading information about Covid-19 and vaccines, and the metaverse could serve to broaden the reach of such information and worsen harms caused.

4.3 Awareness and adoption

Even where certain supply-side issues can be negotiated, stimulating user awareness and adoption could remain a challenge. In a recent survey, people in Singapore reported mixed views about the metaverse, with a smaller proportion of people feeling positive about it compared with individuals in other Asian markets.⁵⁴ To encourage demand, users will need to be educated and persuaded as to the metaverse's advantages for socialising, learning, entertainment and more. Also, companies will want to be assured of the benefits for collaboration and productivity before purchasing hardware and funding VR work programmes from firms such as Immersed or Virtual Desktop. The challenge may be compounded by mobility and comfort issues associated with cumbersome VR headsets, which are expected to be the main conduit to future immersive experiences.

In the tech sector, it can take several years of R&D for an idea to come to life and to go mainstream, with many use cases later undermined by a lack of mass demand and scalability issues. Some individuals may be put off by the way commercialisation permeates digital spaces that were envisaged to offer an escape from a globalised society. To engage the addressable market, innovators – and their investors – may need to focus now on the hooks (e.g. content or platforms) that will convince users that it is useful, safe and worth spending time in the metaverse's many worlds, which will ultimately create network effects as the user base grows.

4.4 Digital divide

The Covid-19 pandemic has brought into sharp focus the fundamental importance of connectivity, which has acted as a lifeline for citizens, companies and institutions. Its value has been profound in enabling many business activities to continue and in sustaining social interactions between friends and family.⁵⁵ However, the pandemic has also exposed clear digital divides between countries, regions and demographics. Despite its promise, the much-heralded metaverse could worsen digital inequality, further segregating the 'haves' from the 'have nots'.

While a smartphone and an app may be sufficient to experience the metaverse to some extent, navigating and engaging in it fully may require someone to acquire AR smart glasses, a VR headset and a premium device equipped with 5G. The metaverse could therefore create even more connectivity and hardware challenges for those already facing exclusion. Moreover, with literacy another barrier to the adoption of technology and use of the internet, digital literacy programmes may be needed to develop awareness, acceptance and adoption of the metaverse.

4.5 Regulation

There is undoubtedly another challenge in devising and putting into effect appropriate rules and oversight mechanisms for the metaverse and its actors. In Europe and the US, regulatory bodies are responding to anti-competitive behaviour and privacy abuses, especially with respect to Meta/Facebook and Alphabet/Google, while in China the tech industry is feeling pressure from the government. In October 2021, the China Institutes of Contemporary International Relations (CICIR), a think tank affiliated with the Ministry of State Security, published a research note arguing that the metaverse could pose problems for national security. Regulating the metaverse will be a challenge because policymakers are struggling to catch up with the technology and market disruptions (e.g. the data boom, mis/disinformation, cryptocurrency) that occurred in the mobile internet era.

There are calls for the metaverse to be open and decentralised and to have community at its heart. Regulation may therefore need to address the risk of a corporate land grab in the metaverse,

where one firm sets the terms of the game and relegates users to mere consumers. Moreover, there could be regulatory challenges relating to responsibilities for owning, controlling and processing the massive amount of data the metaverse will generate. There could also be challenges with regard to the setting of global intellectual property rights. Copyright – and the issue of infringement – is a “possible severe limitation of the growth and reasonable use of the metaverse”.⁵⁶

5. Call to action

As ambiguity persists around how the metaverse will evolve, it is also unclear whether tomorrow's internet users will be attracted by tech giants' visions and whether the forecasted demand and market value will materialise. Nevertheless, like with space and some bleeding edge technologies, the metaverse is seen by some as a race that some parties want to win in order to set the rules and capture users and monetary gains. Appropriate policymaking will therefore be needed to ensure a level playing field and to mitigate concerns that could impact users.

Enable mobile network deployments

5G has the ability to unlock a fully fledged version of the metaverse and associated use cases. However, in order to do so, network rollouts must continue apace. 5G will generate positive externalities, but deployment costs are significant, revenues are uncertain and ecosystem development is still at a nascent stage. For example, the European Investment Bank estimates the EU digital infrastructure investment gap to be at €42 billion per year between 2020 and 2025.⁵⁷

Access to harmonised and affordable spectrum, flexible regulatory regimes, liberalisation of foreign investment rules and the avoidance of sector-specific taxes and fees all have the potential to facilitate investment in 5G network deployment. More flexible forms of net neutrality should be explored to support the development of and investment in 5G (including network slicing or virtualisation technologies), which in turn will enable the types of bespoke offerings that will power the fully fledged metaverse.

Collaborate to drive the metaverse forward

Given the many shared experiences and interdependencies across the tech ecosystem, there is considerable work to be done among stakeholders in bringing a fully fledged metaverse to fruition. Future inhabitants of virtual 3D platforms will need compatible AR and VR solutions to gain access, while new protocols and standards must be developed to bring together disconnected metaverse components, thereby enabling a seamless user experience. Mobile operators can be an enabling force by working with content creators and developers to lower interoperability barriers and with consumers to build trust and awareness. Many different players will therefore need to be involved to build the metaverse ecosystem, from members of the tech industry to civil society. Said actors should collaborate and share knowledge, and also realise that the future digital reality is broader than any one firm or category of application.

Identify opportunities and carve out a niche

With some weddings having already taken place in the metaverse,⁵⁸ the digitisation of marriage ceremonies indicates how almost any sector could face disruption. The investments being made and the partnerships being forged across the tech ecosystem also suggest that the hype should be taken seriously, particularly as the metaverse takes shape. While there is no guarantee it will become the big revenue driver that mobile operators are hoping for, they should be looking to seize opportunities to drive the development of innovative use cases or establish new niches.

However, only a handful of operators – including AT&T, SKT and Verizon – have commented publicly on their predictions or visions for this future digital reality. The current fast pace of the metaverse's development will have consequences for mobile networks, and operators should prepare for that eventuality. Relatedly, a part of 5G-Advanced standard setting is about the metaverse. If this is part of an operator's strategic planning, the operator will need to be ready to follow and provide input to the 3GPP 5G-Advanced Release 18 process.

Ensure regulation is informed and appropriately targeted

If the metaverse is to represent the internet of tomorrow, then stakeholders should consider whether the current regulatory regime is flexible enough to address future services or what appropriate new regulation looks like and, in turn, how oversight will impact the virtual worlds in which many will live and work. Several issues relevant today, such as safeguarding fair competition and encouraging innovation, will continue to apply. In addition, concerns around safety and mis/disinformation may become more problematic. As the race to the metaverse intensifies, regulators will need to be suitably agile and forward-looking to keep pace with the rapidly evolving digital landscape. The policies they implement should be guided by a collective effort of informed stakeholders, including governments, industry leaders and users from diverse communities, and should provide clarity without risking overreach or political interference.

Make data privacy, safety and security top priorities

Policymakers will need to make important considerations stemming from the interrelated issues of data privacy and security. The amount of data generated by metaverse experiences – and what can be inferred from that – requires strong, horizontal data protection and privacy measures, particularly in the case of sensitive data, and may contradict data minimisation and consent principles established by legislation such as the GDPR. In some markets, new rules will be needed to facilitate cross-border data flows so that cloud-based services can thrive.

In parallel, regulators will need to safeguard against abusive and inappropriate behaviour, and address security implications (or even weaknesses) of AR/VR devices and applications, especially where there could be risks to the physical and emotional wellbeing of children or other vulnerable groups. Firms that take these issues seriously may be better placed than their competitors to improve brand recognition, build trust and appeal to consumers – and therefore reap the predicted rewards of the metaverse.

Pay mind to bridging the digital divide

As conversations unfold around the power and potential of the metaverse, pursuing equitable access and inclusive design from the outset is imperative. Doing so would ensure that the future digital reality is not a preserve of the rich and is instead able to reach and benefit as many as possible – whether for education, work purposes or social interaction. Designing content and tools with different demographics in mind and effecting policies and initiatives to improve connectivity and reduce the cost of AR/VR technologies could help to avoid deepening existing digital inequalities and encourage cross-societal engagement with the metaverse. This could also support digital talent and innovation by providing opportunities for creators to build new virtual experiences.

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