Wholesale Opportunities for Edge Computing in the Digital Ecosystem

Double-sided circular paradigm, driving EC collaboration for emerging technologies & use-cases

Whitepaper

February 2021

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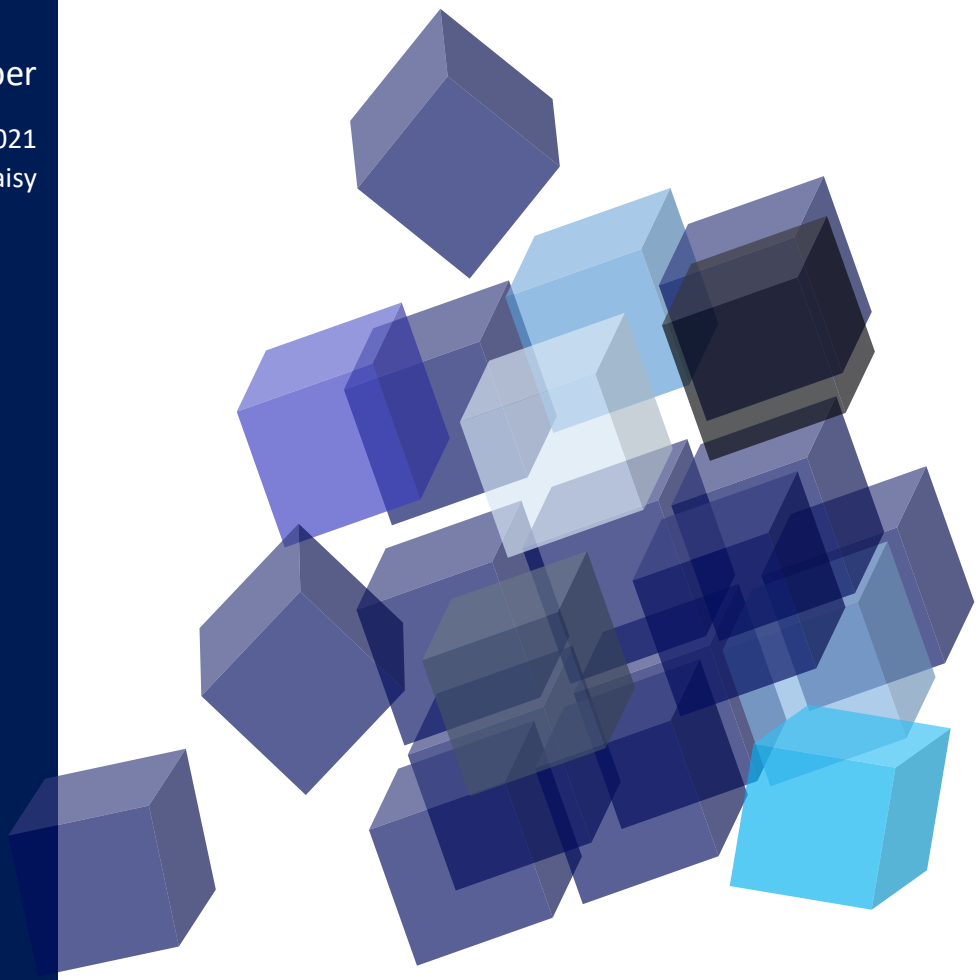
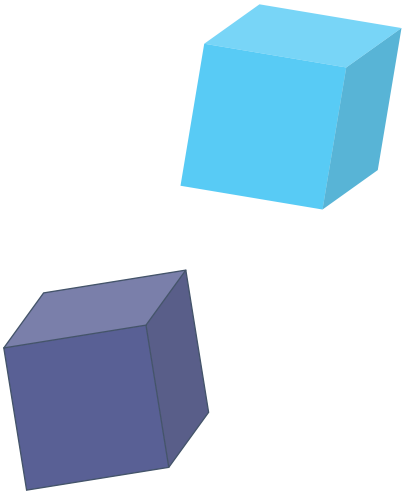




Target Audience: *This whitepaper describes the services that Edge Computing ("EC") can serve public and private customers alongside commercial principles. This whitepaper provides insight on how ICT wholesale and retail Service Providers (such as Cloud Service Providers, Telecom Operators, infrastructure providers) and End-User (SMEs, Large cooperates, general consumers, etc.) contribute to and/or benefit from the capabilities of EC services. It also discusses how EC services can bring value to End-Users.*

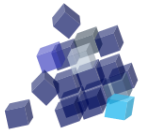
After briefly describing the key principles of the EC technology, the whitepaper identifies the main market drivers that have resulted in the emergence of EC. It then discusses how EC can provide new opportunities for wholesale service providers to capture new markets (other than the traditional wholesale and retail telecom markets) and offer carrier-neutral services by developing new service platforms that can serve different demand segments and use cases of the digitalized economy (such as Industry and Service 4.0, smart cities, smart public services for example).

Readers are invited to collaborate with the author through the interactive platform on the DigiConomy website[1], that is designed to consult with experts and the general public.

[1] http://www.digiconomy.info/

Executive Summary

We live in a rapidly changing world, in which Information and Communication Technologies ("*ICT*") affect every parts of our lives including the way we work, stay in touch with family and friends, shop and learn. The application of ICT into digital services have allowed the emergence of modern consumer-based systems which adapt in real-time to the constantly evolving needs of consumers and enable seamless access to the services that people want and need. The digitalization of all services and businesses is changing the way businesses operate and create value, how products and services are conceived and delivered and even how end-users can access and use such products and services.



Digitalization is here to bring a wave of innovation in ethos

Edge Computing ("EC") is needed to stimulate ICT wholesale and retail Service Providers (such as Cloud Service Providers, Telecom Operators ("TelCos"), infrastructure providers) and transform service designs for mobile devices, autonomous vehicles, healthcare, smart cities, cloud services, data centers, artificial intelligence, robotics, IoT and manufacturing, as depicted in Figure 1.

Digitalization is here to bring a wave of innovation in ethos, and in how policy makers and private sectors think of investment & infrastructure deployments; To enable new emerging technologies supporting deployments of 4.0 Industry domains and applications, which will dramatically improve our lives.

Consumers' behavior is rapidly evolving. When people access digital services, they expect a seamless experience that is centered around the events of their life. However, current businesses' operations and activities are fragmented, and certain components are served via major platforms (digital platforms such as GAFA[2], delivery hailing, etc.) rather than being part of an integrated digital ecosystem. Businesses are witnessing a paradigm shift that affect all sectors; the suppliers do not just respond to the consumers' needs anymore: they anticipate and, in some cases, even influence such needs. The economy is moving away from an agency-centric model (that offers what the organization can), to one that puts people and the wider consumer-experience first (for what the consumer needs). Anticipating the needs and expectations of consumers will enable industry players, service providers and governments to deliver enhanced consumer experience. Digital services present

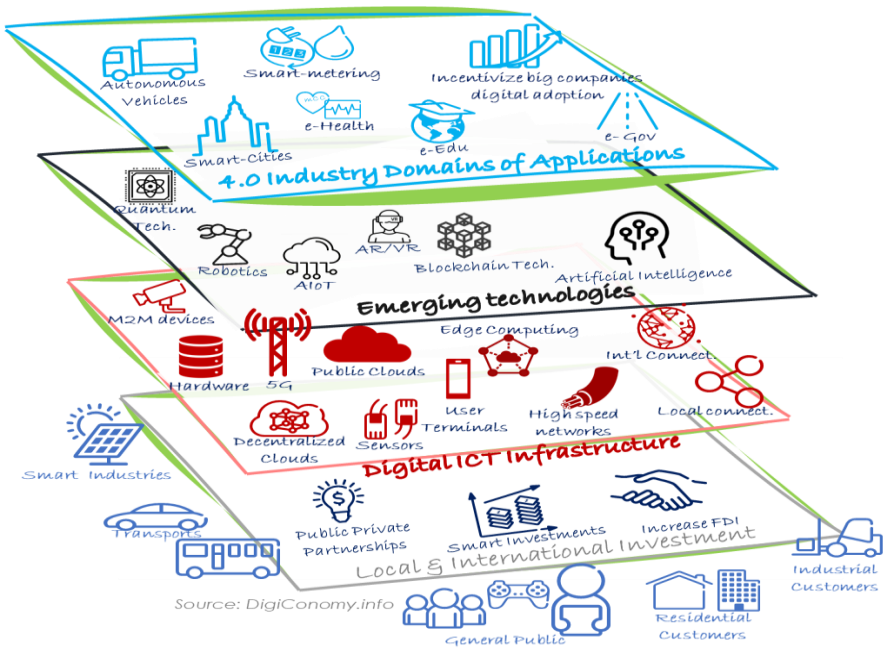


Figure 1: re-imagining Digital Service ecosystems

[2] Google, Amazon, Facebook, and Apple.

opportunities to re-imagine services design and ultimately to provide services that evolve in real-time to adapt to people needs as circumstances change.

Many of us went virtual in 2020 by necessity, as COVID-19's social distancing requirements forced millions into remote activities. With the continued growth and adoption of digital services. It is expected that 2021 will demand even more from the digital economy and will rapidly catalyze the digital transformation. For example, Fortnite's creator Epic will bring large-scale social events like concerts and esports into the virtual world[3]. Augmented ("AR") and Virtual Reality ("VR") gadgets will certainly gain wider adoption, as Apple releases its own AR glasses[4]. Financial transactions are now being embedded into these systems, thus changing the nature of banking currencies and the consumer expectations thanks to new technologies such as Blockchain and Cryptography.

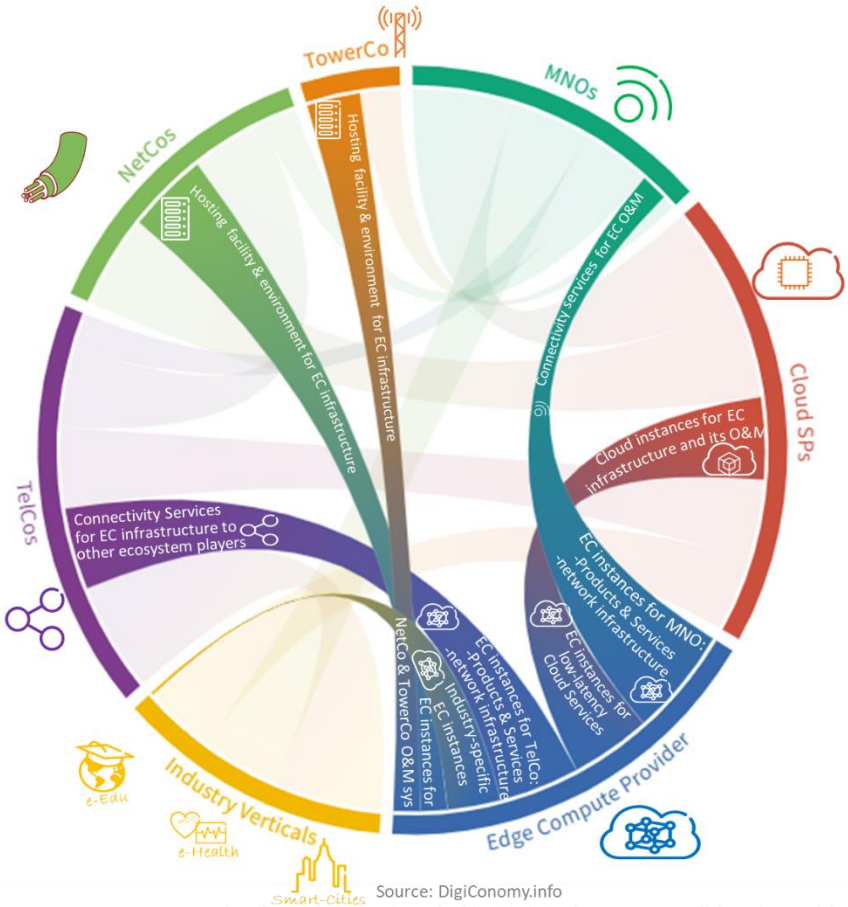
Increasing number of connected devices, immersive experiences and industry digitalization will require processing power closer to the action. By 2022, Gartner predicts, that 50% of enterprise-generated data will be produced and processed outside data centers, and by 2025 about 75% will be processed at the edge of networks[5].

Key Takeaway Messages

1. Computing power at the edge is currently required, it will increasingly be located closer to where the data is created, processed, and demanded by the growing number of applications and devices at the edge of networks, within consumer's proximity. Especially when combined with Artificial Intelligence ("AI") capabilities, with low-latency and high-throughput availabilities.

An EC SP shall leverage on its double-sided circular collaborative ecosystem with CSPs, and other digital ecosystem stakeholders

2. New wholesale entrants or existing wholesale providers (such as Cloud Providers, TowerCos or NetCos) have an opportunity to monetize the current wholesale EC gap by positioning themselves as an EC wholesale carrier-neutral provider. An EC Service Provider shall leverage on the double-sided circular collaboration with cloud providers, and other stakeholders of the digital ecosystem. An EC service provider is a customer as well



Source: DigiConomy.info

Figure 2: examples of Services leveraging a double-sided circular ecosystem collaboration model

[3] https://www.washingtonpost.com/video-games/2020/09/11/fortnite-live-events-planning/

[4] https://www.techradar.com/news/apple-glasses

[5] Gartner, "What Edge Computing Means for Infrastructure and Operations Leaders" by Rob van der Meulen, Oct 2018

(examples of the different services that can be offered and acquired are highlighted in Figure 2).

3. EC service providers may start immediately to offer computing power services to TelCos and mobile network operators ("*MNOs*") as MNOs are already evolving towards a virtualized, 5G-oriented cloud-based model; as well as CDNs and Cloud Providers. In addition, an EC service provider may offer the EC infrastructure to other non-telecom industries such as Education, Healthcare, Government agencies and others, in order to reduce the local and international connectivity costs while improving latency.

Figure 3: Data Never Sleeps 8.0

Governments are adopting Cloud-first policies for enhanced agility, reliability, security, and innovation at the public and private sectors

Introduction

The COVID-19 pandemic has changed the world fundamentally, the human adaptive nature and consumer behavior have changed as well. Almost every aspect of life has moved online, making people much more dependent on digital services and on the internet to study, socialize, work, and entertain. To be convinced, one may only look at how much data is being generated, processed, and consumed every minute on the internet[6] (Figure 3). The increase of the internet traffic in terms of volume and diversity is a trend that has only being growing since the inception of the internet. As the world changes, consumer behavior changes, influencing businesses to adapt and transform not only to survive but to grow. International Data Corporation (IDC) projects that the total IoT-connected devices is to exceed 41 billion worldwide by 2025, generating almost 80 zettabytes (ZB) of data[7]. Governments from developed and developing economies are adopting Cloud-first policies to enhance agility, reliability, security, and innovation at the public and private sectors[8].

In such a context, new ways of delivering, processing, and creating data are constantly and rapidly emerging. Many jurisdictions are acting quickly to jump on the bandwagon of digital transformation by setting national digital strategies to transform their economies and cope up with the worldwide shift in protecting traditional economies from sinking due to the COVID-19 and the upcoming expected

[6] Source: DOMO.com
[7] Help Net Security "41.6 billion IoT devices will be generating 79.4 zettabytes of data in 2025" - June 2019
8 CITC – an overview on the global gov efforts on fostering the use of CC – Dec 2020

economic crises[9]. This is further discussed in the NDTS whitepaper[10].

Evolving consumer trends which Edge Computing can address

In any business or new-industrial scenarios, wherever mass amounts of information are being generated or required, EC technologies allow organisations to browse through information and differentiate between the time-critical data (i.e., low-latency data transmitted over networks must be prioritized) from the less time-critical data (high-latency data) which may be sent to centralized data centers for storage and processing. This dramatically helps to minimize the amounts of data that crosses over the entire transport networks of TelCos or Cloud Service Providers.

EC technologies are not only used by enterprise customers but are greatly valuable to TelCos with all the imminent IoT and 5G applications and use-cases that demand for greater infrastructure and devices densification. Typically, IoT devices transfer the information to neighboring devices that has encryption, storage, and network properties. Usually, information is processed and analyzed for decision-making resulting in micro actions which, when assembled, form an autonomous system. For example, an autonomous vehicle is capable of sensing its environment, through many sensors, and operating without human involvement. Many use-cases and applications in industrial, healthcare, media, and entertainment (e.g., gaming) sectors, depend on cloud computing services located within the end-user's proximity by leveraging EC interconnected devices, referred to as Edge Clouds. As IoT data-generating devices densely grow, the quantity of information will skyrocket. EC is playing an important role in in processing and acting upon the data quickly and accurately. EC technology permits data storage and processing to be performed nearer to wherever it is being collected/generated, and consecutively helps organizations to analyze information in close to real-time[11].

To process data at the edge, the future of IoT is going to require more compute infrastructure than the industry has ever deployed. This will have a profound impact on industries under the form of industrial manufacturing, e-waste, and smart cities[12]. EC will profoundly be in most industries future[13].

Key features of Edge Computing

EC represents the availability of ubiquitous connectivity and computing power at the network edge, being closer to the end customer. In contrast to today's centralized architectures, whereby the processing and storage of data are consolidated at the heart of the network (or within regional Data Centers) and access to such facilities is dominated and controlled by costly connectivity.

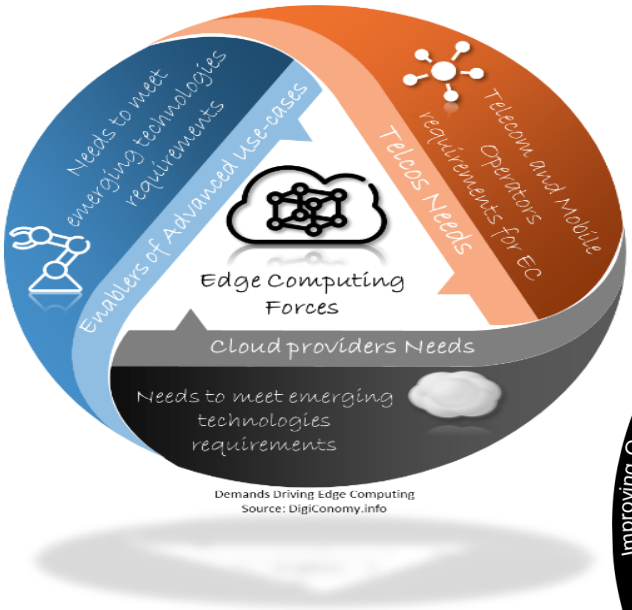
Edge Computing implements a distributed cloud-computing model that pushes these functions out to the network edge, where applications can be hosted in highly distributed and localized smaller edge data centers closer to devices and to the end

[9] Global Economy: Heading into a Decade of Disappointments? - Global Economic Prospects - World Bank Group- January 2021
[10] Digitalization main challenge for policy makers: how to think across boxes – DigiConomy.info – Jan 2021

[11] State of the Edge Report– 2018
[12] Top 5G Real-life Use cases- ABI Research – Feb2020
[13] Taylor, Anne. "Edge computing is in most industries' future." *Network World* - April 2019.

users. In summary EC, can help TelCos and MNOs to bring computing capacities and core network functions to the edge to build optimized and cost-efficient networks.

EC is designed to offer real-time data processing and management, ultra-low-latency connectivity, and localized content caching in a highly cost-effective and efficient manner. As such, the transmission of traffic between core and access networks (which is detailed in the Connectivity for TelCos Transport Networks whitepaper[14]) is minimized to reduce latency, offload core networks, and save on transport costs such as backhauling, and even on the cost of international capacity (the economics of international connectivity will be discussed in a dedicated International Submarine Connectivity whitepaper).



Demands Driving Edge Computing
Source: DigiConomy.info

Demands driving Edge Computing

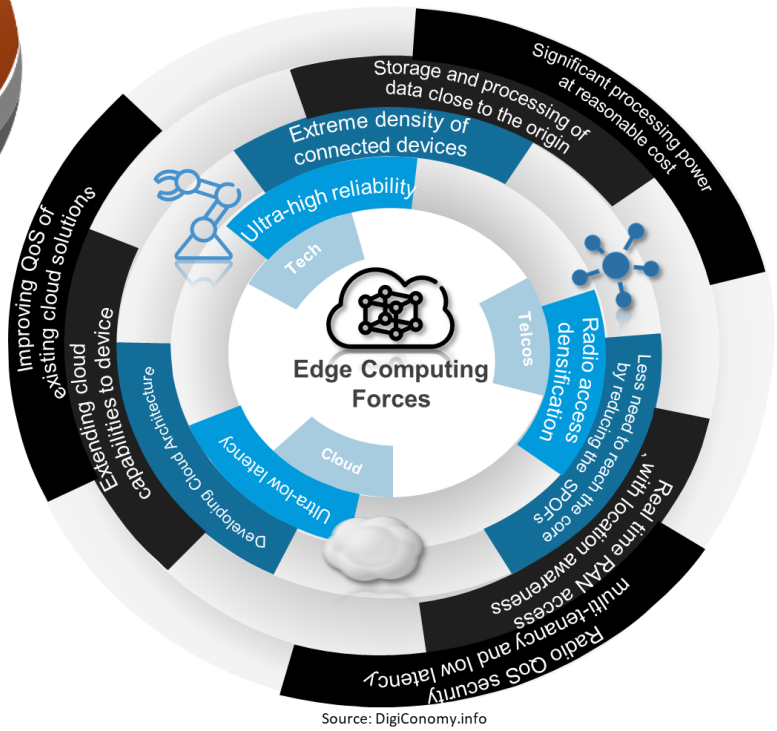
As depicted in figure 4, the advancement of EC is driven by three main forces:

- TelCos advanced Services;
- Cloud Computing penetration; and
- Technology advancements.

Telcos and Cloud Service Providers are likely to lead the first wave of EC deployments

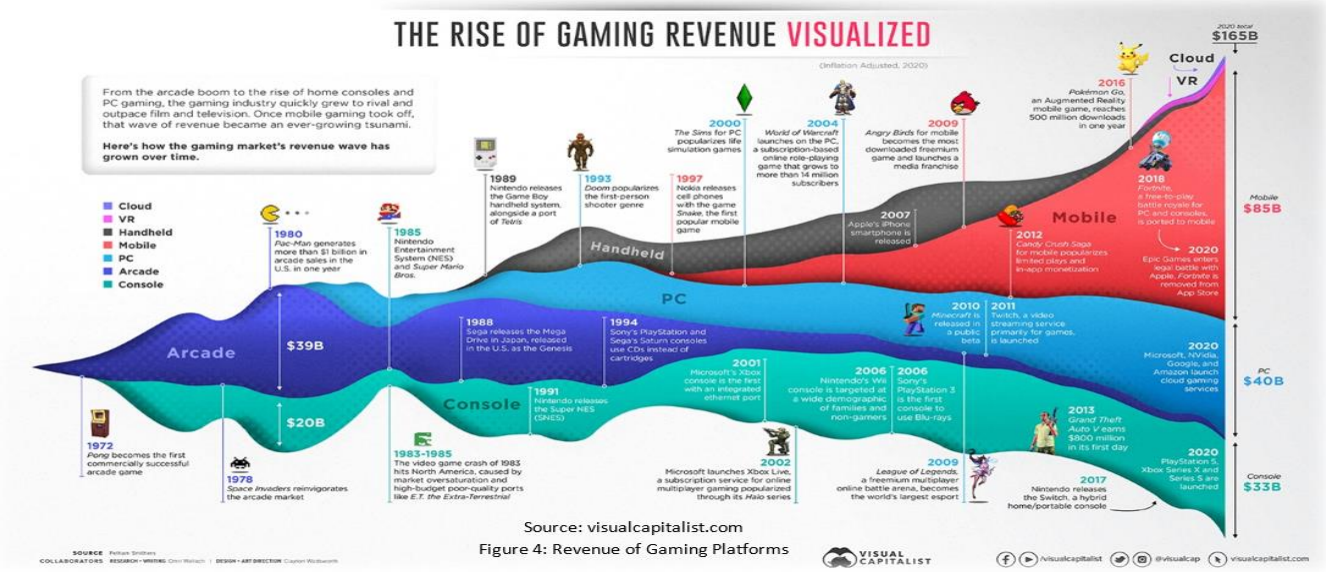
TelCos and Cloud Service Providers are likely to lead the first wave of EC deployments, by relying on 5G, and shall therefore offer services with greater capacity, enhanced speeds, and massively reduced latency.

To better monetize and exploit new revenue streams, TelCos will not only focus on the 5G enhancement for Mobile Broadband ("MBB") but shall also design new products and services that are suited for what is beyond 5G business applications. This includes a wide range of B2B and B2C applications and services for enterprise and industries such as connected and autonomous vehicles, ultra-low-



Source: DigiConomy.info
Figure 4: Demands Driving Edge Computing

[14] DigiConomy.info



Source: visualcapitalist.com

Figure 4: Revenue of Gaming Platforms

latency gaming, Smart-cities, industrial machinery, and processes (Industry 4.0 use cases), AR and VR (combinedly termed as XR). It is fascinating to monitor, how for example the gaming industry has evolved in the previous 50 Years (by Revenue Stream[15], as depicted in figure 5), and how VR and cloud gaming's market shares have increased within only 4 years. TelCos can also quickly realize the rewards of Edge Clouds by reducing on expensive backhaul transport and International capacities.

The Power of EC combined with AI, acting in real-time

Many companies are deploying predictive maintenance systems leveraging IoT and smart sensor analysis. Such systems need Artificial Intelligence (AI) machine learning (ML) algorithms to analyze the equipment sensor data at a component level, enabling organizations to better predict and prevent equipment breakdowns, such systems would drive productivity improvements by up to 30% in some sectors[16].

AI at the edge creates a world of intelligent connectivity stimulating consumers, and industries

Utilizing EC power for imminent response and action, will enable new breeds of intelligent services and systems that can execute actions and learn with the support of AI in real time. Leveraging on AI technologies combined with proximate EC power, will uncover trends that people might otherwise not realize nor even predict[17]. AI at the edge creates a world of intelligent connectivity that stimulates consumers, organizations, enterprises, and industries[18].

Challenges to implement EC

The main challenge to deploy EC is not on the supply-side, but on the demand side: an EC network's roll-out shall be optimized for its use cases (as the proximity of the EC devices is linked to the use case and applications). The challenge is to identify the most promising use cases that EC can

[15] 50 Years of Gaming History, by Revenue Stream- Visual Capitalist – Nov 2020

16 IBM Institute for Business Value, "why organizations are betting on edge computing" – My 2020

[17] "ProMare: Unlocking the secrets of the ocean with an autonomous ship operated by AI and edge technology." https://mas400.com/

[18] IBM Institute for Business Value, "Creating new revenue streams and services with5G, edge computing, and AI"- Feb 2020

leverage as a market entry and optimize the roll-out accordingly. Use cases such as autonomous vehicles and XR, where low latency is a critical requirement and proximity to the point of service delivery will be the prime priority. In such instances, an ultra-small-scale local exchange (for wirelines services) or a base station (for Mobile services) would prove as the most optimum location[19]. In some instances, such as data capture for autonomous driving, the EC node might even be located inside the vehicle or devices.

EC SP may create on-demand carrier-neutral system instances for tenants of different industries

Who can manage and offer wholesale Edge Compute power?

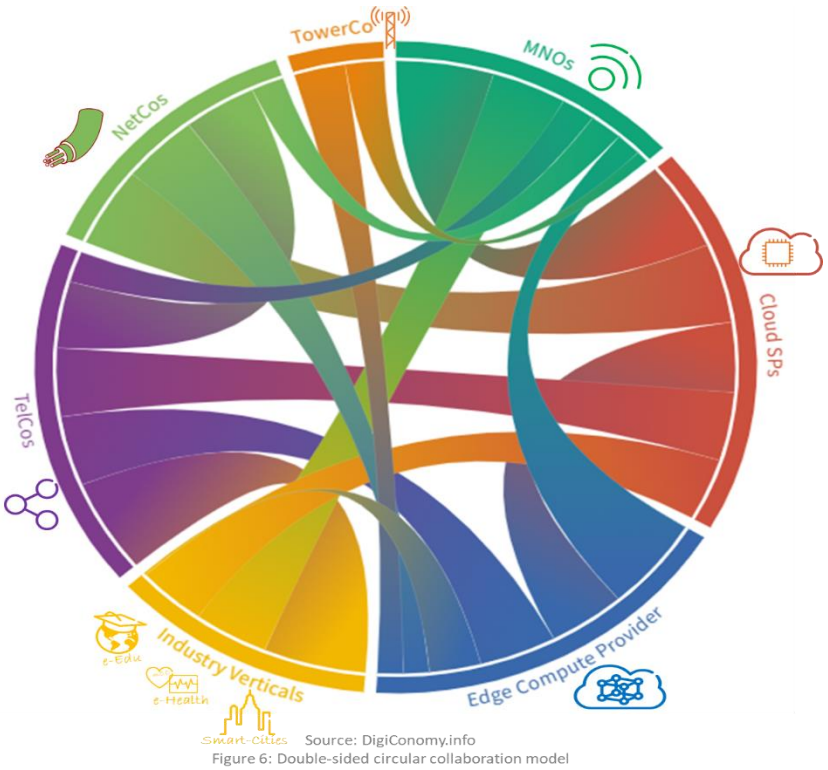
Interests in EC among many stakeholders is growing in a market that, due to its network effects and economies of scale, seems to follow the "winner takes it all" paradigm, players could be:

- Tower Companies (TowerCos)
- Telecom Networks Companies (NetCo)
- Mobile Network Operators (MNOs)
- Telecom Service Companies (TelCos)
- Cloud Service Providers (CSPs)

Hyperscale Cloud Service Providers (such as AWS) are pushing to build their own edge clouds to either sell to TelCos (and MNOs) for their own network's infrastructure, or to sell Edge Cloud services directly to business end users[20].

Meanwhile, TelCos and MNOs are trying to build Edge Clouds to sell their connectivity services to Cloud Service Providers, as TelCos believe that they are closer to end users from a proximity point of view. On the other hand, Network operator Companies (NetCos) and Tower Companies (TowerCos) also believe that they hold the required mix of communication networks and IT skills to build Edge Cloud infrastructure, as their network is already optimized to terminate at a point very close to end users. In contrast, Cloud providers may also partner with existing infrastructure providers or TowerCos[21] (or even NetCos) to deploy smaller scale Edge Compute clouds closer to end customer.

It can be observed that a wholesale Edge Computing Service Provider ("EC SP") may best be positioned to have the aspirations to start rolling out an EC infrastructure from scratch in order to optimize the tenancy ratio of the EC nodes. An EC SP may create on-demand carrier-neutral system instances for the tenants of different industries, depending on their



Source: DigiConomy.info

Figure 6: Double-sided circular collaboration model

[19] Ovum: Driving New Business Opportunities with Multi-Access Edge Computing and 5G - 2019

[20] aws.amazon.com/wavelength/

[21] American Tower continues to increase its interest in EC – Rethink Research – Sep 2019

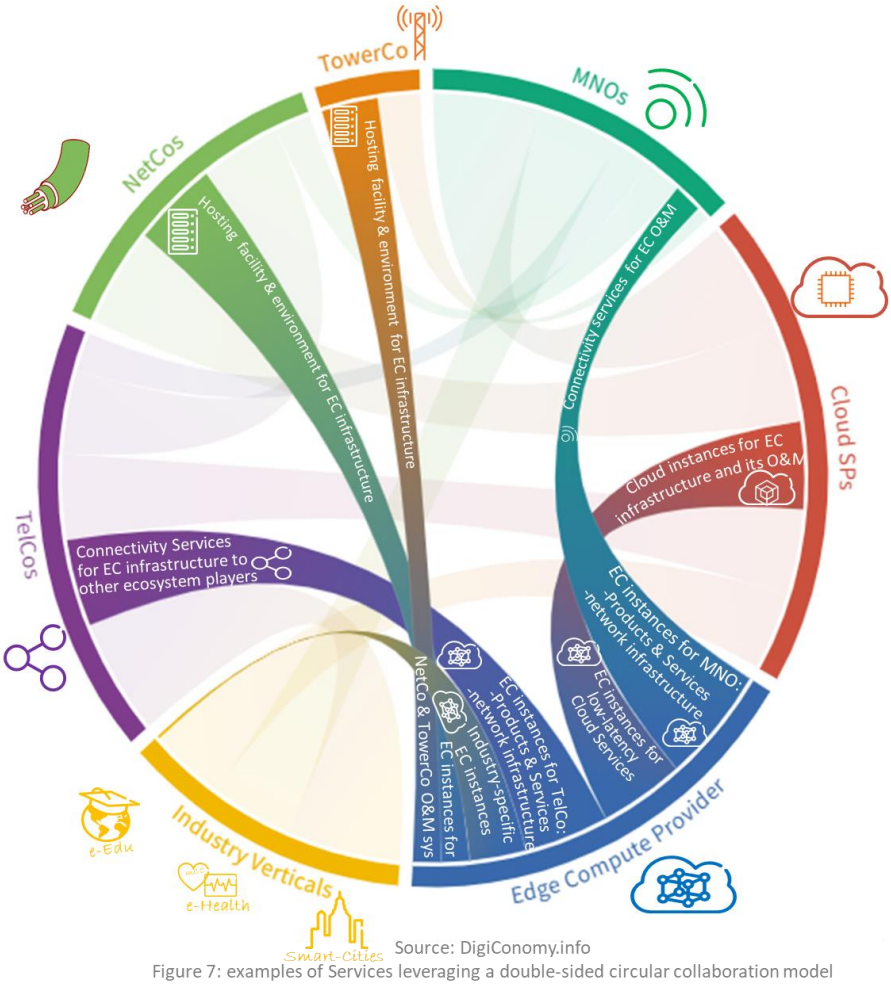
requirements. For example, a TelCo may require a highly available instance at the Edge to deploy NFV and SDN functions to operate their own Telco infrastructure, while at the same time the EC provider would be leasing less-critical instances for offering lower latency-intensive services to enterprise customers of different industry verticals distributed at scattered locations, leveraging on the double-sided circular collaborative ecosystem (in Figure 6).

EC SP may leverage on the double-sided circular collaborative ecosystem

A single EC deployment ideally needs to support more than one use case in order to realize higher economies of scale and therefore propose cost effective pay-as-you-go, build-as-you-grow and on-demand compute power to multiple tenants: from multiple verticals of the digital industry such as Cloud Service providers, TelCos, MNOs, public and on-campus use cases from Government entities, Enterprise users. Such models are best offered by a wholesale EC SP (who can be a Cloud Service Provider, a TowerCo, or a NetCo) located at closer proximities towards the users.

As such, the engagement with application developers will be crucial in designing the roll-out of EC networks, as it must include features such as service APIs in order to enable the exposure of underlying information and capabilities to the different types of tenants utilizing the Edge cloud, to enhance orchestration and management (O&M) for seamless integration, resource management, control, and execution[22]. This will ensure service continuity, content synchronization for applications such as V2X and XR where users are physically moving at the network edge.

EC SP may provide commercial edge cloud services (such as IaaS, PaaS, and SaaS) to the different types of customers of various industries by aggregating the edge resources from cross service providers (Telco, Cloud, Towerco, NetCo for instance) into end-to-end or segmented suites of services. Such services would be accessible through an integrated platform for the users to have a seamless and unified experience, rather than seeking services



Source: DigiConomy.info

Figure 7: examples of Services leveraging a double-sided circular collaboration model

[22]Toward fully connected vehicles: Edge computing for advanced automotive communications – 5GAA – Dec 2017

from multiple providers; while at the same time a TelCo or an MNO would be offering connectivity products to EC provider to connect to Cloud providers and other ecosystem players, as depicted in Figure 7.

An EC SP may offer low latency and high throughput for B2C services to business customer from different industries; in parallel MNOs can also leverage the same EC infrastructure for 5G networks to provide additional features to support new B2B services via the edge clouds. This includes network slicing for guaranteed end-to-end performance, reliability, security, session, and service continuity (SSC) for seamless and ultra-low-latency connectivity. These 5G features will be important to create deterministic networks, capable of delivering differentiated and seamless services that can guarantee performance criteria such as latency according to the requirements of a particular use case, such as Industrial IoT Automation and Smart Venues but can also offer services with less stringent latencies[23].

in need of sustainable data center models, to reduce complexity, accelerate growth and deliver significantly enhanced edge computing economics

Standardizations in Edge Computing

Edge Computing vendors are building sustainable edge technologies with software-enabled mass-scale platforms that combine server-less features with intelligent energy control advancements, enabling software defined power to optimize uptime and efficiency that will run in any data center environment. Major industry players and global agencies are collaborating for setting the standards of the EC to ease deployments and interoperability among existing technologies. The GSMA[24] has formed the Telco Edge Cloud ("*TEC*") group that aims at aligning Multi-Access Edge Computing ("*MEC*") business models, changing principles and commercial deployment considerations. TEC works in partnership with the GSMA Operator Platform Group, which aims at creating the architecture and the technical requirements to guide other Standard Developing Organisations ("SDO") in the development of specifications[25].

In the open-source domain, there are at least 20 on-going initiatives so far across different communities[26]. EC is being specified across standards and open-source forms with organizations such as the 3GPP which has accelerated its activities towards edge as well as the ETSI, the Cloud Native Computing Foundation ("CNCF"), the Open Network Automation Platform ("ONAP") and the Linux Foundation Edge ("LFE"). In addition, there are several industry alliances aligning around their own use cases. Automotive Edge Computing Consortium ("AECC") and the 5G Alliance for Connected Industries and Automation ("5G-ACIA") are good examples of those.

Open-Ecosystem collaboration

What the industry will really be in need of is sustainable data center models, implemented in the right way, to reduce complexity, accelerate growth and deliver significantly enhanced edge computing economics. Cost-efficient and flexible deployments, that are purpose-built to maximize performance, compute density, and energy efficiency are exactly what

[23] The Adaptive Network: A Framework for Understanding the Networking Implications of the Edge Cloud – Ciena - 2020

[24] the GSM Association (GSMA) is an industry organization that represents the interests of mobile network operators worldwide

[25] GSMA October 2020 - Telco Edge Cloud: Edge Service Description and Commercial Principles Whitepaper

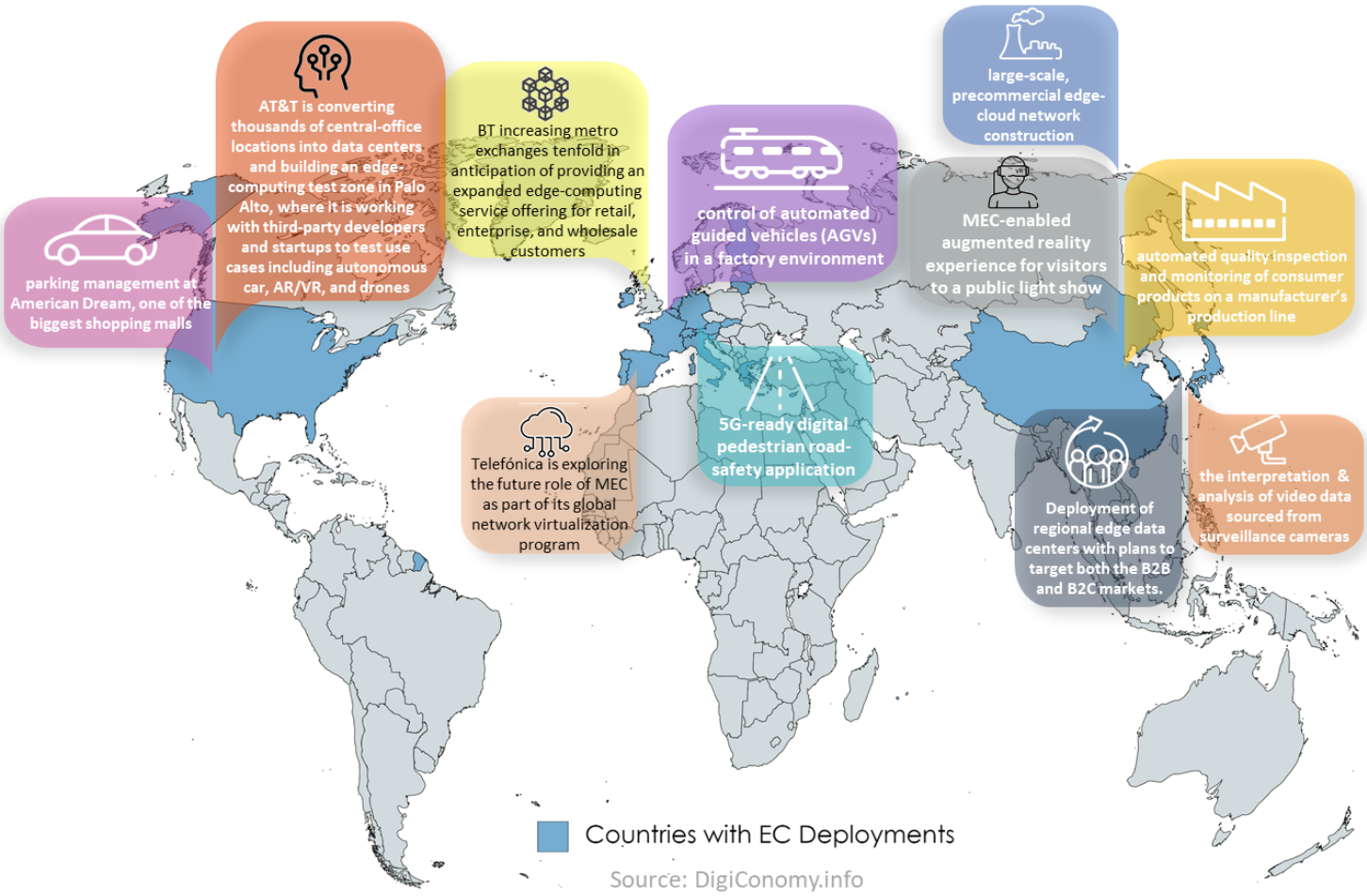
[26] Ericsson Feb 2020 - Edge computing and deployment strategies for Communication service providers

cloud service providers, TelCos and content providers need to accelerate and scale their new applications.

Further work in the ETSI's Multi-access Edge Computing Industry Specification Group (MEC ISG) is already well advanced since 2016[27] in order to define an edge framework for implementation in CSP networks. Covering the architecture, framework, and general principles for service APIs and widen the scope of ETSI MEC to include any access technology and to consider integration with NFV.

Current rollouts of Edge Computing

The enormous value of EC has already been demonstrated in various deployments across a range of use-cases. Applications such as local content distribution, IoT, security and surveillance, cloud gaming, smart stadiums, intelligent transport systems, fleet management and logistics, AR/VR, autonomous vehicles and V2X, manufacturing process automation and monitoring (Industry 4.0), campus networks, some of the examples are depicted in Figure 8[28].



Source: DigiConomy.info

Figure 8: Countries with EC deployments

[27] ETSI MEC Public Overview – 2020

[28] Source: DigiConomy.info Data sourced from Ovum 2019 and aws.amazon.com/wavelength/

Conclusion

Engagement and collaboration among industry associations and public authorities will contribute to build the Customer requirements.

Edge Computing service providers may start to offer compute power services to TelCos and mobile network operators as MNOs are already evolving towards a virtualized, 5G-oriented cloud-based model, as well as CDNs and Cloud Providers. In addition, an EC Service Provider may offer its EC infrastructure to other industries verticals such as Education, Healthcare and Government agencies. Edge Computing has the potential to provide on-demand, high-performance and cost-effective platforms capable of supporting a growing number of use cases.

While TelCos who could lead this revolution, are yet to assess their competitive position to play such a key role, new wholesale entrants have an overwhelming opportunity in monetizing the current gap, to play the role of becoming a carrier-neutral Edge Compute wholesale service provider, entrants such as a:

- Tower Company (TowerCo)
- Telecom Networks Company (NetCo)
- Cloud Service Providers.

would have a much higher competitive edge to start offering such Edge Compute services to new and existing Retail TelCos (or MNOs).

EC SP may leverage on the double-sided circular collaborative ecosystem

Such carrier-neutral wholesalers would unquestionably benefit from their existing infrastructure's proximity to end-users, and the double-sided circular collaboration model.

Meanwhile, the inspiration of this emerging ecosystem is that it is not a 'zero-sum game', it is not a 'winners take-all' concept for potential wholesalers of EC provider, it is a game of collaboration and partnerships. Small or hyperscale Cloud Providers may partner with NetCos or TowerCos to collaborate and complement forces.