



Developing an Edge in 5G Services

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Executive summary

As mobile network operators (MNOs) plan and build out 5G infrastructure, they face new choices about the direction their business will take. Today, most MNOs serve horizontal mass markets, providing voice and broadband data services to businesses and consumers. Even as networks evolved from 2G to 3G and then to 4G, the business has remained highly competitive. Meantime, over-the-top players such as Netflix, Google, Apple, and Amazon have grabbed the largest share of services revenue derived from faster network speeds.

5G networks, however, are creating new opportunities for network operators. Designed to accommodate secure verticalized B2B services through features such as network slicing, 5G networks open new service opportunities in sectors such as manufacturing, healthcare, finance, retail and the media. At the same time, low-latency, high speed 5G networks will enable computing power to sit very close to devices on the edge of the network, whether these are sensors in autonomous vehicles, IoT equipment for manufacturing, healthcare devices, smart city video networks, or immersive gaming headsets in the consumer sector. 5G and Edge computing combined with AI are the forces driving the next phase of digital transformation where sensors and things generate large amounts of data processed at the edge with AI.

Telcos are already in the process of preparing for the changes in services, network usage and architecture that 5G will bring. For example, several of the world's largest mobile operators are cooperating through a GSMA-backed initiative¹ to create an interoperable telco edge architecture that provides a consistent platform for application developers. Called the Telco Edge Cloud (TEC), it will open up edge assets and capabilities such as latency, compute and storage to application developers and software vendors so new applications and services can meet the evolving needs of enterprise clients.

Operators are not only building their own infrastructure and capabilities to explore new edge services, but are also partnering with cloud providers so that each can leverage each other's strengths. The hyperscale cloud providers Amazon Web Services, Microsoft Azure and Google would like to tap into 5G's ability to bring computing power physically closer to the edge of the network where enterprise and consumer devices lie. For operators, partnerships give them access to globally distributed, cloud-based computing environments.

Not every mobile operator will embrace offering verticalized services with the same enthusiasm, or take the same approach to building and delivering network edge services. What is clear is that 5G is set to shift operators' service models away from monthly voice, data and messaging bundles and towards higher value services that are tuned for specific customer requirements — and that it will increasingly make use of edge computing.

In this whitepaper we explore how mobile operators can develop the ecosystems and deploy infrastructure that will put them in a strong position to gain from delivering new edge computing services.

¹ <https://www.gsma.com/newsroom/press-release/telecom-operators-collaborate-to-build-the-telco-edge-cloud-platform-with-gsma-support>



5G

Introduction: Developing an edge in 5G services

Planning for greater agility

Large-scale 5G infrastructure construction is underway. In the Asia-Pacific region alone mobile operators are due to invest over \$400 billion on their networks between 2020 and 2025, of which \$331 billion will be spent on 5G deployments, according to the Asia-Pacific edition of the GSMA's Mobile Economy series.²

But amid the growth in 5G rollout, questions remain about how operators will use 5G to shape their business models during the next five to ten years and beyond. The infrastructure and architectural choices MNOs make now, coupled with how they foster application and service ecosystems, will govern the ease with which they drive new revenue streams and adjust to changes in technology and the way customers use it.

Until now, the roll out of each new generation of mobile technology has primarily been a question of bringing more bandwidth and speed to consumers and enterprises. The

advent of 4G in particular spurred a mass market for mobile broadband, voice and messaging packages. That has greatly benefited over-the-top service providers, as well as handset operating systems that support rich application environments. Mobile operators, meanwhile, have found themselves competing to provide voice and data connectivity packages in a highly commoditized and price-sensitive horizontal market.

5G is designed to be different. When it comes to enterprise customers, 5G will make it possible for operators to provide differential latency on demand and variable bit rates, or to use network slicing to deliver customized services for vertical sectors and private networks.

The July 2020 release of 5G standards, called 3GPP Release 16³, ushered in an array of capabilities that make 5G a high-performance alternative to enterprises' fixed Ethernet, LTE and Wi-Fi networks. One of the latest available advances in 5G is ultra-reliable low-latency communication (uRLLC). Designed to provide a target latency of 1

millisecond, uRLLC will support multiple applications, from enhancing the performance of virtual reality (VR), augmented reality (AR) and video applications to supporting tightly synchronized, delay sensitive, automated manufacturing processes. 3GPP also brings in massive machine-type communications (mMTC). With mMTC operators can achieve extremely high connection densities, enabling industrial-scale IoT that can connect up to a million IoT sensors and devices per square kilometre. Both these advances will be able to work in step with enhanced mobile broadband (eMBB), which was included in 3GPP Release 15 and promises transmission speeds of up to 20 Gbps.

This combination of ultra-low latency, high transmission speeds and greatly increased connectivity densities makes it possible to bring computing and storage functionality out to the edge of the network and make it available to enterprises to improve customer experiences and operational efficiencies.

²<https://www.gsma.com/newsroom/press-release/gsma-report-shows-mobile-industry-continues-asia-pacific-region-investment>

³https://www.3gpp.org/news-events/2129-sweet_re1_16



Taking data processing to the edge

5G's ability to enable edge computing is one of its greatest strengths, particularly when it comes to serving B2B markets. By moving IT functions to the edge of low-latency, high-speed networks, enterprises can not only create highly reliable and automated IoTs, driven by real time AI, they can also reduce the cost of moving data to and from the point where it is generated, captured and used.

Research company IDC predicts that by 2023 more than 50% of new enterprise IT infrastructure will be at the edge rather than in corporate datacenters, up from less than 10% in 2020⁴.

The development of 5G edge computing also aligns with growing investment in digital transformation within manufacturing.

A PWC survey of German industry outlined in its report 'Digital Factories 2020' found that 98% of industrial companies expect to increase efficiency with digital technologies such as MES (manufacturing execution systems), augmented reality or predictive maintenance.

5G edge computing will make it possible for a range of industries to use AI to analyze in real-time data captured by on-site video camera systems. With NVIDIA's Metropolis platform⁵ and intelligent video analysis (IVA), retailers get access to precise real-time insights into customer journeys through their stores, cities can improve traffic flow by automating intersection signalling and designing better roadways, airlines can improve ground operations and reduce aircraft turnaround times. Ultra-low latency connectivity will make it possible for industries from manufacturing and healthcare through to retail and mining to use AR and VR applications that render a new high-quality image every time the user's head or head-mounted display moves.

Indeed, manufacturers are already working to harness the benefits of augmented reality on the factory floor. BMW Group⁶, for example, has announced it is using a new augmented reality (AR) application to speed up vehicle concept and

prototype engineering by as much as 12 months. BMW has deployed the AR application at its Vehicle Pilot Plant in Munich, where it undertakes research focusing on cloud-based visualizations and smart object recognition.

The AR goggles allow real, physical geometries on a vehicle body to be overlaid with true-to-scale holographic 3D models, according to BMW. This gives employees the information they need to more cost-efficiently assess the best way to assemble a car.

In the port city of Rotterdam in the Netherlands, meanwhile, 5G-connected ultra-high-definition cameras have enabled the visual inspection of a 160,000-kilometer pipeline network⁷.

Autonomous vehicles will also require highly localized analytics supported by uRLLC and 5G's multi-access edge computing (MEC) so that vehicles can share data with each other in real time and both receive and analyze information from the surrounding environment.

⁴<https://blogs.idc.com/2020/06/01/edge-computing-not-all-edges-are-created-equal>

⁵<https://www.nvidia.com/en-gb/autonomous-machines/intelligent-video-analytics-platform>

⁶<https://www.press.bmwgroup.com/global/article/detail/T0317125EN/munich-pilot-plant:-bmw-group-uses-augmented-reality-in-prototyping>

⁷<https://www.huawei.com/en/news/2018/11/huawei-KPN-Shell-5G-Applications-Rotterdam>

The key to the smarter city

Operators of 5G networks have the potential to be an important partner to local governments, whether they are helping develop smarter cities, giving emergency services access to the intelligence they need to resolve issues, or supporting educational services.

Many urban centers worldwide have already started developing smarter cities, but going further will require a combination of MEC and mMTC to enable cities to aggregate and analyze data from millions of connected devices close to where the IoT data is collected. With 5G enabling AI on the network edge, authorities can automate and quickly act on decisions that impact everything from street lighting, parking and traffic control, to personal safety and air and water quality, without huge amounts of data travelling to and from centralized servers.

There are already examples of how combining AI analysis of video coupled with the speed and low latency of 5G can make it safer and faster for emergency services to react to fast-evolving natural or man-made disasters.

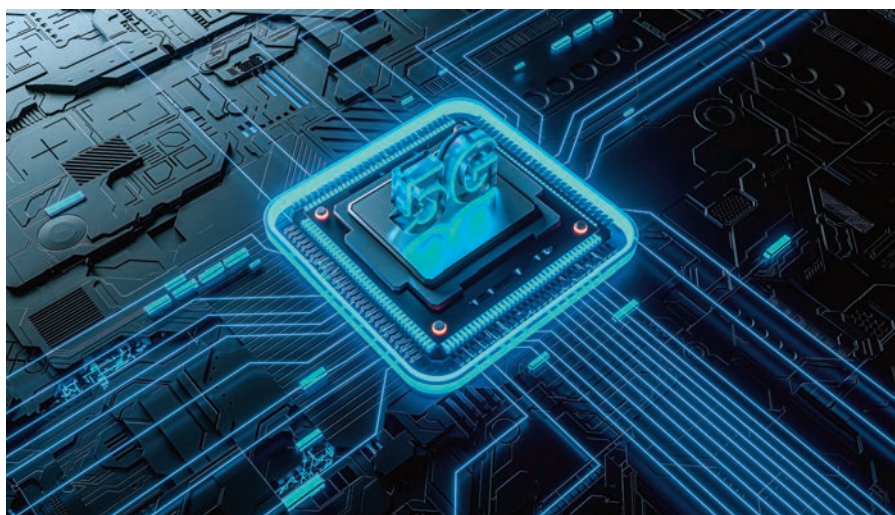
In China, for example, China Mobile used its 5G network to help authorities deal with a forest fire. Drones equipped with high-resolution cameras and infrared detection technology transmitted footage of the fire over 5G networks to emergency dispatch headquarters. Experts back at headquarters were then able to quickly parse the video with AI image algorithms running on NVIDIA GPUs. In this way they could analyze the situation and plan responses without having to wait for the drones' return⁸.

Multiple other initiatives to analyze video are underway. In Liverpool, Australia, the city has partnered with researchers to turn the video data captured by the city's closed-circuit televisions into information that can improve city management without compromising data security and citizens' privacy⁹.

And, again in Rotterdam, the city plans to use augmented reality in urban development. Applications include making it possible to walk around and visualize how building plans will impact an environment.¹⁰

5G will also drive cutting-edge uses of video for consumers. In the UK, national operator BT is leading a consortium that is researching how to view immersive sporting events from all angles on almost any device using XR — a combination of VR, AR and mixed reality.¹¹

The Grid Factory, a London-based provider of GPU-accelerated products and services, is part of the UK government-funded 5G Create¹² consortium and will help create a range of immersive sport experiences, including holograms for boxing matches and motor races. The Grid Factory will use NVIDIA technology, including NVIDIA RTX™ GPUs, virtualization software and NVIDIA's CloudXR™¹³ to bring XR to 5G. CloudXR is a solution for streaming virtual reality (VR), augmented reality (AR), and mixed reality (MR) content from any OpenVR XR application on a remote server.



⁸<https://blogs.nvidia.com/blog/2019/12/18/china-mobile-egx-5g-infrastructure/>

⁹<https://blogs.nvidia.com/blog/2020/07/02/liverpool-wollongong-traffic-analytics/>

¹⁰<https://www.rotterdaminnovationcity.com/News/the-5g-digital-revolution/>

¹¹<https://blogs.nvidia.com/blog/2020/09/23/the-grid-factory/>

¹²<https://www.gov.uk/guidance/5g-create#about-5g-create>

¹³<https://developer.nvidia.com/nvidia-cloudxr-sdk>



Shaping a new business reality

Switching from a mass market provision of SIMs and connectivity to delivering transformational connectivity solutions to enterprises, health services and government, each with their own very different needs and complex IT environments, will demand a sizable shift in MNOs' business models.

One approach could be to focus on developing vertical sales, services and technology expertise for a single or a limited number of sectors, much as Telus Communications in Canada has done with the development of its Telus Health arm, which specializes in offering communication-based health solutions.¹⁴

Equally, operators may decide they cannot cost-effectively compete at

scale in providing IT and connectivity solutions to specific verticals. Instead, they could choose to expose network capabilities that will enable enterprises within different vertical sectors to develop and deploy new applications that make use of 5G's specific strengths.

They will also have to consider the role they want to play in providing Private 5G networks. A number of large industrial companies are likely to opt for the security and control that comes from operating a Private 5G network on site, either alone or with the support of an operator. These Private 5G networks will enable the connection and handling of IoT sensors that are wirelessly connected to implement the highest levels of automation. It will also

bring AI to operations and maintenance—not only augmenting the factory with intelligent video analytics systems for crucial processes such as quality control, but enabling personnel to tap into AR/VR to attain higher productivity through assisted assembly.

MNOs could use their expertise to provide and manage Private 5G networks; support secure data exchanges between Private 5G and public networks, or locate edge AI computing on their public network, physically close to the enterprise site. There will also be an opportunity for MNOs to provide Private 5G networking to medium-sized and smaller companies that lack the in-house expertise and resources to run their own system.

¹⁴ <https://www.telus.com/en/health>

Partnering to create new ecosystems

Whatever their business strategy, MNOs will need to be agile and flexible to capitalize on the new services enabled by 5G. It will be crucial, for example, to provide software developers a single set of standardized APIs, whether it is for enterprise applications or network functions.

Operators will also have to build partnerships that bring on board the expertise, services and infrastructure they need to deliver new B2B and consumer services. Many have already announced plans to work with the cloud hyperscalers Microsoft, AWS and Google Cloud, including AT&T, Orange, Verizon, Vodafone, SK Telecom, Telecom Italia and Telstra. Telcos can play a role in enabling multi cloud solutions that leverage their own edge in conjunction with the cloud provider's capabilities.

Telcos, meanwhile, will be able to leverage both cloud facilities and developer ecosystems to serve enterprise customers. Telstra, for example, sees its agreement with Microsoft Azure giving it access to "developers and independent software vendors (ISVs) as they develop solutions that leverage AI, low latency and increased resilience."

Together Telstra and Microsoft want to use IoT, AI, edge computing and digital twin capabilities to develop industry solutions including asset tracking, supply chain management and telematics.

Microsoft Azure's IoT Edge devices, for example, will support NVIDIA's EGX edge platform for customers that are deploying AI workloads targeting EGX-compatible hardware.

MNOs are also taking a parallel approach to creating an open ecosystem to capitalize on their 5G edge assets. A number of MNOs worldwide, including China Unicom, Deutsche Telekom, EE, KDDI, Orange, Singtel, SK Telecom and Telefonica have joined forces to develop an Edge Compute architectural framework and reference platform. The GSMA is supporting this operator-led initiative with its Operator Platform Project.¹⁵ The platform aims to unite existing assets and capabilities, such as voice, messaging, IP data services, billing security and identity management, with new functions such as edge cloud and network slicing.

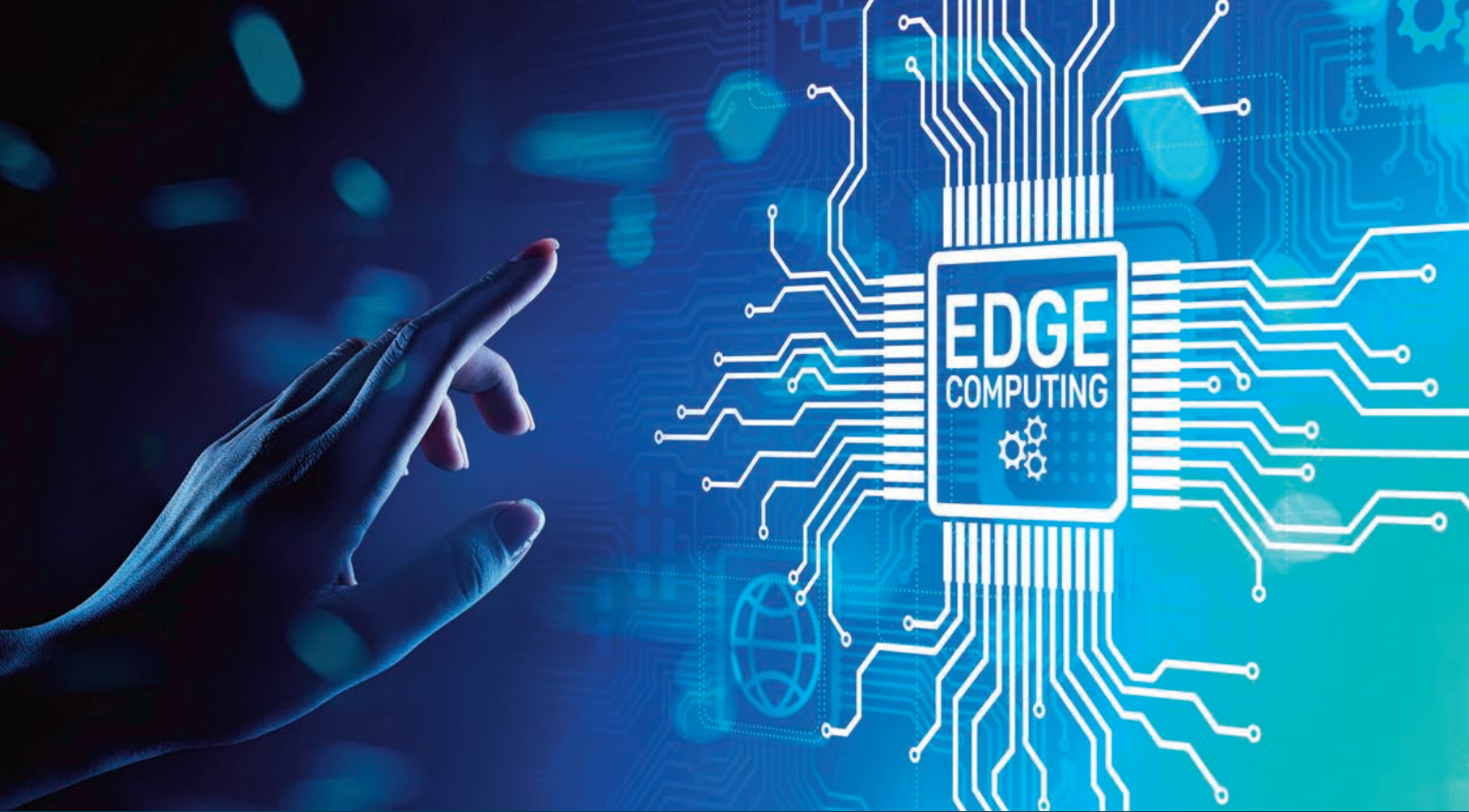
The telcos' Edge Compute initiative will make local operator assets and capabilities, such as latency, compute

and storage, available to application developers and software vendors, with a focus on enterprise applications. The telcos' aim is to achieve global reach, enabling enterprises to operate internationally while complying with local regulatory and data protection laws.

New edge applications are coming from innovators that leverage cutting edge technologies. Some examples are applications leveraging AI and deep learning to analyze video streams and infer insights from it. There is a growing ecosystem of application providers of such applications addressing multiple verticals such as retail, manufacturing and healthcare that could benefit from the GSMA initiative to scale its services through the Telco Edge infrastructure at a global scale.

Another nascent application ecosystem is related to AR and VR that can be streamed from the edge to devices through 5G, enabling much better user experience. AR/VR is an attractive 5G application for both enterprises and consumers that requires the throughput and low latency 5G offers, placing telcos in a strong position to leverage edge computing.

¹⁵ <https://developer.nvidia.com/nvidia-cloudxr-sdk>



5G, AI and edge create the new platform for business innovation

The confluence of 5G and AI is starting the next phase of the Enterprise Digital Transformation, bringing together exciting new use cases that are transforming industries.

5G enables a new connectivity fabric, able to support demanding new services like AR/VR and the explosion of “things”. Artificial Intelligence brings a new computing paradigm in which algorithms learn from the data to efficiently handle the ever-growing amount of information sensors generate.

5G, AI and edge has become the new platform for business innovation. As with any platform, it requires a vibrant ecosystem to thrive and this is the approach NVIDIA brings to the edge.

NVIDIA EGX¹⁶ offers a top-to-bottom edge platform, from the applications to required software/hardware.

NVIDIA EGX servers are offered by all the major OEMs and ODMs vendors. NVIDIA CUDA makes the GPUs programmable and accessible to developers. The EGX software stack simplifies the GPUs lifecycle management and is integrated with cloud native stacks like Kubernetes.

NVIDIA application frameworks and SDKs enable developers to take full advantage of our platforms to quickly create new applications across multiple domains like computer vision, AR/VR, robotics, natural language processing and many others. NVIDIA NGC¹⁷ is a software catalog that offers a range

of industry-specific AI applications, toolkits and pre-trained models.

MNOs are still at the early stages of their 5G journey. Over the next ten years many aspects of their business and platforms will evolve, whether it is changes to their sales structure and service architecture, or the automation of networks and operations. What is clear is they will need to be able to use and deliver AI functionalities everywhere as edge computing ramps up. Whatever their focus, capitalizing on the change will demand careful technology choices that increase flexibility and cost-efficiency and make them the center of the 5G service ecosystem.

¹⁶<https://www.nvidia.com/en-us/data-center/products/egx-edge-computing/>

¹⁷<https://ngc.nvidia.com/>



NVIDIA's invention of the GPU sparked the PC gaming market. The company's pioneering work in accelerated computing—a supercharged form of computing at the intersection of computer graphics, high performance computing and AI—is reshaping trillion-dollar industries, such as transportation, healthcare, telecommunications and manufacturing, and fueling the growth of many others.

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