Axon Advisory Research

- Edge Computing -

"Edge computing is a technology architecture that is key in enabling 5G to meet new human demands, from VR solutions to autonomous vehicles. Our whitepaper: "Edge Computing: a key enabling technology in 5G transformation" explains why

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Edge Computing: a key enabling technology in 5G transformation

1. Introduction

Analysts Team at Axon Partners Group[1],

The development of 5G will not only bring about new capabilities to mobile networks, but also highly disruptive products and services based on data security, high-capacity data transfer, and minimum latency. Business cases such as autonomous vehicles, remote healthcare and high-volume augmented reality are just some of the new entrants that 5G will enable in the near future.

However, whilst 5G technology itself can now provide the low latency to support a new wave of innovation, the network structures currently employed to serve traditional ICT, i.e. cloud, need to catch up. Being designed to store, process and transfer data from an extreme distance, traditional cloud computing may no longer be sufficient in meeting the industry requirements that are being triggered by 5G technology transformation. This is leading organisations, from Telecommunications players to tech start-ups, to employ new network and service architectures that place the necessary processing power at the very place that they are needed: the "Edge".

In this whitepaper, we assess how edge computing can be a significant enabler for 5G technology transformation, how its use in advanced 5G use cases is becoming a necessity, and how it can benefit Operators as a key technology within their 5G strategies.

Total mobile data traffic is expected to be 4 times higher in 2025 than in 2019. 5G is set to play a significant part to cope with this data volume growth

5G is expected to have its most relevant role beyond coping with data traffic growth.

[1] The views and opinions expressed in this article are those of the authors and do not necessarily reflect the view of Axon Partners Group.

2. The 5G Technology Transformation

When talking about 5G, most people focus on the traffic capacity. Over the long term, growth in data volume is expected to continue and even increase as more mobile content is shared but also as new services appear, including connected devices communicating directly, machine-to-machine.

Overall, total mobile data traffic is expected to be 4 times higher in 2025 than in 2019 [2]. 5G is set to play a significant part in this data volume growth, by ushering in new data-intense services and use- cases.

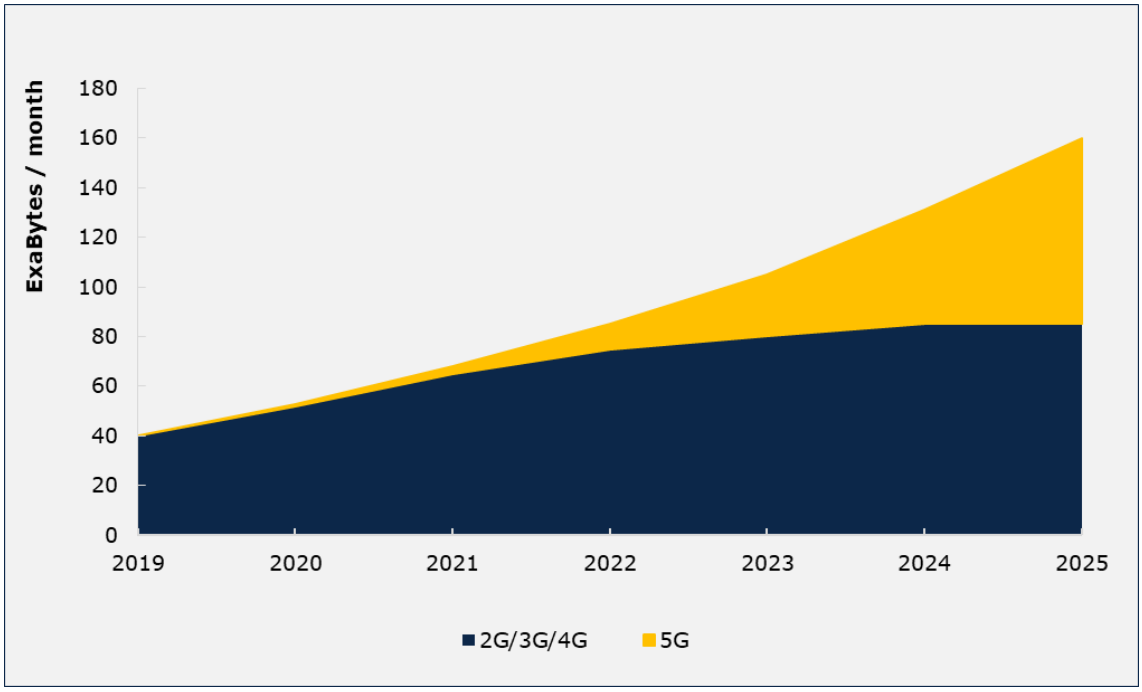

Exhibit 1: Global evolution of mobile data traffic consumption
[Source: Axon based on Ericsson report[2]]

But 5G is expected to have its most relevant role beyond coping with data traffic growth. There are relevant trends in the ICT sector that will drive the accelerating demand for the global connectivity. It is expected that 5G will have a significant

[2] Ericsson Mobility Report, November 2019; **Available here**

role to play in leveraging these trends or driving them forward in the years to come.

Key ICT Trends	
Demand for ubiquitous connectivity *The need for accessing to digital information and services, everywhere and at any time*	**Digitalisation and advanced analytics** *Achieving maximum value from each customer*
Internet of Things (IoT) *Increase in the number of connected devices*	**Proliferation of value-added services and over-the-top (OTT) players** *Telecom operators adapting to changes in the service and content provisioning*
Demand for low latency *Industry applications and use cases that require minimal delays*	**Fixed Wireless Access (FWA) technology** *The great wireless migration*
Global Smart City deployments *Major global initiatives to place cities at the forefront of use of data, sensors, and connected devices to improve services and quality of life*	**Softwarisation, virtualisation and cloudification of networks** *Ability to integrate novel computing functions*

Exhibit 2: Major trends in the ICT sector and role of 5G
[Source: Axon]

Error! Reference source not found. shows key digital trends in the ICT sector, which are likely drivers of growth, innovation, and disruption across industries. These digital trends serve to generate several potential roles for 5G as a provider of the following:

- Continuous connectivity
- Cost-effective and energy-efficient high-speed connectivity
- Quick response times
- Large amounts of data in real-time

As such, 5G will, at least in part, act as an enabler of these trends, and in doing so will give birth to a number of innovations and new business models. However, 5G New Radio will not be alone in meeting the requirements of the digital trend.

Technologies such as Edge Computing will be necessary to reveal the full potential of 5G

3. Edge Computing

The concept of "edge computing" is one of the most important enablers of 5G technologies and its requirements. The following exhibit illustrates the different types of computing layers and their technical implications.

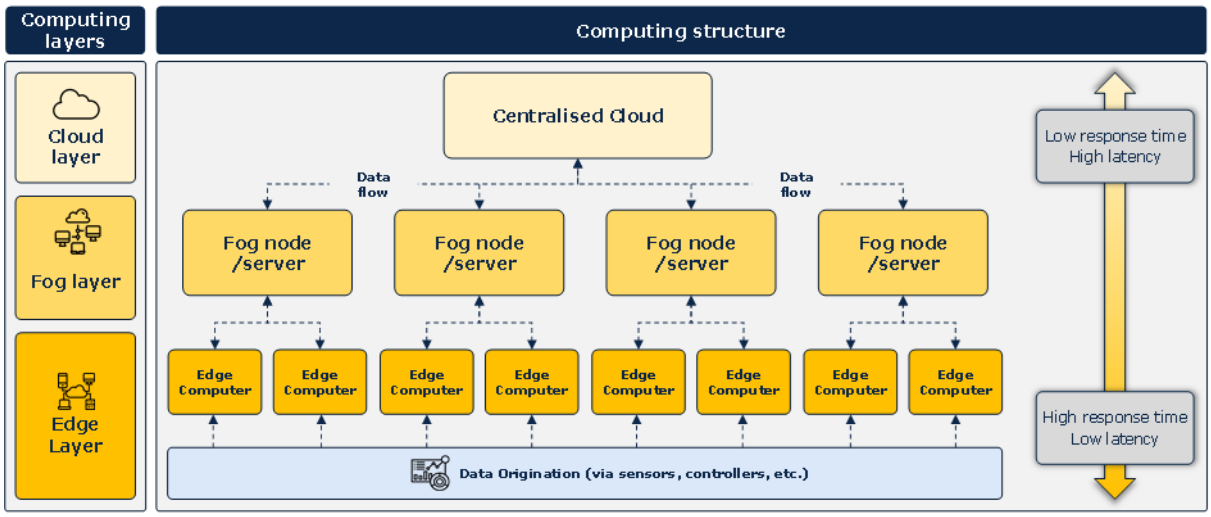

Exhibit 3: Data processing layers of computing types
[Source: Axon]

Cloud computing is an architecture used by organizations to store and process data in a centralised location far from the multiple devices and sites that use it. This means that users and devices have access to great computing power and storage capacity from anywhere in the world. The benefit to organisations is that they are able to unload localised hardware, data storage and processing power from the site.

Such capacity reduces CapEx, increases flexibility, and allows accessing to the economies of scale that cloud service providers can reach.

Fog computing, like cloud, provides unloading of processing and storage power from devices themselves, however it does so in a nearer location. This is to say that Fog architecture is like a local cloud that places intelligence at the local area network (LAN). As such, Fog architecture is able to provide dedicated cloud-like services to a focused network, handling data from a large number of devices spread in multiple locations within the same LAN, and acting as the coordinator and gateway for these endpoints.

Edge computing is an even more decentralised cloud architecture than Fog, in that it provides execution resources (computation and storage) with sufficient connectivity (networking) at very close proximity to the data source itself, typically within or at the boundary of access networks. Edge computing therefore places intelligence and processing power directly at the "edge" of the networks.[3] This difference in architecture means that the edge device is dedicated to a smaller number of devices, meaning that there are no longer such economies of scale, but, it gives one key advantage: speed.

Edge places intelligence and processing power closer to the device or data source where it is most needed

Combining Edge Computing and 5G can provide key benefits both operationally and commercially, serving as a strategic tool within the Telecoms space

The term "Edge computing" refers to computing as a distributed paradigm. It brings data storage and computational power closer to the device or data source where it is most needed. Information is not processed on the cloud or filtered through

[3] Ericsson - Edge computing and 5G, 2019

distant data centres; instead, the cloud comes to device itself. This distribution eliminates lag-time and saves backhauling bandwidth, both of which are in increasing demand as current ICT trends such as data analytics and IoT prevail. Accordingly, even today there are a considerable amount of use cases to which edge computing contributes, as exemplified below:

Use case	Description[4]
 **Autonomous Vehicles**	• Self-driving cars need to be able to absorb, learn and react to information without connecting to a distant cloud to do so, requiring edge computing architecture to be used. • According to some third-party estimates, self-driving cars will generate as much as 3.6 terabytes of data per hour from the clusters of cameras and other sensors. • **Role of Edge:** An edge computing architecture can be employed to provide dedicated processing power to all of the cars' sensory devices whilst remaining connected to and moving with the car itself.
 **Industrial Automation**	• Industrial automation helps to create machines that sense, detect, and learn things without having to be programmed • 5G service could play a vital role in Industry 4.0 since the anticipated low-latency wireless connections could eliminate traditional wired connections to robotic assemblers, allow quicker updates and ultimately enable products to reach the market faster. • **Role of Edge:** Edge can serve to centralise the intelligence of automated machines by utilising high speed 5G connectivity.
 **Augmented reality (AR) and virtual reality (VR)**	• Creating entirely virtual worlds or overlaying digital images and graphics on top of the real world, convincingly, requires a great deal of processing power. Even when phones can deliver this power, the trade-off is an extremely short battery life. • **Role of Edge:** Edge computing addresses those obstacles by moving the processing out of the device in a way that feels seamless, giving the effect of high-power, wearable computation. This functions without sacrificing on latency (as a traditional cloud would do), thus avoiding dizziness and nausea.

[4] FCC Technological Advisory Council – 5G Edge Computing Report. See the following **Link.**

 **Drone fleet / robot fleet control**	• The necessary AI technology to control and automate the work of drone and robot fleets currently exists and easily caters for large volumes. However, its implementation requires serious processing power and response rates, especially at scale. • **Role of Edge:** Edge computing can provide the dedicated processing power, with near instant speed, to operate such a fleet, allowing the command of actions and tasks that require instantaneous response (e.g. collision avoidance).

Exhibit 4: Selected use cases where edge computing can contribute
[Source: Axon based on FCC's Report]

Common among these use cases is a necessity for high-speed transmission, processing, and quick return of response to the device. Therefore, just as the previous shift from device-based to cloud-based computation was driven by a need for greater storage and computational power, the required data volume, rate of transfer and, more importantly, latency is rendering the current paradigm of cloud-based architecture sub-optimal or, in some cases, unfeasible.

4. Edge Computing as an Enabler of 5G Technology Transformation

As remarked previously, edge computing is an enabler for the 5G technology transformation. It is estimated that edge computing will be vital for 25 percent of 5G use cases.[5] We have identified six main roles of edge computing to support the transformation of 5G technologies and realize the defined use cases[6]:

Major aspects	Description	Instance of use cases
Storage	Edge computing offloads a massive amount of data from UEs (user equipment) to edge clouds. While edge servers offer distributed local storage for a significant amount of data, yet their storage is much lower than that in the cloud, which has virtually unlimited storage capacity.	Internet of Things, Industrial Automation

[6] Ericsson - Edge computing and 5G, 2019

Computation	Edge computing offloads computation and process from less complex (e.g., smart phone) and highly complex (e.g., surgical tools and smart factories) UEs to edge clouds. It is an intelligent computing system that provides local computation and data processing capabilities close to UEs in an independent and autonomous manner.	Smart factories, smart homes, surgical tools
Real-time big data analysis	Edge computing processes and performs critical and real-time data analysis on a massive amount of raw data gathered from different applications in close proximity to generate valuable information. The capability to make data analysis locally reduces the latency required to send data to, as well as to wait for responses from, the cloud.	Real-time and predictive data analysis
Decision making	Edge computing helps entities to make real-time decisions and corresponding actions in an automated manner, based on well processed data. The capability to make decisions locally reduces the necessity for further data or information exchange, leading to improved system availability and improved bandwidth availability.	Local data analysis for decision making
Operations	Edge computing enables remote control and monitoring – particularly critical devices including those in unsafe environments – from a distance, or a more comfortable or convenient place.	Autonomous cars, smart factories
Security enhancement	Edge computing improves the network security, including UEs with limited resources. Due to the close proximity of edge computing, malicious entities have less entry points to attack and can be more quickly detected, isolated, and responded to in real time. This helps to minimize service disruptions.	Malware detection, software patches distribution

Exhibit 5: Major aspects where edge computing become an enabler for 5G transformation [Source: Axon based on IEEE's Report[7]]

With respect to the above-mentioned use cases, in each case Edge Computing acts as a key technological "stepping stone" to their implementation with 5G, providing

[7] IEEE Access - Edge Computing in 5G: A Review, 2017

an intelligent node in the system to pre-process, filter and oversee data traffic flows between the data source and the central processing hub, mitigating the need for long distance data transmission.

5. 5G and Edge in Telco

For Operators, the marriage of 5G with Edge Computing can provide key benefits both operationally and commercially. As such, Edge can serve as a strategic tool within the Telecoms space. Some expected benefits to Telco players are:

- The combination of Edge and 5G will afford the increased network capacity necessary to support the use of new, data-heavy media services. This means a more dedicated and seamless service is provided, for example for the streaming of OTT packages, live events, or gaming, at higher and higher qualities. Alternatively, Edge infrastructures can also give operators a potential competitive advantage against OTTs through increased service quality.
- Edge computing can also offer Operators further revenue streams, with one possibility being through integration with cloud networks and selling access of edge infrastructure to online service or content providers in an "edge-as-a-service" style model. To this extent, Edge Computing is already actively being explored as a new revenue-generating technology by major Telco players as part of their R&D strategies.[8]

The strategic relevance of Edge Computing in Telco is therefore significant. So much so, in fact, that it this year led several major global Operators to collaborate in the creation of an interoperable Edge Computing platform, dubbed as the "Telco Edge Cloud",

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[8] Telefónica – Open Access and Edge Computing, 2019

alongside the GSMA. [9] This initiative will serve to help operators more accessibly find paths to monetisation of Edge capabilities.

6. Key takeaways

The promise of 5G is set to be transformative, driving new growth in data consumption and unlocking a great deal of business innovation. However, the true power of 5G is reliant on further technological advances.

Complementary technologies such as Edge Computing architectures will help to bring the benefits of 5G to users faster, with greater service and at a more affordable price point.

The combination of these two technologies can give birth to an array of benefits to industry and will help drive innovation in these areas.

For Operators, the opportunity of Edge computing is too large to miss, either as a 5G-enabling technology, a cost-cutting tool or as a standalone revenue stream. As such, Edge Computing should already be forming a part of Operators' 5G strategies, with the aim of identification of paths to new revenue streams and accelerated 5G deployment.

7. About Axon Advisory

Axon, through its Advisory arm, is an international investment and advisory firm offering world class consulting and corporate finance services to a broad client base in the ICT industries.

In the last 10 years, Axon has executed +500 projects in +60 countries in the ICT domain for major private companies, institutional bodies, and technology companies worldwide. Axon has an in-depth familiarity with the ICT markets in Europe, being currently working with all EU countries in collaboration with the EC.

[9] GSMA – Operators & GSMA join forces on edge computing push, 2020.See the following **Link**