

5G Network Slicing Business Opportunities for Multimedia

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Foreword: GSMA

The world is on the cusp of the next industrial revolution: an era of Intelligent Connectivity that combines 5G, AI, IoT and Big Data.

5G will transform the way that we live and work, connecting people and things faster than ever before. It will bring faster, richer and more immersive entertainment that will be critical to driving revenue growth across the mobile industry but perhaps more importantly it will drive efficiency, productivity and help us all use finite resources more effectively across every industry. In addition to the huge benefits for business and the economy it will also offer important breakthroughs in the provision of health care, skills and education.

This whitepaper provides an insight into the future, showing how ultra-low latency and ultra-fast 5G mobile, supported by network slicing can create specialised virtual networks that will bring to the fore new services and capabilities previously unattainable on 4G networks.

This new era will provide operators with the opportunity to evolve their business model from one based on data consumption, to one with deeper engagement and more profitable partnerships across an ecosystem that includes cloud providers, content owners and application developers.

Alex Sinclair, Chief Technology Officer, GSMA

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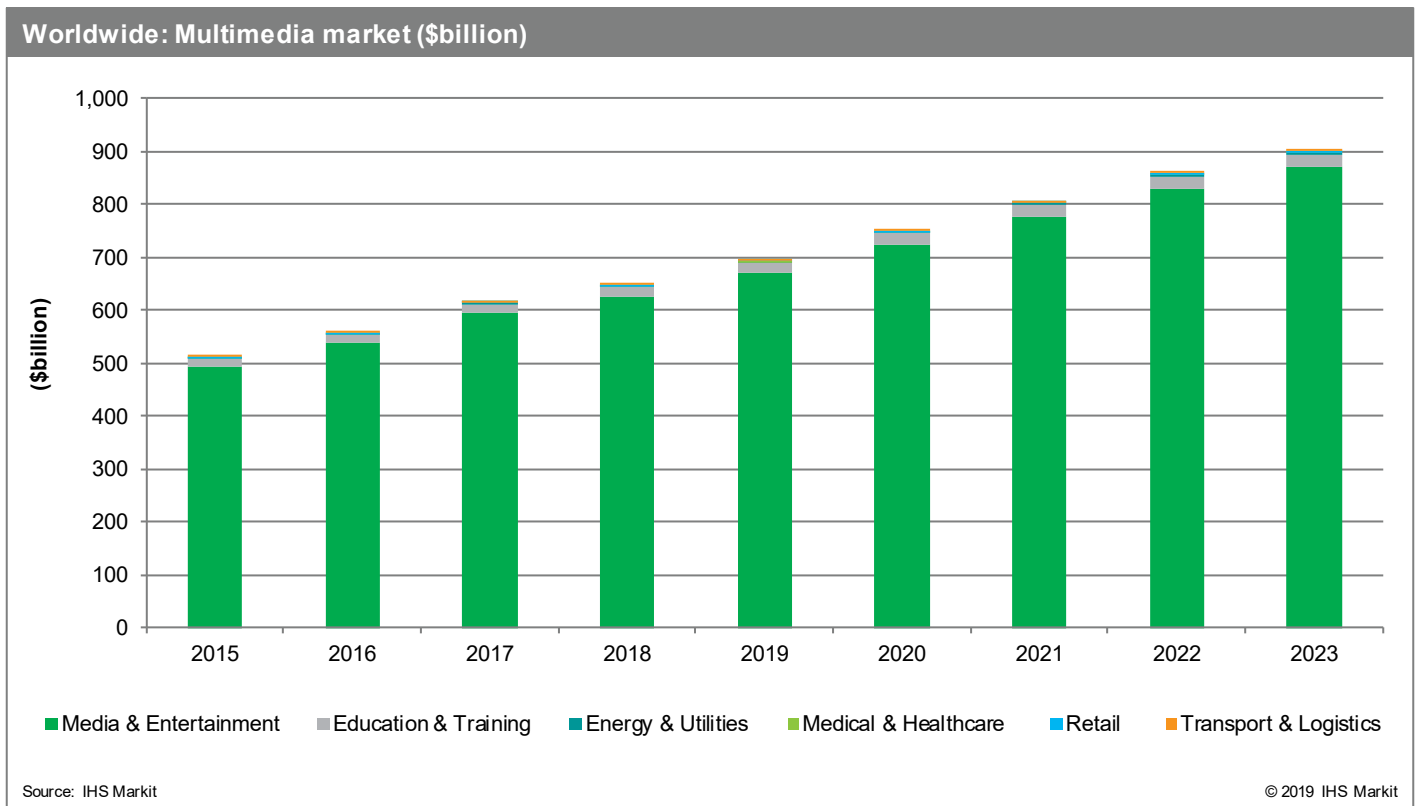
Part one: Multimedia Introduction

1.1 Introducing Multimedia – the \$900 billion opportunity

As 5G technology moves from hype to reality, multimedia, consumer mobile, and entertainment use cases are important early drivers of 5G activity. Multimedia covers a wide range of use cases including the combination of text, images, animation and video delivered electronically. The cases presented later in this whitepaper will focus on broadcast content, VR, and games.

Multimedia content and technology can cover both interactive and non-interactive applications across a range of industries, notable examples include:

- **Media & Entertainment:** including video, games, live events, virtual reality (VR), music
- **Energy & Utilities:** for remote monitoring etc.
- **Education & Training:** online learning, immersive VR training, all academic audio-visual content
- **Medical & Healthcare:** virtual or remote surgery
- **Retail:** online shopping and in-store multimedia content
- **Transport & Logistics:** including infotainment, tracking and other audio-visual services



IHS Markit analysis of the overall multimedia market – including business-to-business revenues, and consumer media and entertainment – forecasts that the total market will grow from \$649 billion in 2018 to over \$900 billion by 2023. Of this, consumer opportunities outperform business-to-business opportunities by 2023 and entertainment and media accounts up for 80% of total consumer opportunities.

Multimedia use cases extend beyond these specific industries including for general corporate, hospitality, and government and security requirements.

Since the rise of enterprise computing in the 1970s and 1980s and PCs in the 1990s, each new wave of computing or communications technology has enabled advances in how multimedia experiences and services are delivered. The type of experience that can be created has also been transformed.

Developments in multimedia technology cover rapid shifts in home video entertainment including from broadcast to cable and satellite TV, the introduction of home video to DVD and online video on-demand.

In education, this includes the shift from text books to e-books, journals in libraries to online, the introduction of educational interactive CD-ROMs to massive open online courses (MOOCs).

In video games, each console generation has brought advances in technology alongside other new specialist and non-specialist games devices for VR, PC and mobile.

The shift in media business models in North America and Europe since the rise of online and mobile distribution shows how technology enables business model disruption. Since 2007, the share of music and video revenues from online subscription services has grown from less than 5% to more than 60% by 2018. Unlike in other regions, these markets had the most established models for legitimate physical e.g. DVD, CD distribution which have been disrupted by online services. In other markets the rise of online services has enabled the creation of entirely new revenue streams and business models, where previously none existed.

As 5G develops, new services enabled by network slicing will emerge to create experiences, applications and use cases that have not yet been possible. Areas of focus across multimedia include services requiring ultra-low latency and high bandwidth including: VR; remote medical procedures; consumer gaming and entertainment; AR; and advanced video content.

Technology transformation has created huge demand for online content and with it the increased reliance on network technology. These shifts have not just transformed the nature of distribution from physical to online, but also the nature of the players involved, and the business models for how content and services are monetised. Subscriptions, microtransactions, and advertising revenues are increasingly taking share from transactional and retail models.

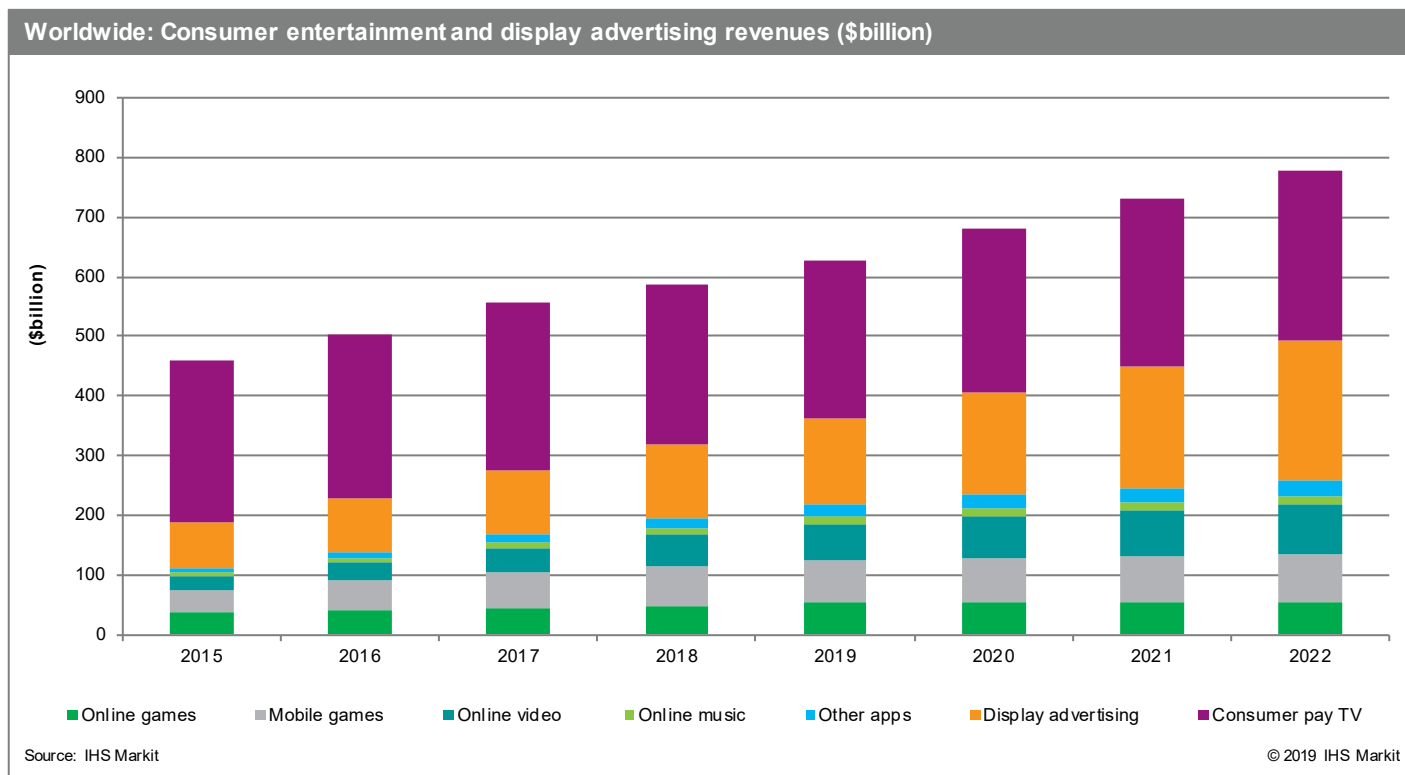
1.2 Multimedia market opportunities

Consumer opportunity

Each new technology generation enables transformations in experiences and business models. The arrival of 4G mobile networks helped fuel the rapid growth of the mobile apps market – which increased from \$2.1bn in 2010 to \$82bn in 2018. IHS Markit forecasts further growth in consumer spending on mobile apps to reach \$105bn by 2022. Consumer spending on online video, games, music and total online display advertising revenue will grow from around \$300bn in 2018 to almost \$500bn by 2022. Early 5G adopters will be a key driver of growth, spending more on content than the average customer and generating much higher

advertising revenues. IHS Markit forecasts that by 2022, 5G customers will be responsible for generating over \$100bn digital entertainment and multimedia spending and advertising revenues.

Many early 5G multimedia use cases will be based on those currently available on 4G LTE, 5G adoption and coverage will need to grow to create a large enough addressable market for content developers to create advanced multiplayer, 4K, or VR/AR experiences that require 5G delivery.



As 5G reaches wider scale, more transformational experiences will emerge that can provide true differentiation:

- **VR and cloud gaming:** which rely on very high bandwidth and ultra-low latency to deliver experiences that cannot be matched at scale on today's 4G networks.
- **VR broadcast and advanced live video:** 5G and networking slicing enable new business models for delivering live location-based and eventually social VR broadcast video content; experiences not possible over 4G LTE today. As the market shifts to higher resolution 4K UHD content for on-demand services, these will also be boosted by the shift to 5G. These use cases will also create new business models for operators and content companies, driving **much closer collaboration across the value chain.**

Business-to-business opportunity

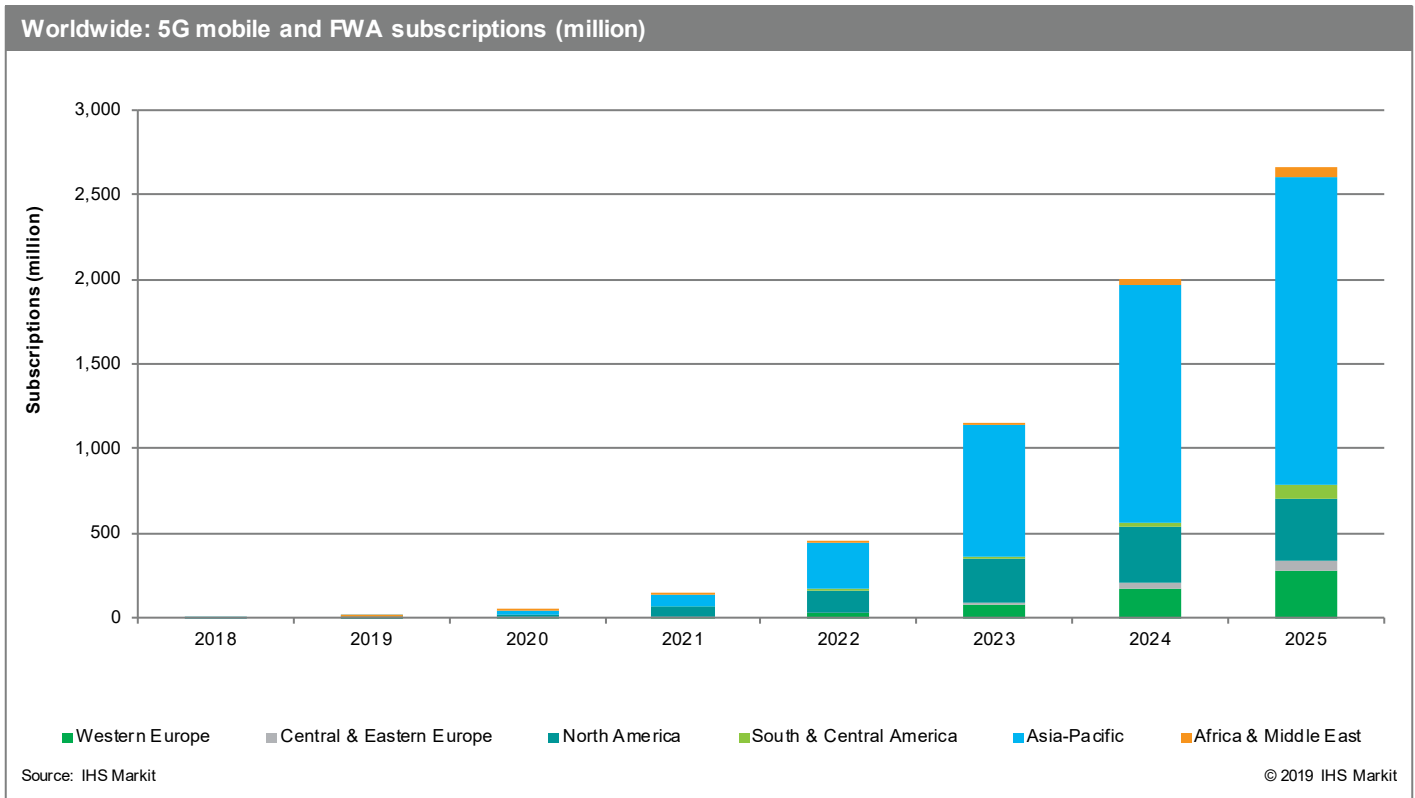
Turning specifically to the business-to-business opportunity, IHS Markit analysis of B2B revenues across different multimedia related industries highlights the importance of the entertainment and media industry in terms of the overall revenue. Considering the total opportunity for equipment and service revenues across key industries (excluding general corporate, government, and hospitality) total B2B multimedia revenues will reach \$90 billion by 2024, up from \$63 billion in 2018. Entertainment & Media will account for over 65% of this total throughout this period.

Part two: 5G and network slicing introduction

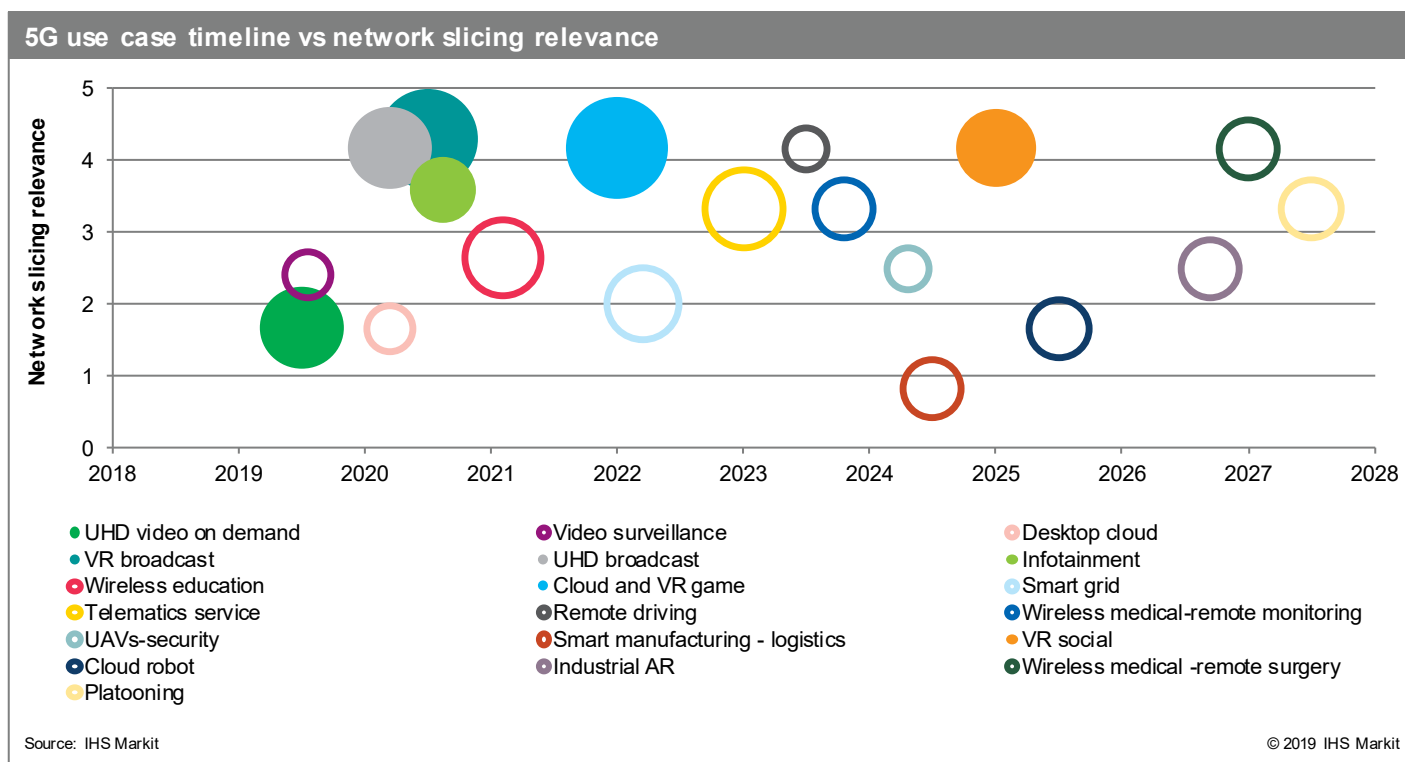
2.1 5G use cases and industry pain points

5G networks are now a reality. The first deployments address consumer mobile or enhanced mobile broadband (eMBB) use cases; longer term opportunities will focus on massive IoT and ultra-reliable low latency (URLLC) or mission critical services. Each of these will benefit from the unique characteristics of 5G including: greater mobility; enhanced coverage; higher bandwidth and speed; customization through APIs; and mission critical services. IHS Markit forecasts that there will be over 1.2bn 5G connections by 2023 including mobile and fixed wireless access (FWA) subscriptions.

Before the implementation of 5G network and slicing, many multimedia use case and applications face specific pain points. These include: poor VR experiences due to the high latency of services delivered over existing networks; hardware barriers for advanced game experiences that require on-device computing; delays when viewing live broadcast sports and event content because of bandwidth and latency limitations; requirements for remote applications such as surgery, monitoring and high resolution video that cannot be delivered in real time.



IHS Markit, through discussions with industry players, has identified a number of different use cases for 5G that can be enabled by network slicing. The chart below reflects the overall demand for these services (the size of the bubble), the expected timeline for widespread adoption or deployment (horizontal time-series axis) and the relevance of network slicing to enable these services. The bubbles with a solid color represent the multimedia use cases especially entertainment, which are mostly among the earliest in terms of adoption, and also higher in terms of network slicing relevance.



2.2 Network slicing: introduction and overview

IHS Markit's definition of network slicing in this report is:


'An end-to-end network slice is a logical partition or a virtual piece of a physical network, including fixed and mobile, physical and virtual, that has connections, capacities (bandwidth), and characteristics (e.g., SLAs) that make the slice look and act like a physical network to the user, program, or process that is using it.'

IHS Markit


Industry standards body the 3GPP identified a list of more than 12 network slicing requirements. These include the ability to dynamically create slices for different scenarios and devices, the ability to access different slices, that each slice not negatively impact another, and guarantees around flexibility, customization, and API access.

In general, network slicing can be used to provide:

In general, network slicing can be used to provide:




High bandwidth/
capacity



Low latency/mobility



Quality of Service (QoS)



Dedicated security

Source: IHS Markit

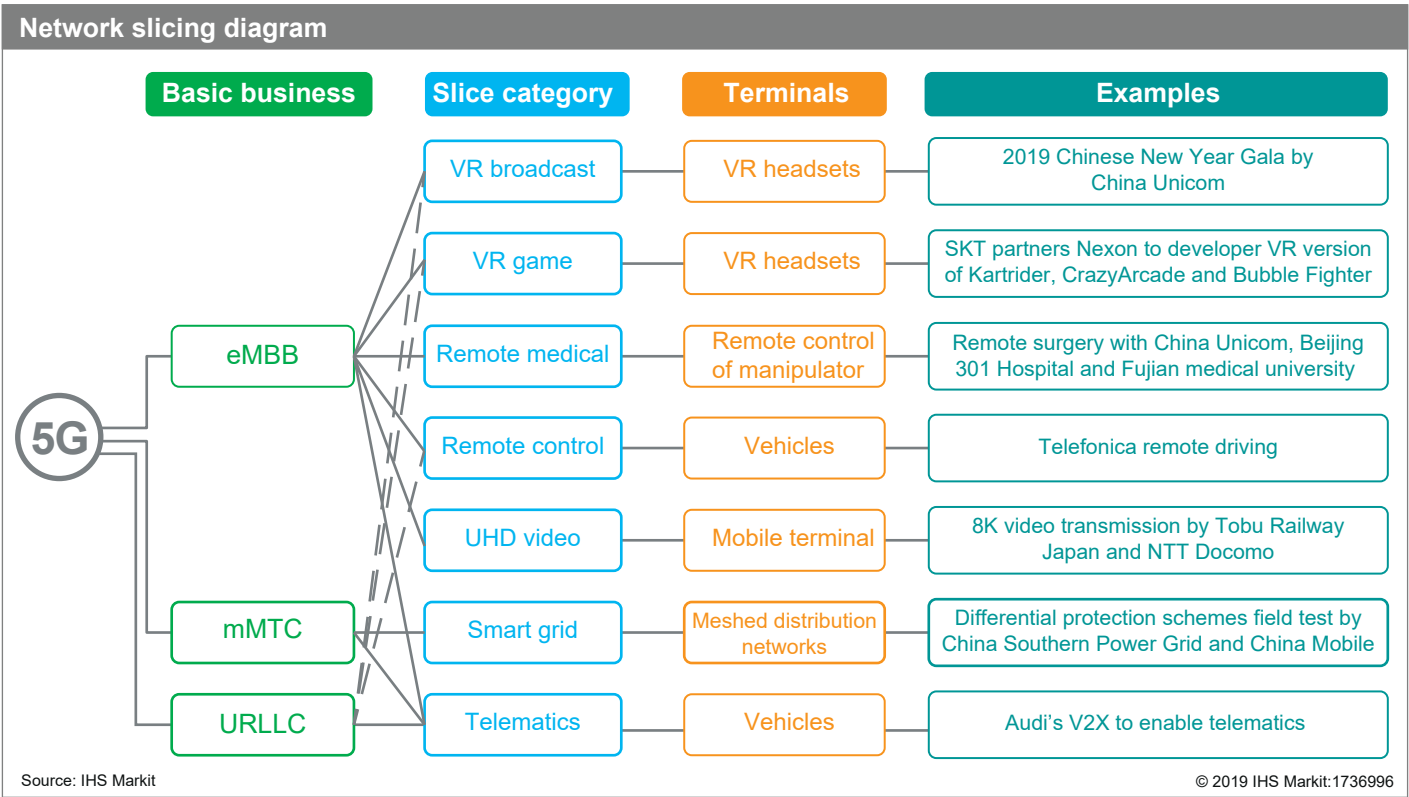
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Satisfying multiple use cases at the same time

In practice, network slicing enables operators to create dedicated slices of their networks for specific use cases. An operator can dedicate, and potentially charge for, network resources to meet different business demands guaranteeing a quality of service to the end user. One customer may have a requirement for high bandwidth services, others may need mission critical reliability or low latency.

Managing networks more efficiently

Previously, operators may have needed to build dedicated networks to guarantee services for such different use cases – for which the costs would have proved prohibitive. The move to 5G enables network slicing to deliver this more efficiently. 4G allowed for some limited customization, but 5G is built with network slicing as a solution from the ground-up. 5G network slicing enables each use case to have a slice that can be optimized



and scaled to its requirements and at the same time operators can use their virtualized infrastructure to repurpose and re-use slices as necessary.

Managing multiple applications

Network slicing can be applied end-to-end across different elements of a network, incorporating terminals, core, access and transport networks. With each slice, operators can serve a different use case or behavior. Rather than have networks with infinite slices, it is likely that types of slice will be used to satisfy different business and end-user requirements.

2.3 Network slicing: use cases

Network slicing use cases with benefits		
Use case	Description	Business model/benefits
Entertainment and Media	VR, AR, advanced and live video, multiplayer gaming - requirements for high bandwidth and very low latency	Publishers and developers can guarantee and differentiate through service quality; operators benefit from network efficiency, differentiated services, direct charges for network slice access.
Massive IoT	Potential to connect millions of devices - which will have different demands and therefore customizable slices to serve each use case	Faster deployment, IoT customer guarantee of service. Operator charges for network slices to new customer segments and more efficient network management.
Industrial	Requirement for ultra-reliable low latency communications (URLLC) or mission critical for monitoring and control	Longer term opportunity - new market for operators to charge end customers; industrial customer cost savings for remote access and guaranteed quality.
Automotive	Combination of requirements from entertainment, IoT, and critical services	Flexible combinations of network slices may be necessary to deliver all automotive use cases

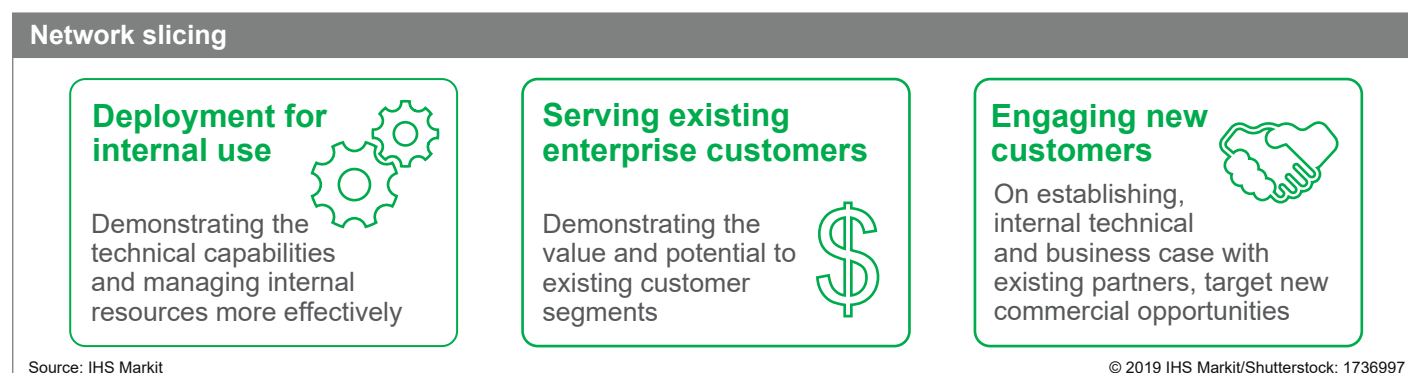
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2.4 Network slicing: strategies and models

Mobile trade association the GSMA has worked with partners across the industry to development different scenarios for the commercial deployment of 5G network slicing. These include a focus on building out these capabilities from the outset to avoid having to retrofit networks after launch.

The GSMA identified three broad categories for operators' 5G network slicing deployment:



Source: IHS Markit

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Early benefits to focus on operational gains

IHS Markit expects that the very early benefits of 5G and network slicing may not come from launching services and business models for new revenue streams, but rather by creating efficiency improvements that enable operators to provide an improved service to keep or attract new customers to their services.

New revenue streams are a more long-term prospect

Longer term, operators can also look to generate new revenues from industry segments by charging for dedicated network slices to guarantee a level of service through service level agreements (SLAs). Operators can be more flexible than previous technology generations have allowed by using APIs for further customization. Operators using network slicing, along with other advances offered by 5G, can grow their role across the value chain from providing connectivity to hosted and managed services to industry customers. Through addressing these wider industry use cases the GSMA forecasts that operators could be able to address a revenue opportunity worth \$300bn by 2025 (Source: GSMA, “Network Slicing: Use Case Requirements, 2018). Taking the delivery of multimedia applications specifically, IHS Markit estimates that the revenue for multimedia and related services could account for around one third of this total, representing an opportunity of around \$100 billion over the same time frame.

2.5 Painpoints and network slicing advantages

The challenges that 5G network slicing can address across different multimedia industries and applications include:

- Low latency which is critical for both media and entertainment (providing a smooth VR experience, multiplayer gaming, live video e.g. sports) as well as medical and healthcare (for remote medical services, diagnostics and surgery) and in other industries for mission critical applications such as remote video monitoring and control.
- Dedicated quality of service is also essential across different industries and can be guaranteed through 5G network slicing in ways that were not possible with previous network generations (e.g. for remote medical, mission critical, and guaranteed video delivery).
- Providing access to dedicated locations is a feature of 5G network slicing that can solve specific issues for different multimedia industry use cases and applications which may not require the demands for widespread 5G coverage and service. 5G network slicing enables this without the need for dedicated or private networks (e.g. for energy and utilities monitoring and control). Providing dedicated access to entertainment locations such as sporting events which have peaks in capacity is also a pain-point that can be addressed through network slicing.
- Much higher bandwidth is a key demand for consumer entertainment with higher capacity requirements for VR video, advanced gaming and for advanced video content resolutions 4K and 8K. These higher resolution video requirements will also be critical for other remote applications such as medical – for which high quality imagery is essential.

2.6 New business opportunities

Advances – which will rely on network slicing - can provide new revenue opportunities for players across the value chain:

- Premium experiences – initially available to higher tier customers with higher-end devices, and therefore can drive new revenue streams for operators and content companies

- Partnerships - operators can partner with content and service companies to add value to customers and push them onto higher tier 5G data plans
- Differentiation - Operators can use these services to differentiate; operators can charge for dedicated network slices enabling content providers to guaranteed quality and availability of services which they can use to differentiate their services
- Cost savings - and improved network efficiency by creating dedicated slices for different use cases and customers or content types
- Quality of service - Content companies can guarantee end users a premium quality of service through network slicing agreements
- New business models and value chains – the adoption of 5G and network slicing will open opportunities for telecoms operators to work more closely with a range of industries and in different parts of the value chain – as providers of networks, managed services, co-branded experiences etc.

Part three: Network slicing use case studies – Games and VR

3.1 Use case studies: Introduction

Of the multiple use cases for network slicing, IHS Markit expects gaming and broadcast video to be among the most significant early opportunities considering both the size of the potential market and the ability to solve specific industry problems.

Network slicing will enable new services not previously possible. Based on IHS Markit's analysis of current operator strategy, device expectations, consumer demand, and industry readiness, the early focus is likely to be on entertainment and gaming.

Consumers spent \$129 billion globally on games content and services in 2018, and this will grow to \$145 billion by 2022. 5G will be one of the major triggers for cloud gaming that mitigates hardware limitations and content development hurdles.

These developments mean mobile gaming or VR gaming could offer an experience comparable to a console-based service to attract a wider audience with both high game quality and greater convenience. The online video market is expected to reach \$108 billion by 2022 with live video featuring strong social activity a significant growth driver.

Network slicing as one of the key features of 5G can enable a better immersive experience with faster, more uniform data rates at lower latency and lower costs, it also provides solutions to recent challenges and bottlenecks.

Broadcast and gaming are early drivers for 5G network slicing

Video and broadcast



- Advanced formats and resolutions (including 4K, UHD, 8K, 360/VR immersive video)
- Live broadcast events
- Interactive content

Education and training



- VR training and education
- Interactive online/remote learning

Transport/logistics



- Infotainment
- Tele-operated driving
- Autonomous driving/V2X

Gaming



- Advanced multiplayer mobile gaming
- VR and AR games
- VR esports
- Cloud gaming

Health/medical



- VR/remote video surgery (and 4K/8K video)
- VR training
- Remote monitoring

Retail



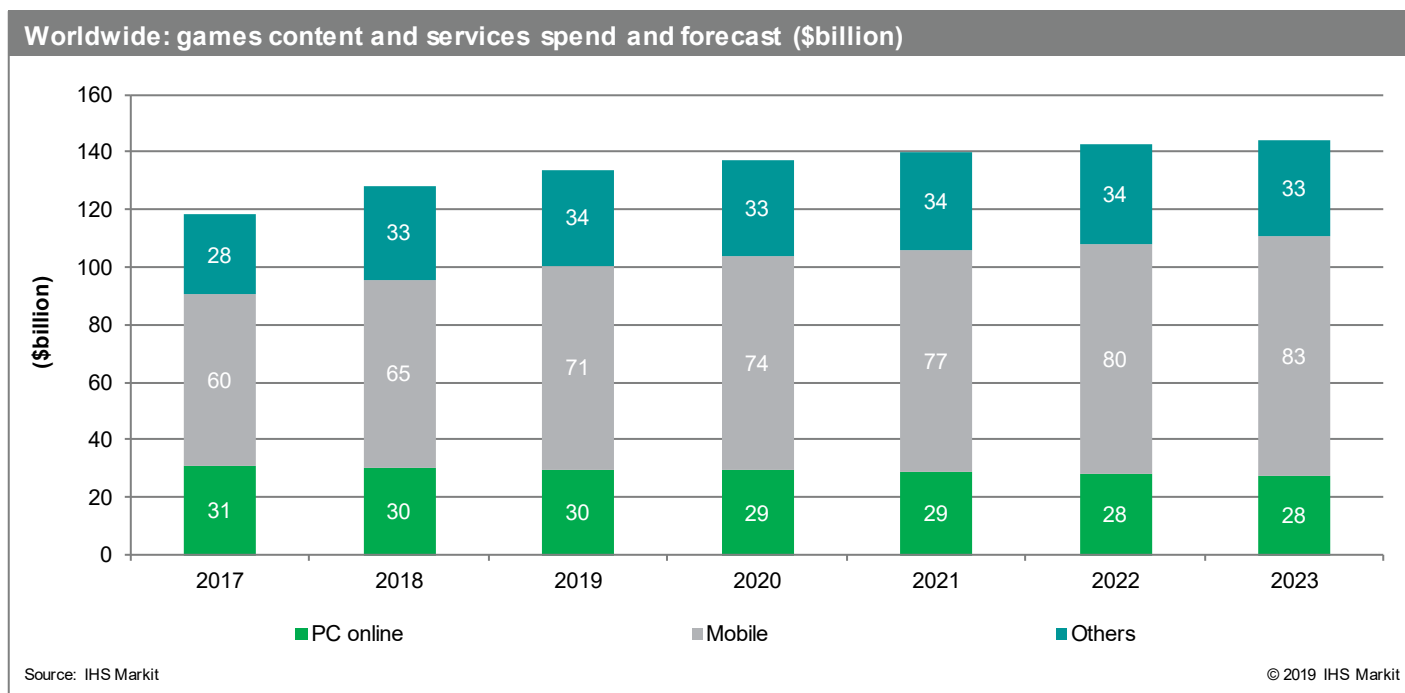
- AR and VR commerce, in store content

3.2 Games use case: Market overview

Games market shows great growth potential across regions

This rise of mobile gaming will continue to fuel games industry growth, but there are differences in the structure of major markets. China is the world's biggest games market, reaching \$31.9 billion in 2018. It is a mobile first opportunity, but it also has a strong market for gaming on PCs. Japanese consumers spend more on mobile gaming per capita than any other territory. North America is the biggest console market and is well penetrated for games devices. Europe is more fragmented and diverse in terms of platforms and devices. In the 5G era supported by network slicing, telcos have more opportunities to address the huge PC and mobile games market expected to reach \$111 billion in 2023.

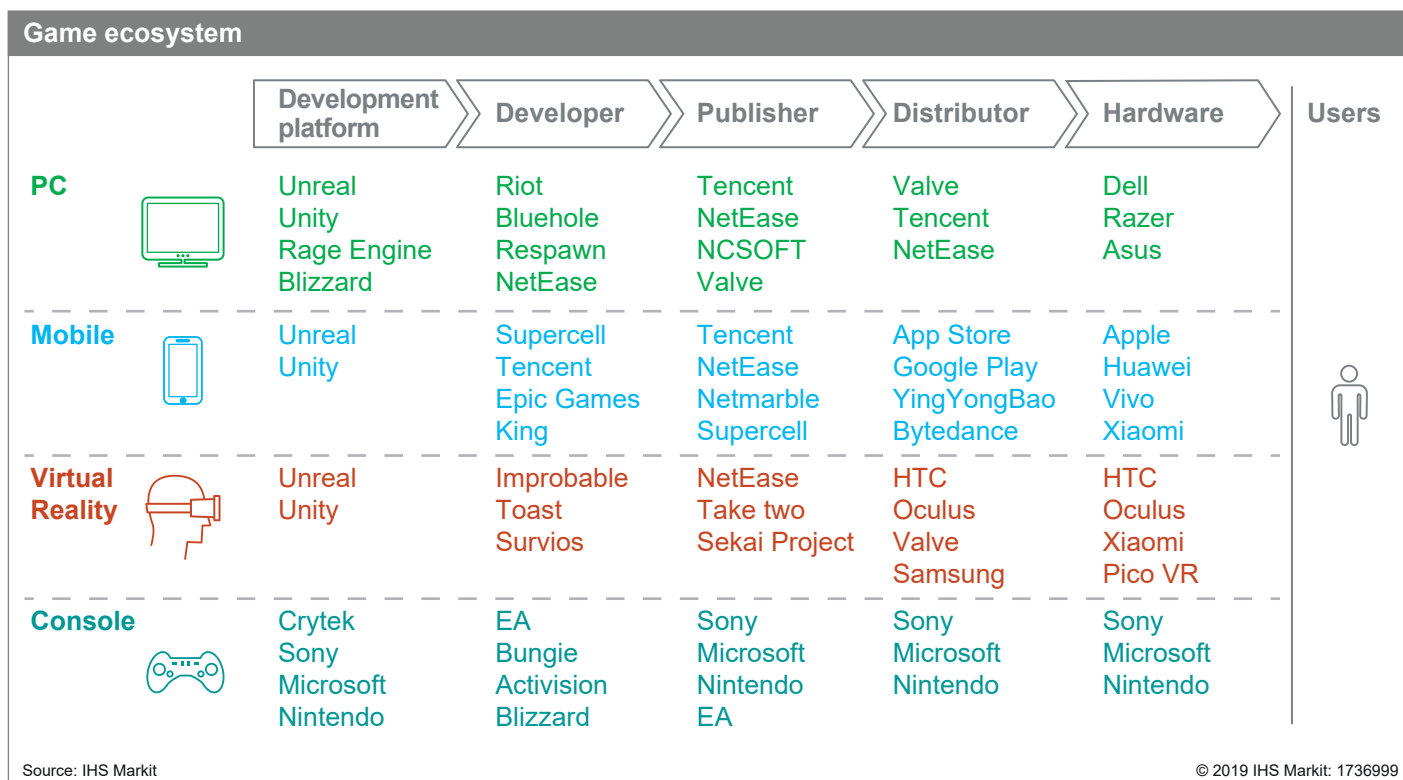
Over the last ten years, the market has transitioned from a console and PC-based opportunity to one that is increasingly mobile first. Across many major markets mobile gaming is now the biggest games opportunity and the broadest in terms of audience size and demographics. In key territories such as China, Japan and South Korea, consumers play a wide variety of games on mobile devices including high-end games that originate on PC and console platforms. This has increased demand to either migrate PC and console games to mobile platforms or to develop higher-quality mobile games. Online and Mobile content dominates the global games market – accounting for the majority of global business. The combined revenue of PC online and mobile games will reach \$111 billion by 2023 from \$95 billion in 2018. This is a large market segment that operators can address through network slicing.



3.3 Games use case: Current games ecosystem and major companies

The value chain for games is divided between development platforms, developers and publishers, and distributors of content and hardware to end users. Most of the value is in content, services and distribution. The shift to cloud-based services enabled by 5G network slicing will accelerate this trend. Cloud gaming services give consumers access to a portfolio of games on-demand across different devices. The concept of

cloud gaming – accessing games whenever a user wants and on a screen of their choice – has long been held up as a theoretical end game for the distribution of games content. It lowers the barriers to entry for consumers to access high-end games by removing up front hardware costs, and presents new opportunities for telecoms operators to secure a role in the value chain.



3.4 Games use case: how cloud gaming and 5G network slice can transform the ecosystem

The consumer benefits of using network slicing to deliver cloud gaming include:

- **Lower barrier to entry:** Less need for expensive consoles or gaming PCs (or GPUs) to enjoy high-end games content. Non-specialist hardware means that gamers can play high-end games anytime and anywhere, provided there is connectivity.
- **Instant access and improved experience:** Access to games- once available on the server - takes a matter of seconds. Removing the need to download creates a better experience.
- **More opportunity for software spending:** Removing upfront high hardware costs can increase user spending on in-game items and subscriptions.

The industry benefits of using network slicing to deliver cloud gaming include:

- **Audience reach:** Reaching a mainstream audience where specialist devices are under-penetrated as well as offering an appropriate tool to upsell other services to existing players through a continuous relationship.
- **Ease of deployment:** Cloud services allow publishers to license/develop AAA titles to a wide audience without worrying about specific hardware requirements.

- **Ease of distribution:** Cloud gaming is a way for other companies to access a market largely dominated by a handful of established platforms – consoles and major PC storefronts.
- **Additional monetization:** Cloud gaming services offer another way to monetize older catalogue titles.

The move to cloud gaming provides a broader shift in the value of the video games market away from hardware and devices and more towards content and software (and services to support their delivery), providing greater opportunities for games publishers and developers. This also increases the opportunities for operators to enable this new type of delivery through network and cloud expertise, managed services – and consumer bundling and data plans. Leading games publishers and platforms are already looking to partner with mobile operators to leverage the benefits of 5G network slicing to deliver superior games experiences.

Hatch Entertainment offers mobile game streaming

Hatch Entertainment (Finland) was spun out of leading mobile games publisher Rovio and offers premium mobile games streamed from the cloud and rendered on mobile devices. This is offered via an ad-funded or subscription model. Hatch works with operators as a distribution and marketing channel, including Hatch games helps to promote operator bundles. The gains in bandwidth and the low latency offered by 5G will make Hatch Games a more compelling proposition and help sell 5G connections. The company has proprietary IP that reduces bandwidth requirements, latency and streaming costs.

Hatch has a clear strategy of partnering operators to grow its reach:

- It works with Deutsche Telekom for zero-rated data while playing Hatch as part of the operator's StreamOn program.
- Hatch is included in SK Telecom's 5GX Game Pack bundle– zero -rated until June 30 2019. It has also partnered with LG Uplus in Korea.
- Sprint USA promotes Hatch Games as part of its 5G roll out a with three-month free trial subscription.
- NTT Docomo is promoting Hatch as part of its 'd-account' bundle and 5G.

The application of 5G network slicing to deliver games through Hatch and similar services will enable the distribution of much more advanced high-end multiplayer games than some of the more casual titles that are currently available. In time this will mean that services can justify higher subscription prices, serve more premium advertising and attract higher spending users. These games will have higher bandwidth and lower latency requirements that are not currently served through existing networks.

3.5 Games use case: Cloud gaming additionally could accelerate adoption of VR games

Cloud gaming drives adoption of VR games

Games will be the largest category of content spending on all three major VR headset categories. When it comes to VR, 5G offers improvements not just over mobile 4G LTE technologies – but also over existing home WiFi networks. This is important as VR is often delivered in a fixed location. 5G outperforms WiFi in terms of latency, speed, and network management given the increasing number of devices connected to home networks. Even as the most commercially advanced VR content category, gaming still faces across production and distribution channels.

Cloud VR/AR gaming involves next-generation interactive games content streamed over 5G which allows games to be rendered in the cloud and streamed to thin client headsets. This would be available to consumers at much lower price points. It supports a more mobile implementation of VR and longer battery life. In addition to mitigating hardware limitations, cloud VR/AR based on 5G network slicing ensures low latency connectivity for multiplayer VR games. User acquisition has been a hurdle for VR games growth, telcos' expanded position in the value chain should give this market a boost by partnering with VR platforms for more clear marketing, distribution and monetization channels.

Network slicing guarantees high-quality VR games experience

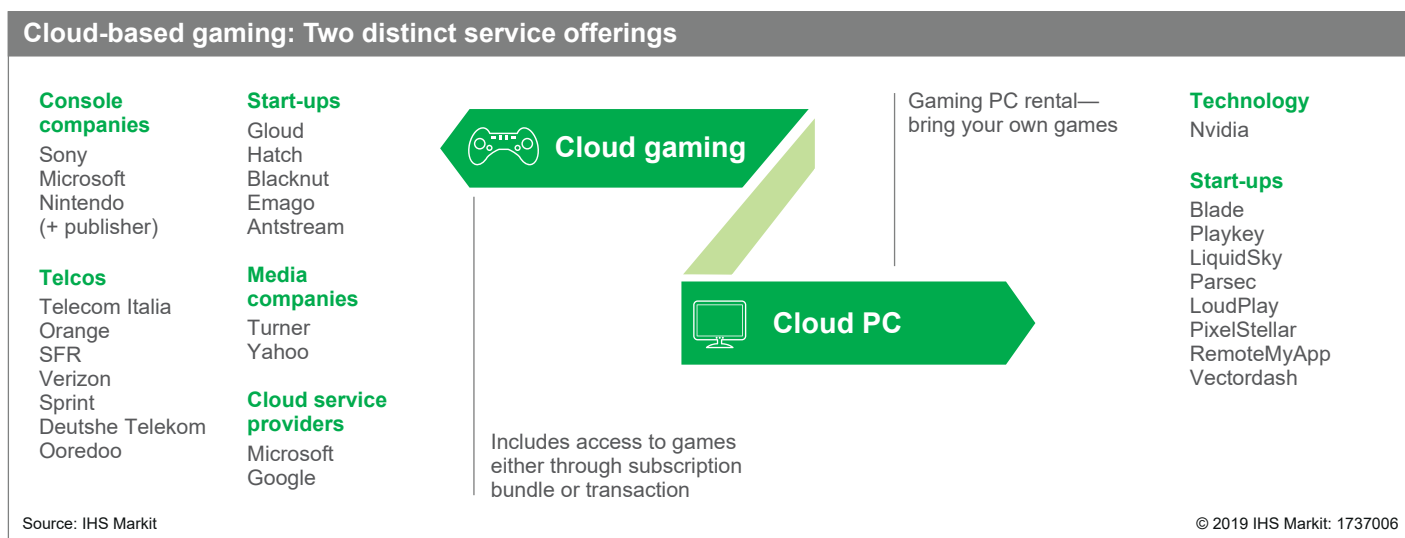
As VR experiences develop, more advances in content and video quality and resolution and increased interactivity (requiring lower latency) mean the demands for network slicing will grow. It is only through delivering experiences through dedicated network slices that highly interactive, high quality levels of service can be achieved and guaranteed.

VR experience requirement						
	Basic VR experience (limited interactivity)	Advanced VR experience (limited interactivity)	Highest VR experience (limited interactivity)	Basic VR experience (high interactivity)	Advanced VR experience (high interactivity)	Highest VR experience (high interactivity)
Resolution/format	8K, 2D, 3D	12K, 3D	24K, 3D	8K, 2D, 3D	12K, 3D	24K, 3D
Speed requirement	40 Mbps – 60 Mbps	340 Mbps	2.3 Gbps	120 Mbps – 200 Mbps	1.4 Gbps	3.4 Gbps
Latency requirement	20 ms – 30 ms	20 ms	10 ms	10 ms	5 ms	5 ms

Source: IHS Markit adaption of GSMA data © 2019 IHS Markit

3.6 Games use case: How network slicing solves critical cloud gaming challenges

Companies with cloud gaming and more general cloud PC plans or services include a broad range of organizations, showing that close collaboration across the industry is necessary. Operators and network slicing will play a critical role.



Network slicing solutions to cloud gaming challenges

Network slicing solutions to cloud gaming challenges		
	Key challenges	Solutions
Latency	<ul style="list-style-type: none"> Multiplayer online battle arena (MOBA) requires <100ms and highly interactive games need <20ms Cloud gaming services under real network conditions suffer latency constraints even with improved round-trip time The closer to data center, the better experience, which limits the audience 	<ul style="list-style-type: none"> A dedicated network slice for cloud service providers to guarantee latency (theoretically to 1ms) Telcos have developed edge computing infrastructure which will have an advantage over cloud service providers where proximity to the end user is importance for reducing latency
Speed	<ul style="list-style-type: none"> High-end games working on any laptop or mobile device require faster internet speeds 100mbps broadband could offer at best 12.5mbps for end users while Google recommends at least 25mbps 	<ul style="list-style-type: none"> 5G can be as much as 20x faster than 4G with optimal download speeds of 20Gbps Network slicing solutions allow service providers to guarantee this speed while managing their networks more efficiently
Compression quality	<ul style="list-style-type: none"> Under a GPU-based cloud gaming solution, video frames are compressed to reduce transit time, resulting in poor presentation at the client end High-quality video transmission requires large bandwidth support 	<ul style="list-style-type: none"> A dedicated network slice for cloud service centers could reduce transit time and enhanced video quality Video compression time can be optimized without impacting overall latency and end user experience
Business model	<ul style="list-style-type: none"> Telcos are struggling to take a role in the gaming value chain with no advantages compared to over-the-top app stores The shift to in-app purchases reduced operators' ability to bundle games content as they had done with other media 	<ul style="list-style-type: none"> The arrival of largely subscription-based cloud gaming services creates a new opportunity for operators to bundle and partner with games services Telcos could generate revenue from both B2B and B2C business

Source IHS Markit

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3.7 Games use case: Telco's expanded role in games value chain

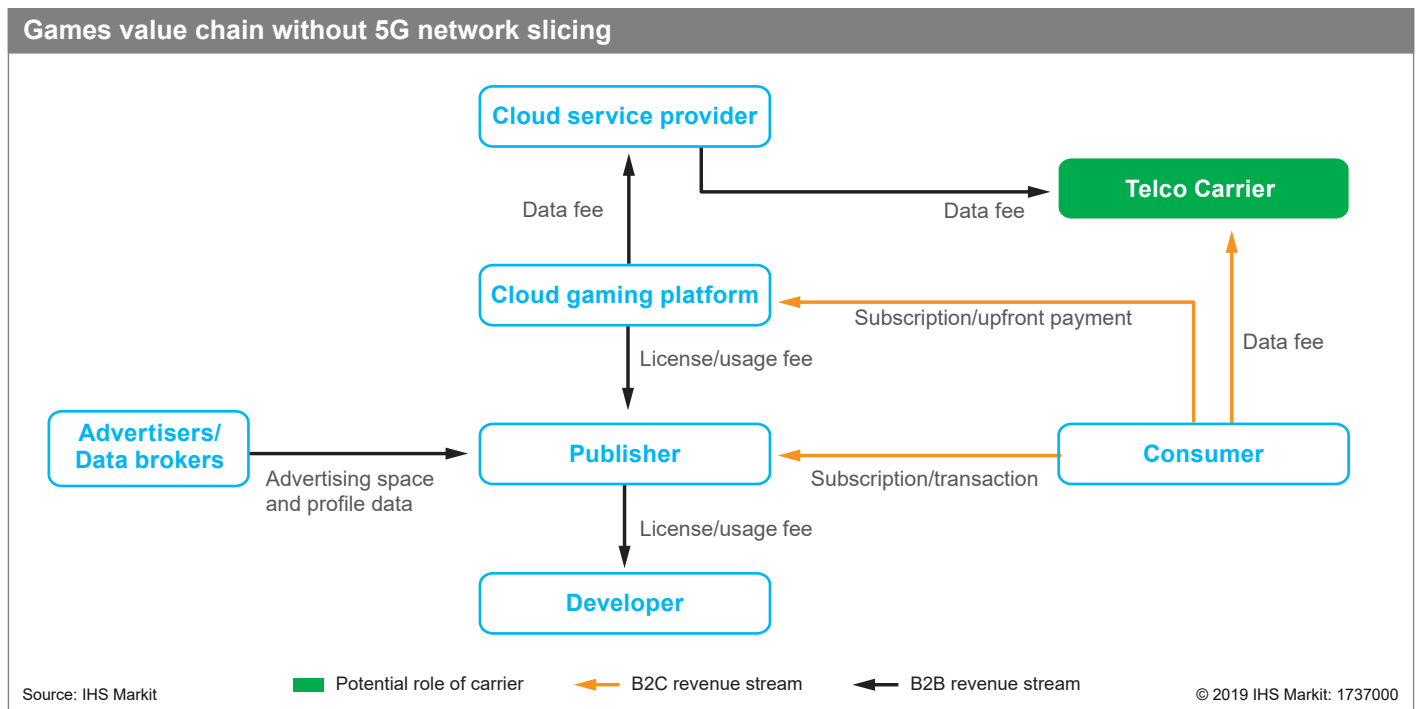
Telcos are well positioned to offer 5G cloud gaming services enabled by network slicing. Operators have so far played a relatively limited role in the mobile and cloud games value chain. In some markets, mobile operators have been able to launch and maintain their own content platforms and stores to distribute and sell games directly to customers. But these are the exceptions rather than the rule, as the market has become dominated by over the top application stores. Operators' roles have been more limited to providing network access (in some cases dedicated data plans), billing support (where available), but not their own games services. Moves towards 5G network slicing and cloud gaming can open new opportunities for mobile operators.

5G network slicing allows telcos to operate diverse business models across different parts of the games value chain including:

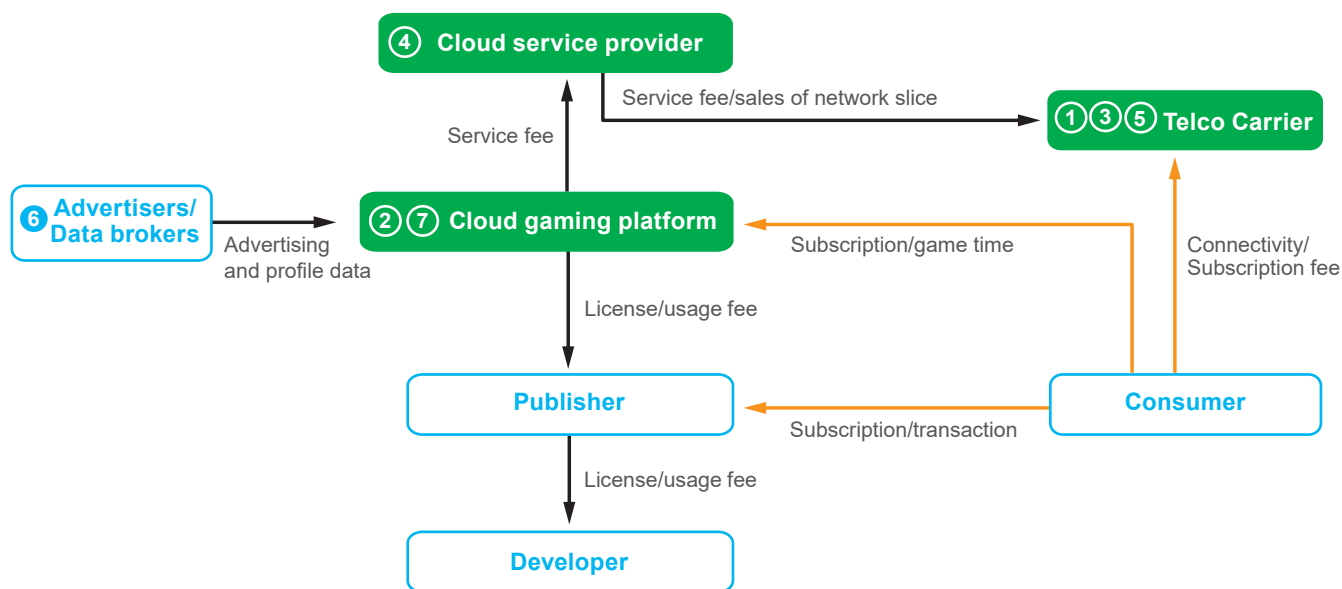
- **New services:** Launch or partner to take revenues/share from premium cloud-based subscription services.
- **Content differentiation:** Leverage the popularity of games to enhance the bundle of premium services to consumers alongside music, video etc. This can include driving users onto premium tier, high or unlimited data plans, or simply to provide a point of differentiation from competitors.
- **Quality of service:** Focus on quality of service and leverage the value of partner content to differentiate from other operators.
- **New business models:** Charge games service providers (or cloud services) and content companies for using the dedicated network slice for games creating a wholly new business model.

- **Enhanced role in the value chain:** Combine network slicing and cloud services to move more heavily into the games value chain through hosted and managed services.

Comparison of games value chain with and without support of 5G network slicing



Games value chain with 5G network slicing



Source: IHS Markit

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Revenue generating services

- 1 Connectivity Service:** High speed, low latency 5G connectivity as well as dedicated network slice to guarantee advanced games experience.
- 2 Games Service:** Cloud gaming platform can offer diverse PC and mobile and VR games services.
- 3 Hardware Sales:** Telcos could rent or sell hardware to its own customers via subscription bundle or one-off offering. The hardware includes VR headsets and controllers, set-top boxes.
- 4 Cloud Services:** Telco cloud platform and infrastructure services that help to minimize latency and maximize bandwidth for cloud gaming platforms.
- 5 Network-as-a-Service:** NaaS enables telcos to provide differentiated services to their customers.
- 6 Advertising Space/Broker Profile Data:** Ad space and anonymous gamer profile data sold to ad networks or advertisers.
- 7 In Game Add-ons:** Platforms transaction fees on in-game add-on revenue.

Possible go-to-market approaches

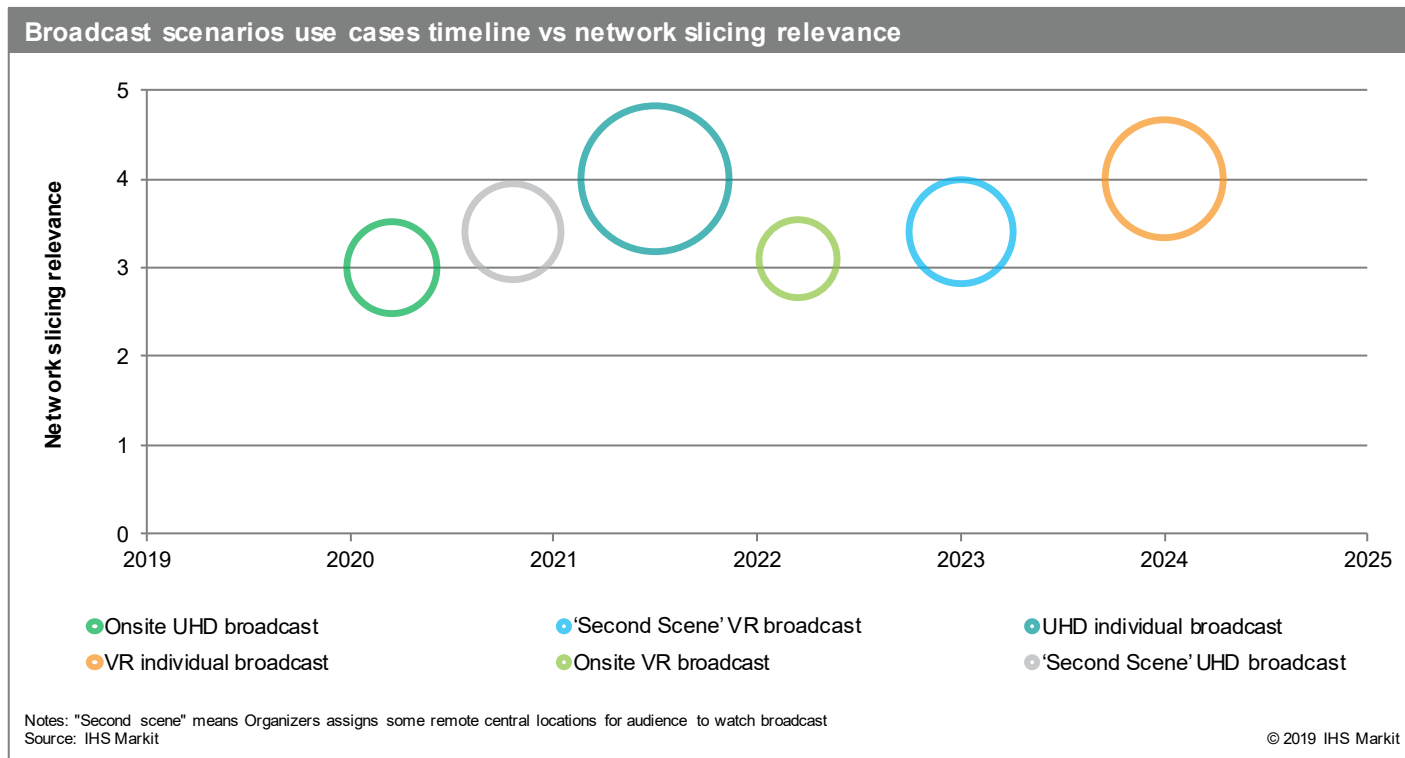
- 1 Connectivity:** Sell benefits of 5G for cloud gaming.
- 2 3 7 Value-added Service:** Establish its own cloud gaming platform to step into games value chain. Performs as hardware and subscriber distribution channels.
- 1 4 5 Cloud and Network Services:** Open network and cloud platform to cloud gaming platform.
- 6 Advertising and User Acquisition:** Add advertising and data brokering to own brand cloud gaming platform: Performs as user acquisition channel to VR game apps.

Part four: Network slicing use case studies – Broadcast, Video and VR

4.1 Broadcast roadmap and use cases

The application of network slicing to the broadcast industry has the potential to impact various players across the broadcast ecosystem. Key players include:

- **Operators and service providers:** including mobile network operators and providers of TV and video across all platforms. 5G network slicing could eventually transform the distribution channels and business models for video content. Key players include companies like: AT&T, Verizon, China Mobile, Sky, Vodafone, Telefonica, Disney, Netflix, Amazon.
- **Broadcast and video delivery infrastructure:** business-to-business vendors of video infrastructure solutions to operators and video service providers including: Akamai, Huawei, AWS, Tata Communications, Telstra.
- **Content owners and producers:** creators of original video content including independent producers, major studios, television channels. Also includes creators of more niche content including VR and AR video.
- **TV and Video channels and networks:** covering both traditional and online channels including Netflix, Amazon, BBC, Discovery, NBC, Hulu, ProSieben, China CCTV and Migu.



5G network slicing has the potential to disrupt broadcast markets and value chains, triggering new business models and allowing scenarios which have been unrealistic in the 4G era. This is particularly relevant to the delivery of content with high bandwidth and low latency requirements. However, as 5G networks will take time to reach wide

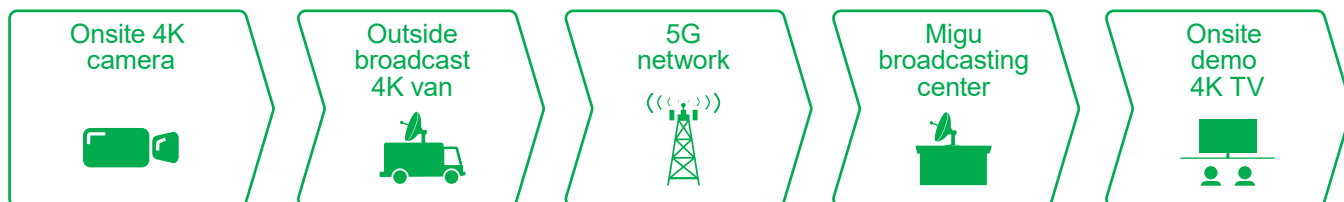
coverage, stable UHD/4K broadcast for commercial deployment is achievable in the short term. With the support of AI editing, viewers can watch live events from multiple viewing angles. In the long term with wider 5G coverage, more mature immersive VR technology, and increased consumer adoption of VR devices, the commercial case for VR broadcasting for exhibitions, concerts and live events, and social VR video can be established.

Migu launches 4K broadcast with 5G network slicing support

China Mobile subsidiary Migu and Huawei partnered to broadcast the 12th Annual Migu Music Awards in December 2018, which is the first worldwide 5G+true 4K music awards broadcast. With the support of Huawei's network slicing solution for China Mobile (Shanghai) 5G networks, Migu succeeded in delivering true 4K video broadcast. Migu confirmed the use of 5G+true 4K end-to-end broadcast including 4K cameras, 4K video transcoding and 5G network transmission to deliver what it claimed was the first of its kind worldwide large-scale event broadcasting with the use of 5G network slicing.

In January 2019, Migu also announced a strategic partnership with the China Volleyball League as its official exclusive digital joint operator with the new media copyright and co-operation right for the CVL games in the 2018-2020 season. Migu started to broadcast the first CVL All-Star game in late March with 5G+4K resolution via the support of China Mobile (Shenzhen).

Migu 4K broadcast transmission



Source: IHS Markit

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Network slicing can support broadcasting services for different scenarios at the same time. Each slice could achieve end-to-end logical isolation from terminals, access network, transport network to core network, which in this case means that China Mobile (Shanghai) and Huawei offer a dedicated network slice to guarantee bandwidth and low latency for Migu to broadcast this event. This logical network slice guarantees the network's ability to offer higher quality of services but also shows the potential wide use of 4K video delivery in a heavily loaded network environment.

China Media Group completed UHD live streaming through 5G SA network slicing support

Additionally, The China Media Group, China Mobile and Huawei completed UHD live streaming verification through a real end-to-end 5G network slice. This trial uses 4K cameras to shoot videos in the outdoor field China Mobile Beijing at Dong Zhi Men. And the encoded and compressed video streams are backhauled to the 4K TVs through the 5G SA Network. This trial verifies that the E2E 5G SA network slice offered by China Mobile and Huawei could guarantee ultra-high bandwidth and ultra-low latency for live streaming services by China Central Television (CCTV). The smooth, clear live streaming with high-priority assurance is ensured when traffic increases sharply on the RAN, transport network, and core network.

Indeed, 5G network slicing changes the 'single runway' service model of the traditional 3G/4G network, and provides dedicated 'runways' for different service scenarios. The solution enables carriers to almost literally slice a network into multiple virtual E2E networks on the same hardware infrastructure. This trial uses the

SA base station, SPN transport network, and brand-new 5GC network from China Mobile to build dedicated cannels based on 5G network infrastructure and slice services for a guaranteed 4K UHD video playback experience. After this test, the three parties will continue to explore more application scenarios and slice types under mobile environment in the phase-2 test.

IHS Markit data indicates that the total video transport market will be worth approximately \$25bn in 2019. Until now, operators have played a relatively limited role. 5G network slicing to deliver broadcast video content will only address small subsets of this in the near-term, but the size of the overall market means that even a small share can be significant for operators that launch services. Looking specifically at the costs and revenues associated with outside broadcasting (relevant for event-based content) this market will generate around \$700m on equipment fees in 2019. Here operators can play a role by offering broadcast solutions at a lower cost without the need for fiber leased lines and dedicated vehicles.

Reduced reliance on leased line fiber: Existing venues most commonly use dedicated fiber leased lines, which at best could offer upstream speeds at 8mbps, and event organizers/broadcast solution providers need to negotiate with venues for renting the fiber leased lines and plan onsite cable installations months in advance. Recent fiber leased lines cannot satisfy the low latency demands for VR broadcast as well as 8K video delivery. Network slicing offers an alternative and superior option for event organizers without cable installations. When broadcasting CVL All-Star games, China Mobile (Shenzhen) partnered with Huawei to install its 5G digital indoor system (DIS) with 5G LampSite Pro and 5G CPE Pro to provide 5G coverage for the sport venue. This does not interrupt existing venue cables, nor does it compromise venue aesthetics.

Onsite TV guarantees user experience – The onsite 4K TV demo ensured users could experience 4K resolution broadcast with low latency. During the CVL All-Star game, the onsite audience could switch screens to watch the live events based on their interest rather than following the main TV screen. The fixed location under 5G coverage enables relatively easy deployment for a video streaming platform to guarantee 4K broadcast without compromising resolution and poor connection. However, it might take a longer time for users to be able watch 4K live video across different use cases including out of home. Progress depends mainly on the expansion of 5G coverage and penetration of 5G-supported devices, rather than specific technical challenges.

There are two ways in which operators can create new business models to address this opportunity:

- Upstream: here business models focus on telcos charging broadcasters or solutions providers for either network access, data, and/or managed services to deliver content to consumers. Telcos could structure this in different ways including:

Fees per event

Fees per end user

Fees based on data volume

Wider managed services contracts

Partnerships and revenue shares for co-branded/delivered services

- Downstream: this focuses on the B2C opportunity through which operators either charge consumers for dedicated access to content delivered by network slicing; create premium tiers or data plans; or use it as a wider retention differentiation play; and content partnerships.

4.2 Broadcast use case: 5G network slicing to accelerate broadcast VR

Previous attempts

VR broadcast trials are not new. In the US, Verizon hosted a VR Super Bowl experience over a 5G connection to a limited group of employees in early 2018. In the UK, a BBC app provided a VR FIFA World Cup experience, allowing viewers to choose their own camera angles and to point at players to retrieve stats and detailed information.

A major development in China was the four-hour VR broadcast of Faye Wong's concert in 2017, with the support of VR streaming platform Whale VR, and Digital Domain as the broadcast solution provider. Whale VR reports that around 90,000 users watched the concert live in VR for a \$4.30 ticket fee, this compared with 21 million viewers of the concert video live via Tencent's video app (available up to UHD).

Considering pay-per-view fees and device requirements, the volume of concurrent viewers reflects the strong market demand, but there has been negative feedback from some early VR broadcast trials including: **poor video quality, high latency and a lack of high-end headsets**. 5G and network slicing technology could improve the VR broadcast experience and accelerate user adoption.

How 5G can transform VR broadcasting

Poor video quality – Digital Domain set up several Kronos and Zeus 4K VR cameras in the video. The image data captured by Kronos was stitched and processed in real time to produce the VR live stream. But, as the company did not rent the venue fiber leased lines and thus had to use public networks, the 4K video had to be compressed to enable smooth transmission and save bandwidth. 5G network slicing can offer a dedicated network slice to guarantee bandwidth for broadcasting without using the venues' fiber leased lines or general public networks.

A lack of high-end headsets – Whale VR is the only high-end headset compatible with the Whale VR streaming platform, while users could also use smartphone adapters to watch this live, these did not support the highest quality immersive experience due to their low spec. Cloud technology enabled by 5G could deliver better experiences without the need for high-end headsets. This will help accelerate mass market VR adoption.

However, offering immersive experiences for the home audience also requires downstream transmission at high speed, which will rely on full 5G full coverage. As a result, VR broadcasting at sub-meeting places (or secondary fixed locations) will be a likely earlier use case for VR broadcast content – particularly in China.

4.3 Broadcast use case: VR and UHD broadcasting

VR and UHD Broadcasting to secondary locations or “second scene” events

The delivery of broadcast VR/UHD content from live events to secondary locations or second scenes presents good early opportunity for 5G network slicing. Mass market consumer use cases will require widespread coverage, but for location-specific services, coverage can be focused. The implementation of 5G network slicing solutions should provide a clear cost benefit to event/content companies (no fixed line or heavy equipment costs) and for operators it presents a new revenue stream and business model.

In these scenarios, centralized secondary locations are established in cities remote to the main venue. Organizers and solution providers broadcast the live events and stream the content to attendees at the

secondary location (second scene). The business model for the event providers here is similar to other events including ticket sales, sponsorship, merchandise and advertising – for operators, the business model is similar to exhibitions in providing a new customer base of event organizers or locations.

VR/UHD second scene broadcast transmission



Source: IHS Markit

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In the typical scenario in 2019 in China outlined by IHS Markit, event organizers could generate extra revenue of \$126,000 from VR broadcasting at secondary locations for concerts (based on two secondary locations of three hundred attendees each), and telcos could obtain a 30% share of the extra revenue.

Although this extra revenue is small compared to \$387,000 generated from Faye Wong's VR broadcast concert, it requires only focused rather than widespread 5G. The high-quality experience can drive user demand for VR broadcasting and generate consistent revenue streams. Compared to VR broadcasting, UHD broadcasting is expected to address wider audience, with no requirement for headsets. As a result, supported via high-quality of broadcasting and growing 5G coverage, extra revenue generated from VR and UHD broadcasting together could reach \$1.8bn in 2025 of which telcos could generate \$720million.

China: second scene VR/UHD events

In the typical scenario in 2020 in China outlined by IHS Markit, event organizers could generate extra revenue of \$31m from VR broadcasting at secondary locations for concerts (based on two secondary locations of three hundred attendees each), and telcos could obtain a 30% share of the extra revenue.

It requires only focused rather than widespread 5G. The high-quality experience can drive user demand for VR broadcasting and generate consistent revenue streams. Compared to VR broadcasting, UHD broadcasting is expected to address wider audience, with no requirement for headsets. As a result, supported via high-quality of broadcasting and growing 5G coverage, extra revenue generated from VR and UHD broadcasting together could reach \$1.8bn in 2025 of which telcos could generate \$720million.

China: second scene VR/UHD events

	2020	2021	2022	2023	2024	2025
Annual events with VR and UHD broadcasting	1,500	2,300	3,500	4,500	5,000	5,200
VR/UHD broadcasting events with secondary locations	300	575	980	1,600	2,000	2,500
Number of secondary locations for each event	5	7	15	25	40	60
Average secondary location capacity	300	500	500	400	300	300
Ticket price for secondary locations	\$70	\$70	\$70	\$50	\$50	\$40
Extra revenue	\$31 m	\$140 m	\$515 m	\$800 m	\$1,200 m	\$1,800 m
Telco share	30%	30%	30%	40%	40%	40%
Telco revenue	\$9.5 m	\$42 m	\$155 m	\$320 m	\$480 m	\$720 m

Source: IHS Markit

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Onsite UHD broadcast at events and live UHD content

Second Scene VR/UHD events as discussed above provide a clear use case and business model that relies on 5G network slicing, but there are other business models and use cases for 5G network slicing and broadcast content.

Onsite broadcast creates enables a significant uplift in revenue

As with VR, earlier opportunities for broadcast UHD content using 5G network slicing will center on specific locations, avoiding the need for widespread 5G coverage. The most likely opportunity identified by IHS Markit is for sporting events, for which delivering in-stadium or arena video content to attendees can deliver a significant revenue uplift. Delivering in-stadium video content to event attendees places significant strain on network capacity, real-time information requires very low latency, and charging for such services necessitates a guaranteed quality of service.

Without 5G network slicing this will not be possible. IHS Markit has analyzed typical scenarios for how this can be monetized and estimates a total potential revenue uplift of between 5% and 10% for a typical sporting event. Expanding this theoretical scenario out to the global live sports industry is difficult given the different ticket prices, attendance levels, and technology infrastructure across stadia globally. But with estimates for global sporting ticket sales of over \$30 billion (Deloitte, 2017), the additional uplift from 5G network slicing should create a further multibillion-dollar opportunity.

Onsite sports broadcast scenario for 5G network slicing

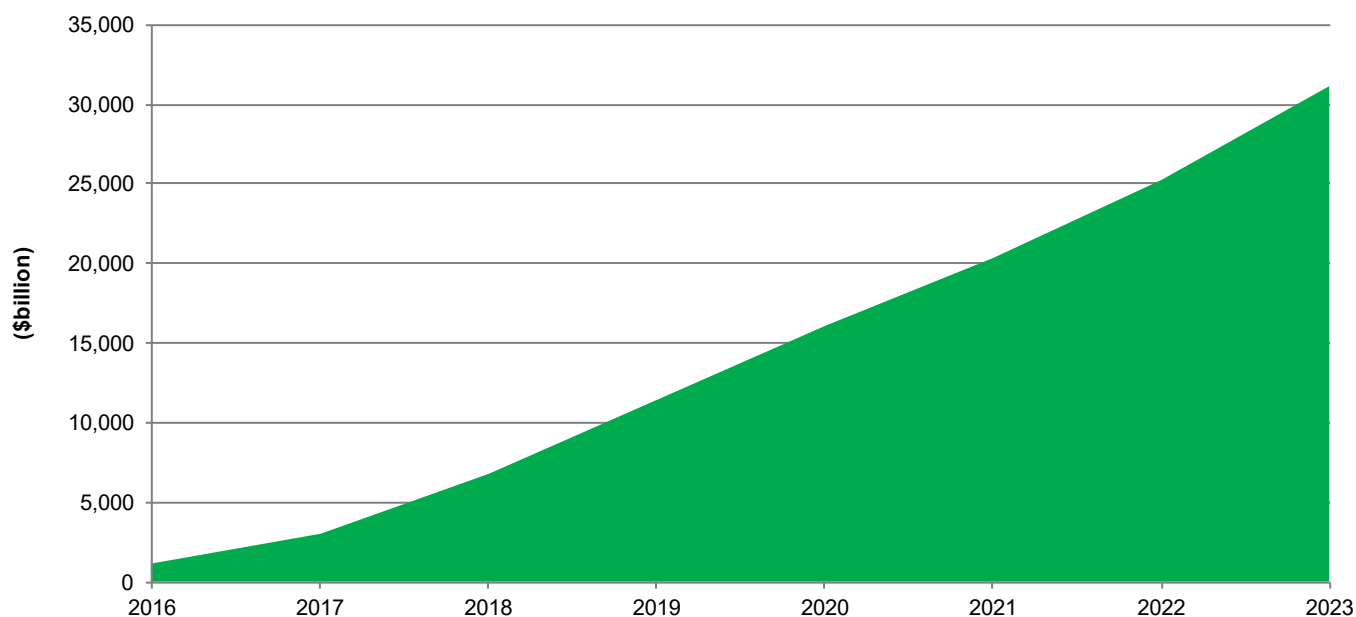
Scenario 1:	Typical ticket price	Increase in ticket price for premium video	Share of audience paying extra	Number of attendees	Typical increase in revenue
Premium tickets	\$50	Up to 25%	c. 20%	50,000	5%+ / \$125,000+ per event
Scenario 2:	Typical ticket price	Advertising revenue per viewer per event	Share of attendees viewing full video	Number of attendees	Typical revenue uplift
Advertising	\$50	\$5-\$10	30%	50,000	6%-10% / \$150,000 - \$250,000 per event

Source: IHS Markit© 2019 IHS Markit

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General live individual broadcast UHD is a longer term, but potentially more lucrative opportunity

Globally, the overall revenue opportunity for advanced online video content is growing. IHS Markit forecasts that consumer spending on online UHD, VR and immersive/ 360 video content will grow from around \$6.8bn in 2018 to more than \$31bn by 2023. Online video providers already aim to deliver UHD content over existing networks, but this is centered around on-demand rather than live content. Delivering broadcast live video content to a mass audience presents more significant challenges that 5G network slicing can address. IHS Markit forecasts that the total opportunity that can be addressed by 5G network slicing for live online or individual broadcast content UHD and VR will grow from around \$100m in 2019 to \$2.2bn by 2023. China will be one of the leading markets, accounting for around \$200m by 2023. This is based on IHS Markit's tracking of the online video and pay-TV video markets over more than two decades. As 5G coverage expands beyond this forecast period, the revenue opportunity in China and globally will still see significant growth.

World: Consumer spend on online UHD, VR and 360 video (\$billion)

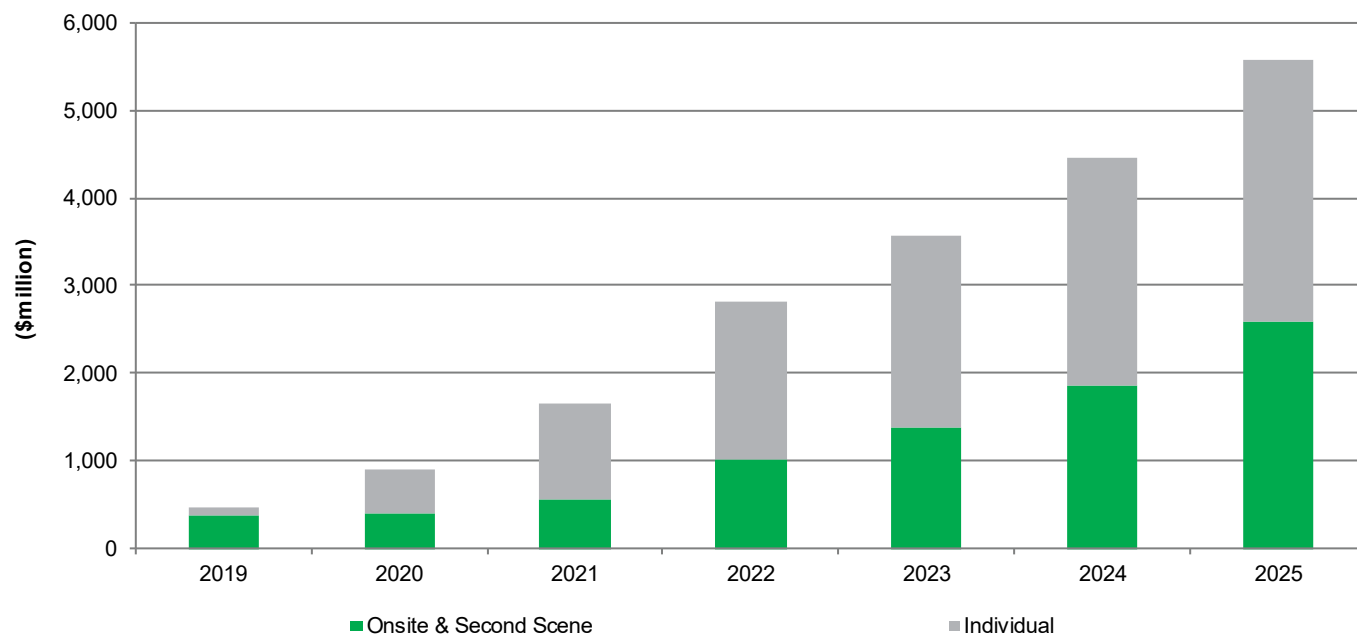
Source: IHS Markit

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5G network slicing will trigger broadcast revenue in the near future

In general, the delivery of broadcast VR/UHD content from live events to secondary locations or second scenes will present a good early opportunity for 5G network slicing. Additionally, onsite sporting events also enables monetization from premium ticket sales and advertising via the support of 5G network slicing. But, with the development of 5G coverage and telcos' capability to support more network slices, VR and UHD broadcasting to individual's device as well as broadcasting VR/UHD content by individuals to a wider audience will become more feasible. As a result, we expect Individual UHD and VR broadcast revenue opportunity will outperform onsite and second scene broadcast to reach \$2.2bn by 2023 while the latter two will be \$1.4bn aggregately. At that time, the share of revenue generated from different scenarios varies and will be dependent on event demand, popularity of broadcasters, and marketing activities. Regardless of the specific revenue share, this offers telcos more additional revenue streams and helps to develop their role in the broadcast value chain. In order to forecast the overall potential opportunity from network slicing for broadcast VR and UHD content – for both event based onsite and second scene content and individual online video – IHS Markit has considered: the typical revenue scenarios outlined above, the overall size the of each market, assessment of the consumer appeal for each service and the size and growth of the overall live UHD video market globally. The forecast for UHD is based on the pricing and subscriptions for live online video content tracked by IHS Markit and the availability and delivery of UHD content. This tracks operators and services globally.

Worldwide: UHD and VR broadcast revenue opportunity (\$ million)



Source: IHS Markit

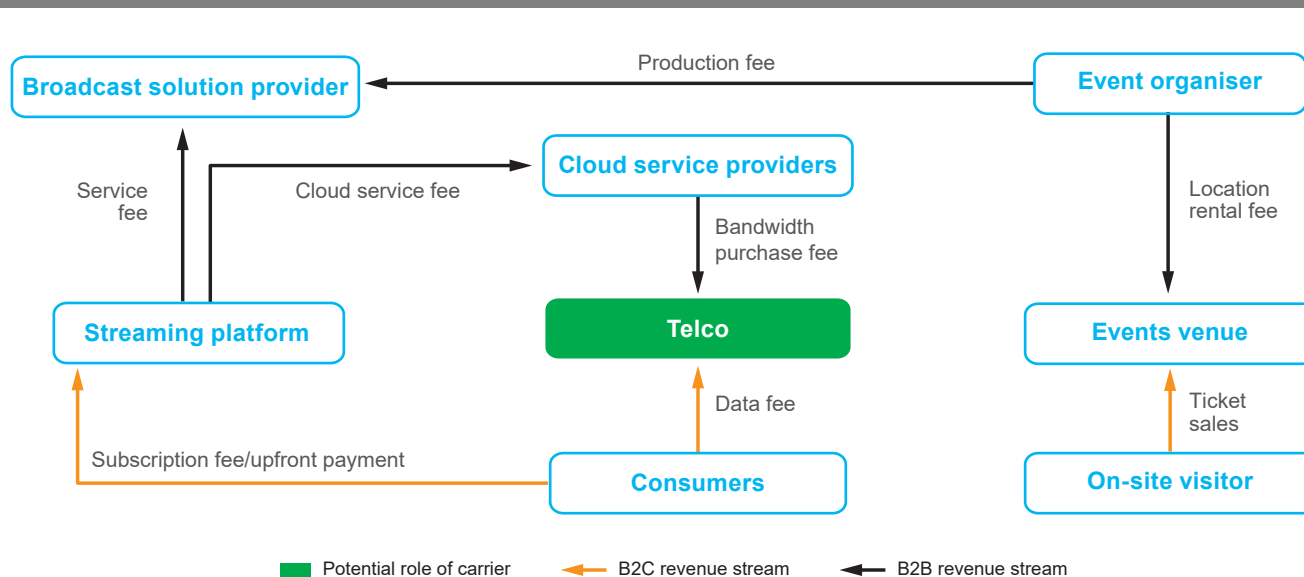
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4.4 Broadcast use case: Extensive engagement for telcos in the value chain

As we move into the 5G era, telcos will not only act as a distribution pipe, but also expand their role in the content value chain to build additional revenue streams through additional hosted and managed services.

Comparison of broadcast value chain with and without support of 5G network slicing

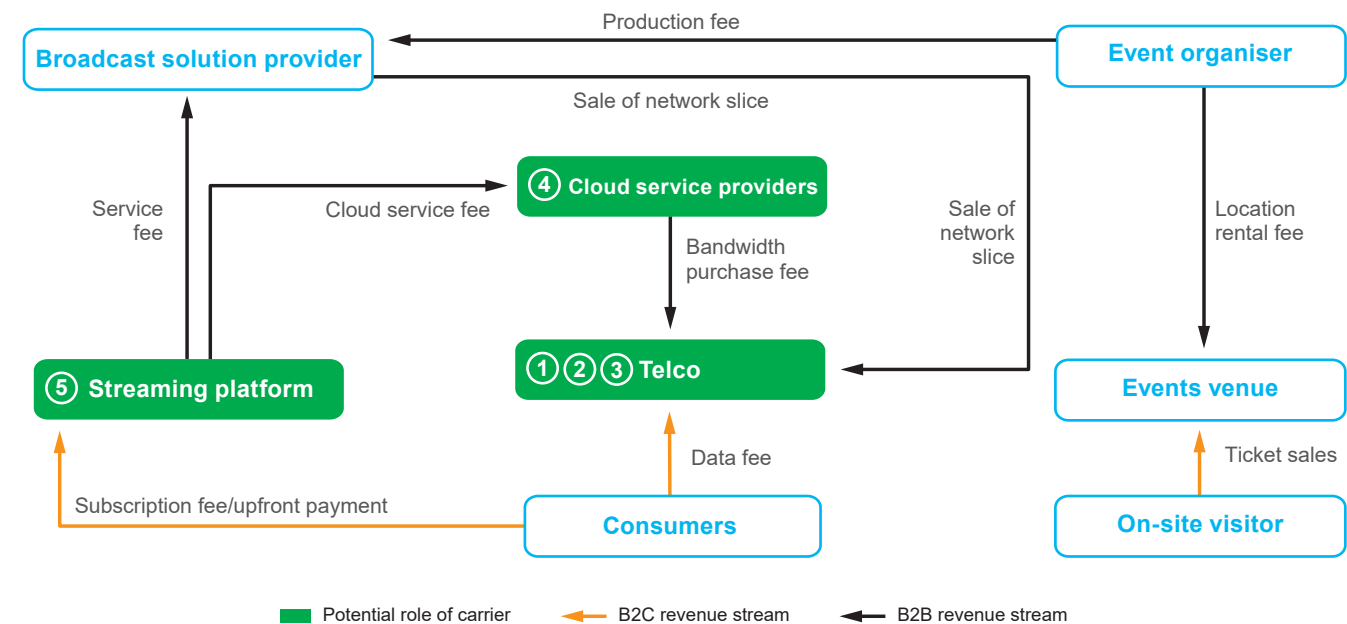
Typical broadcast value flow without 5G network slicing



Source: IHS Markit

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Broadcast value flow with network slicing



Source: IHS Markit

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Revenue streams

1 Events service, connectivity and hardware

Promote or resell a third party or own brand VR events service in a connectivity and hardware package. Resell tickets for events and earn commission.

2 Event Tickets:

Resell tickets for events and earn commission.

3 Network-as-a-Service:

NaaS enables Event platforms to provide differentiated services to their customers.

4 Cloud Services:

Open cloud platforms to VR Events platforms and content producers to process huge data volumes locally and reduce latency.

5 Event Streams:

Telcos could broadcast events via its own streaming platform and thus generate viewing fees.

Possible go-to-market approaches

1 2 Event Service, tickets, connectivity and hardware:

Promote or resell a third party or own brand events service and tickets in a connectivity and hardware package.


3 4 Network and Cloud Services

Open network platforms and sales of network slice to guarantee broadcast quality and viewer experience.


5 Event Streams

Telcos could generate extra revenue from streaming events and acquire users to its own streaming platform.


4.5 Broadcast use case: Further benefits for mobile operators



Data bundle



Sales of network slice



Content delivery

Basic and premium data plans to address a larger audience

Offer VR headsets rental service in partnership with VR hardware manufacturers.

Offer bundled plans of mobile and broadband to acquire users from its competitors

Sell a network slice to vertical enterprise for dedicated events

Dedicated network slices for certain areas like VR venues where a heavy number of users may demand specific applications requiring large bandwidth and low latency

The growing importance of edge computing to ensure delivery of high- quality VR content suggests telcos' involvement in downstream transmission, due to its evolving edge computing capability to optimize network latency

With the control of 5G networks, telcos' existing video streaming platform could partner directly with events organizers for VR broadcasting, leveraging its 5G data subscribers

Source: IHS Markit

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Part five: Conclusions and recommendations

Digital services are increasing cloud based on-demand

Digital services are shifting from on-premise hardware and software to on-demand cloud-based services. The cloud services revolution has been driven by innovators taking advantage of ever more advanced and widespread telecommunication networks. This trend is happening across all verticals and segments including enterprise, manufacturing, health and entertainment.

Operators and network slicing have a key role to play in the value chain:

Many future centralized cloud applications are limited by the quality of the network connection to customers. Examples include industrial control and remote surgery, as well as services demonstrated in this whitepaper: cloud gaming and live VR and UHD broadcast services. Operators can guarantee the performance of these applications within the network they control with network slicing. Service providers need to cooperate with operators to unleash the potential of future digital services.

Consumer media and entertainment is an early driver of network slicing

Consumer demand for cloud gaming, AR/VR and UHD Video, and operator interest in supporting these services to engage consumer interest, ensures that these markets will be early drivers of network slicing. Other services for enterprise, industry and B2B multimedia use cases will follow in the medium to long term as innovative solutions and business models emerge to take advantage of what will become possible.

Business model impacts

In addition to enabling new services that may not have previously been possible, the deployment of 5G network slicing for multimedia services also creates new business models for telecoms operators. There are various ways in which operators can look to monetise network slicing for both B2B and B2C business models.

B2B business models include:

- **Moving up the value chain to provide managed services:** in this context operators don't simply provide network access with service quality guarantees, but they play a more active role in delivering, hosting and managing content delivery on a network as a service (Naas) mobile with additional value to content companies.

- **Charging content and services companies for access based on:**

Data consumption – a model that scales based on the amount of data consumed

Number of end users – a fee based on the number of end users provisioned to access a service e.g. for event and location-based or live services

Location or event-based fees – based on the number of live events or locations supported

- **Partnerships and revenue shares** – rather than the content or services company directly, operators can partner with third-parties to take a revenue share from consumer (or enterprise) spending on multimedia services enabled by network slicing.

B2C business models include:

- **Charging for premium services not previously possible:** this can be utilised by both operators and content companies with direct monetisation through consumer spending on new multimedia experiences enabled by 5G network slicing. Outside specific event-based content, these will most likely be delivered through subscription services.
- **Differentiation through quality of experience:** more a focus of operators than content companies, operators can use the services enabled by 5G network slicing to promote the overall attractiveness of their 5G networks to drive subscriber retention and acquisition.
- **Bundled services:** these involve partnerships between operators and third-parties to add premium multimedia services to existing subscriptions and driving monetisation through higher tier plans and/or increased overall subscriptions.

Operators need new operating and business models

The deployment of network slicing requires a transformation in how operators work with industry partners. Much closer collaboration is needed between telecoms companies and service providers to leverage the benefits of network slicing. Operators need to be able to on-board and manage partners network slices at scale and on demand. Also, in this context operators don't simply provide network access with service quality guarantees, but they play an active role in delivering, hosting and managing content delivery.

Operators need new operating and business models



Phase 1: Operator channel

Operators provide network access to specific content types and bundles for content, services or hardware



Phase 2: Operator platform

Using network slicing to create a single managed platform for multiple use cases including VD, video, games, commerce, social and industrial applications



Phase 3: Shared API platform

Using network slicing to enable a cloud-based platform that allows API access for customisation and self-serve tools across applications

Source: IHS Markit

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This independent analysis of 5G network slicing by IHS Markit was commissioned by Huawei Technologies Co., Ltd. and includes contributions from the following entities and individuals.

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China Mobile Research Institute

MIGU Co., Ltd.

Digital Domain Holdings Ltd.

4K Garden Network Technology (Guangzhou) Ltd.

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