THE FUTURE OF THE ELECTRONIC COMMUNICATIONS SECTOR AND ITS INFRASTRUCTURE

This document aims at complementing BEREC's responses to questions 1-5, 12 and 32 of the European Commission survey: The future of the electronic communications sector and its infrastructure[1], published on the 23rd of February 2023.

Overview of technological developments and trends (questions 4 and 5)

Regulation needs to keep pace with the emerging technological and market developments

The digital sector features constant change and innovation. The latest technological trends are not only changing the way we communicate by means of new services but also adding complexity and reshaping the internet ecosystem by the entry of new players, the changing roles of traditional players or the creation of new competition bottlenecks in the value chain and the removal of others. In addition, new challenges related to ensuring end-users rights and cybersecurity in the new context emerge and the regulatory focus is expanding to actively contribute to achieving sustainability goals. Evolution of the digital ecosystem will also have to be driven in light of the sustainability challenge: in particular, the mitigation of all relevant adverse impacts related to the digital sector should now be a common objective, to which BEREC is contributing[2].

In this context, the International Telecommunications Union (ITU) has called for a 5th generation of regulation,[3] the OECD has reflected on the impact of the networks of the future[4] and, in light of these, issued a Communication on the regulators of the future[5]

[1] https://digital-strategy.ec.europa.eu/en/consultations/future-electronic-communications-sector-and-its-infrastructure

[2] *Cf.* In particular BEREC Report on Sustainability: Assessing BEREC's contribution to limiting the impact of the digital sector on the environment: https://www.berec.europa.eu/en/document-categories/berec/reports/berec-report-on-sustainability-assessing-berecs-contribution-to-limiting-the-impact-of-the-digital-sector-on-the-environment
Ongoing work on indicators are also to be mentioned: https://www.berec.europa.eu/en/document-categories/berec/reports/draft-berec-report-on-sustainability-indicators-for-electronic-communications-networks-and-services

[3] https://gen5.digital/explainers/the-story-behind-five-generations-of-regulation-g1-to-g5/

[4] OECD (2022), "Broadband networks of the future", *OECD Digital Economy Papers*, No. 327, OECD Publishing, Paris, https://doi.org/10.1787/755e2d0c-en.

[5] OECD (2022), "Communication regulators of the future", *OECD Digital Economy Papers*, No. 333, OECD Publishing, Paris, https://doi.org/10.1787/f02209e6-en.

and BEREC has recently published a 2030 Action Plan[6] along the same lines. The three organizations share the view that regulation (and, consequently, regulators) must gain a holistic perspective.

Guided by the principles enshrined in article 3 of the Electronic Communications Code (EECC), regulation and regulators are evolving to keep pace with the emerging technical, market and competition developments. This evolution is necessary to ensure that these overarching regulatory goals can be met. Against this backdrop and within its remit, BEREC has continuously adjusted itself to advance regulation as markets evolve and individuals' and businesses' needs change. Looking towards 2030, BEREC aims at actively facilitating and fostering open, secure, high-quality, competitive, and sustainable digital ecosystems that will be the key to empowering people and businesses in future societies. In particular, the mitigation of all relevant adverse impacts related to the digital sector is becoming a common objective to which BEREC is contributing[7].

BEREC strives to keep abreast with advancements in technology and the changing market demands and requirements. Through specific fora, and other encounters, BEREC meets with stakeholders to discuss particular technologies, and their evolvement, together with market needs.

BEREC has a long list of publications - guidelines and reports – which were prepared to either evaluate and review explicit technologies (for example AI), or to identify, deliberate and potentially audit (QoS - Quality of service, for example) the networks upon which the technologies will operate. Such publications build BEREC's information base. They also assist and guide NRAs and stakeholders in their preparedness for future technological developments. Some of these recent reports include:

- BEREC Report on the 5G Ecosystem BoR (22) 144[8],
- BEREC's Input paper on potential Regulatory Implications of Software-Defined Networking and Network Functions Virtualisation BoR (16) 97[9],
- BEREC Report on the Internet Ecosystem BoR (22) 167[10]

[6] BEREC Action Plan for 2030 BoR (23) 48 https://www.berec.europa.eu/en/document-categories/berec/others/berec-action-plan-for-2030

[7] *Cf.* In particular BEREC Report on Sustainability: Assessing BEREC's contribution to limiting the impact of the digital sector on the environment: https://www.berec.europa.eu/en/document-categories/berec/reports/berec-report-on-sustainability-assessing-berecs-contribution-to-limiting-the-impact-of-the-digital-sector-on-the-environment
Ongoing work on indicators are also to be mentioned: https://www.berec.europa.eu/en/document-categories/berec/reports/draft-berec-report-on-sustainability-indicators-for-electronic-communications-networks-and-services

[8] https://www.berec.europa.eu/en/document-categories/berec/reports/berec-report-on-the-5g-ecosystem

[9] https://www.berec.europa.eu/en/document-categories/berec/others/input-paper-on-potential-regulatory-implications-of-software-defined-networking-and-network-functions-virtualisation

[10] BEREC Report on the Internet Ecosystem BoR (22) 167 https://www.berec.europa.eu/en/document-categories/berec/reports/berec-report-on-the-internet-ecosystem

- BEREC's Draft Report on challenges and benefits of Artificial Intelligence (AI) solutions in the telecommunications sector BoR (22) 191[11]
- BEREC Summary report of the workshop on Open RAN[12]

Understanding the different roles, business models, investment efforts, and development opportunities of market participants in the internet ecosystem is crucial to understanding the telecommunications sectors. Therefore, these trends underline that ECN and the provision of ECS can no longer be understood separately from other digital services. For this reason, BEREC has repeatedly called for a holistic perspective, which it believes is necessary to approach the complexity of the digital sector in an evidence-based manner.

Service and infrastructure traditional boundaries are blurring

The questionnaire differentiates between the developments of electronic communications networks (ECN) and infrastructure on one side and digital services, on the other. However, the boundaries between ECN providers, infrastructure providers and digital services providers are blurring in recent years. This blurring means that a full understanding of the impact of future developments requires jointly assessing all layers of the internet ecosystem and all different providers. Whereas telecom operators and digital service providers offered services which could clearly be differentiated from each other in the past, these market players are currently active in different parts of the internet value chain and thus cooperating, competing and in many cases depending on each other.

To understand these dynamics in more detail, BEREC prepared its Report on the Internet Ecosystem.[13] In this Report, BEREC analysed how the experience of users of the Internet is affected by different elements of the ecosystem and how the interactions between these elements may have an impact on competition within and among the different layers, which, in some cases, may call for a regulatory intervention. In this regard, a Digital Markets Act was recently adopted to ensure fair and contestable markets in the digital sector and a Data Act was proposed to introduce measures for a fair and innovative data economy.[14]

The following markets and technological trends have contributed to reshaping the traditional separation between ECN and ECS and digital services:

- *Number based and number independent interpersonal communication services developments (NB-ICS and NI-ICS)*

Instant messaging services have significantly evolved in the last years and enable users to communicate in a very diverse way.

[11] https://www.berec.europa.eu/en/document-categories/berec/reports/draft-report-on-challenges-and-benefits-of-artificial-intelligence-ai-solutions-in-the-telecommunications-sector-including-use-cases
[12] https://www.berec.europa.eu/en/document-categories/berec/reports/summary-report-berec-open-ran-workshop-24-may-2022
[13] BEREC Report on the Internet Ecosystem BoR (22) 167 https://www.berec.europa.eu/en/document-categories/berec/reports/berec-report-on-the-internet-ecosystem
[14] See Regulation (EU) 2022/1925 and COM/2022/68 final

The EECC (recital 15) acknowledges that *end-users increasingly substitute traditional voice telephony, text messages (SMS) and electronic mail conveyance services by functionally equivalent online services.* BEREC's Study "Analysing EU consumer perceptions and behaviour on digital platforms for communication" [15] shows that this is a trend throughout all Member States (MS), even if it is not fully homogeneous, as NI-ICS user uptake rates varies across the EU and also because European countries can be grouped into WhatsApp vs Facebook Messenger-dominated markets.

Meanwhile, alongside these developments, "traditional" services such as SMS, telephony, etc. are evolving. This can be seen in standardization efforts such as Rich Communication Services (RCS, the evolution of SMS and able to provide enhanced services) improved quality in recent voice codecs and the ubiquity of VoLTE and VoWIFI.

When NI-ICS were first introduced, it was typically the case that NI-ICS were mainly supplied by digital services providers. Currently this association between NI-ICS and digital platforms and NB-ICS and traditional telcos is not so straightforward. Moreover, the boundaries between NB-ICS and NI-ICS, or even other services, are blurring themselves due to market and technical trends.

With regard to the market trends, as BEREC acknowledged in the "Report on the interplay between the EECC and the EC's proposal for a DMA concerning NI-ICS"[16], a few large digital platforms offer both NB-ICS and NI-ICS.[17] Moreover, NB-ICS and NI-ICS are commonly commercialized in a bundle in some Member States (e.g., Skype in/out, which is a NB-ICS, and peer-to-peer Skype, classified as NI-ICS). Another example of how the services are intertwined are messaging/VoIP systems that allow both person-to-person communication (ICS) and person-to-machine communication (e.g., communication with a bot, IoT devices or a virtual assistant) which would be a conveyance of signal service, not an ICS. Finally, it should be noted that telecom operators offer e-mail services, which also fall under the NI-ICS definition, in addition to NB-ICS.

With regard to technical developments, BEREC observes that Google, one of the largest digital service providers, provides RCS[18] in cooperation with telecommunication operators in some Member States.

Against this framework, the EU legal framework has tended to converge the regulation of NI-ICS and NB-ICS in the last years. The EECC broadened the scope (mainly, regarding sectoral end-users' rights and interoperability) of the regulatory framework to

[15] BEREC Study "Analysing EU consumer perceptions and behaviour on digital platforms for communication" BoR (21) 89 https://www.berec.europa.eu/en/document-categories/berec/reports/analysing-eu-consumer-perceptions-and-behaviour-on-digital-platforms-for-communication-analysis-report

[16] BEREC Report on the interplay between the EECC and the EC's proposal for a Digital Markets Act concerning number-independent interpersonal communication services BoR (21) 85 https://www.berec.europa.eu/en/document-categories/berec/reports/berec-report-on-the-interplay-between-the-eecc-and-the-ecs-proposal-for-a-digital-markets-act-concerning-number-independent-interpersonal-communication-services

[17] E.g. Amazon Connect; Google RCS Message or Microsoft Operator Connect. (Teams))

[18] https://jibe.google.com/

NI-ICS.[19] To cope with future developments, the EECC additionally tasks BEREC to monitor, at least every three years, the implementation of these provisions taking into account the scope of end users' sectoral rights as regards to the types of ECS (art. 123 EECC).[20] In addition, the implementation of the Digital Markets Act (DMA) and, in particular, the interoperability obligation imposed on gatekeepers aims to change the current competition dynamics for the provision of NI-ICS.

- *Bundled connectivity and digital products commercialization*

More and more, connectivity is commercialized in a bundle with digital services. This is typically the case of mass market products with media services but, especially for business services. Operators consider electronic communication services (ECS) and IT/digital services (including key elements like operating systems (OS) and cloud services) moving closer together with customer demand for complex bundles and customized services.

The recently published "BEREC's external Study on Communication Services for Businesses in Europe: Status Quo and Future Trends"[21] sets out information on operators' adaptation to users' demand by blending IT services with electronic communication services. The report also signals that customisation of offers to match the need of all types of business users and be able to differentiate themselves from competitors is increasingly important. This customisation now includes ECS and IT services. In order to provide digital services alongside traditional ECS services, operators enter into cooperations with other providers such as digital, IT providers or vendors. According to the information gathered in this study commissioned by BEREC, operators will most probably continue to collaborate with new players, particularly on specific or highly technical offers. These cooperations are based on various kinds of partnership agreements, the most common being for cloud hosting, but other types require a tight integration of services (e.g., in the case of Unified Communications and Collaboration (UCC) services). Forward looking, some of the ECS suppliers have expressed concerns with regard to their relative importance/bargaining power in relation to the digital players.

- *Providers' integration across the Internet ecosystem*

Some large CAPs are moving upward in the Internet value chain and vertically integrating. They are investing heavily in networks and related infrastructure such as backbones, submarine cables,[22] data centres, satellite communication,[23] or Content

[19] See BEREC Report on the interplay between the EECC and the EC's proposal for a Digital Markets Act concerning number-independent interpersonal communication services BoR (21) 85 for further insights on the specific sectoral rules applying to NI-ICS.

[20] See, for instance, the latest BEREC Opinion on the market and technological developments and on their impact on the application of rights of end-users in the EECC BoR (21) 177 https://www.berec.europa.eu/en/document-categories/berec/opinions/berec-opinion-on-the-market-and-technological-developments-and-on-their-impact-on-the-application-of-rights-of-end-users-in-the-eecc

[21] BEREC External Study on Communication Services for Businesses in Europe: Status Quo and Future Trends BoR (22) 184 https://www.berec.europa.eu/en/document-categories/berec/others/external-study-on-communication-services-for-businesses-in-europe-status-quo-and-future-trends

[22] E.g. Microsoft and Meta Marea submarine cable between EEUU and the EU

[23] e.g. the Amazon Kuiper project, projecting thousands of satellites in order to establish last-mile connectivity or Apple's investment in satellite operator Globalstar.

Delivery Networks (CDNs). While most of such infrastructure was deemed for self-provision at first, CAPs are progressively also offering those services to 3rd parties. CAPs are more and more active in the field of equipment vendors, as through the virtualisation of networks it becomes easier for software specialists to compete with traditional vendors.

With regard to ECN, CAPs investments on submarine cable and satellite communications are particularly relevant. According to TeleGeography, CAPs[24] are becoming major investors in submarine cables[25] to meet different objectives. First, their own increasing connectivity needs entail massive traffic[26] to the point that it is more affordable to build a network than use a carrier.[27] Second, linking their data centres in order to reduce costs, improve performance, and increase resilience. Third, gaining more control (e.g. regarding security) over the network and, thus, the provision of their services.

In addition to network infrastructure, large CAPs are investing heavily in internet technologies such as video/voice compression, (quantum-safe) encryption, internet protocols such as QUIC/RTP, etc

Large CAPs are also active with regard to ECS. For example, Alphabet provides mobile communications (as MVNO) and is deploying a fibre network in the USA.[28] Amazon recently announced allowing third parties to utilize their "sidewalk" network for M2M applications[29]. .

Finally, CAPs are also present in the market of device manufacturers and OS providers; elements are also shaping services and network functions.

In the other direction, many traditional providers of ECS/ECN also make use of economies of scope and vertical integration by providing media services over their network, e.g., linear TV or video-on-demand.

More recently and still on an early phase and significantly more limited in scope, telecom operators are also moving beyond traditional ECN/ECS. For example, a joint venture of major telco providers recently unveiled a product, offering digital marketing and advertising activities[30]. Another example could be the GSMA Open Gateway initiative for the development of Open Application Programming Interfaces (API) designed to provide universal access to operators' networks for service providers and application developers in the form of Network as a Service (NaaS) model.

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[24] This category includes content providers, CDNs, cloud providers, interconnection providers, data center operators, gaming companies, SaaS companies.

[25] This is What Our 2019 Submarine Cable Map Shows Us About Content Provider Cables or please read The State of the Network Report 2022

[26] GAFAM accounted for two-thirds of all used international capacity. Share of used international bandwidth. TeleGeography.

[27] More information on incentives for investment in Submarine cable see at the end of the website https://blog.telegeography.com/the-mystery-of-international-bandwidth-demand

[28] E.g., Google Fi (MVNO) and Google fiber. Also Meta provides connectivity by means of Middle Mile Infrastructure

[29] https://www.iottechnews.com/news/2023/mar/29/amazon-sidewalk-mesh-iot-network-third-party-devices/

[30] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_721

- *Network virtualization and cloudification*

The cloudification of network elements have been enabled by some fundamental technological developments: Software-Defined Networking (SDN) and Network Functions Virtualisation (NFV). These technologies are expected to induce several implications on the telecommunications landscape.[31] Although these technologies are relevant for both fixed and mobile services, they are particularly important in the context of 5G. 5G networks have been conceived as "cloud native networks", meaning that they have been designed to fully exploit the benefits of cloud services. More generally, SDN and NFV have contributed to shape Open RAN solutions.

These developments may also imply changes of the infrastructure providers' business model by allowing them, for example, hosting edge functionalities.

As stated in BEREC's report on the 5G Ecosystem,[32] it is expected that cloud services will act as an enabler for all the benefits that a fully-fledged 5G network can deliver. Network virtualisation and automation will lead to the use of cloud native solutions as well as an increased emphasis on software capabilities. The NaaS cloud solutions will significantly simplify the deployment and operation of services. Furthermore, new models based on a "pay-as-you-use" principle could emerge. As a result, the investment required for vertical industries[33] could be reduced while cloud service providers may expand towards other parts of the supply chain, such as the edge of the access network. Cloud service providers may also assume the role of cloud capacity providers to host virtual and cloud native network functions and even full solutions to private networks.[34]

Network cloudification has led to the emergence of partnerships between cloud providers and telecoms operators for the delivery both of integrated solutions to the end users and for the provision of fixed and mobile telecoms. BEREC's 5G Ecosystem report develops on the different types of partnerships identified in this evolving market environment. MNOs are investing in this regard, and it is perceived that the cloud native nature of 5G when broadly available in "stand alone" operation is an opportunity for traditional service providers to move into adjacent industries.[35] On the other hand, some providers of over-the-top (OTT), cloud and CDN services could be also well placed to assume the role of cloud service network providers taking into account their experience and market position for those services as well as the possibility to benefit from economies of scale.

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[31] "Implications of the emerging technologies Software-Defined Networking and Network Function Virtualization on the future Telecommunications Landscape", Wik Consult, IDATE and TNO, a study prepared for the European Commission DG CONECT, 2016.
BEREC BoR (16) 97 Potential Regulatory Implications of Software-Defined Networking and Network Functions Virtualisation
https://www.berec.europa.eu/en/document-categories/berec/others/input-paper-on-potential-regulatory-implications-of-software-defined-networking-and-network-functions-virtualisation

[32] BEREC Report on the 5G Ecosystem BoR (22) 144 https://www.berec.europa.eu/en/document-categories/berec/reports/berec-report-on-the-5g-ecosystem

[33] Vertical industries encompass a group of companies and customers that are all interconnected around a specific niche or specialized industry. Some examples of verticals are the automotive, transport, healthcare, manufacturing, logistics, agriculture, smart cities or media and entertainment industries.

[34] For example, https://aws.amazon.com/private5g/

[35] "Edge computing – introduction in phases," Ericsson, source: https://www.ericsson.com/en/edge-computing

Infrastructure providers (such as TowerCos or FiberCos) may also have a role in network virtualization. Their specific place in the network makes them able to host future network functionalities, such as edge computing or other virtualised network functionalities that would benefit from being hosted closer to the end-user.

- *Networks are becoming increasingly heterogeneous*

ECN are composed of increasingly diverse elements, and this also affects how end-users can use these networks as well as the market dynamics in these markets. Regarding the composition of networks, for instance, satellite networks are being integrated into terrestrial networks to offer expanded forms of connectivity, in particular in connection with 5G. On the other hand, some infrastructural components such as mobile cell towers are becoming increasingly attractive for holding companies. At the same time, the way in which end-users access content drives the deployment of CDNs and data centres.

Developments regarding submarine cables have been facilitated by innovative technologies such as Open Submarine Cable which disaggregates the wet plant (the undersea infrastructure) from the dry plant (Submarine cable landing station).

Some of these interrelations give rise to new dynamics which need to be considered in terms of their effects on the markets for electronic communications, but also in terms of resilience, environmental impact, and cybersecurity. It is also clear that the question of interoperability requires continued reflection to ensure that the evolution of ECN continue to enable the European single market.

- *Development of Artificial Intelligence (AI)*

As in the case of cloud, Artificial Intelligence (AI) systems will horizontally impact all types of services and industries, including ECN/S. ECN/S are expected to be both enabled enablers for the development of these technologies.

BEREC has assessed the potential of AI systems for the provision of ECN/S including use cases, opportunities and challenges that may entail in the sector in the Draft Report on challenges and benefits of AI solutions in the telecommunications sector (including use cases).[36]

Based on the feedback gathered in this report, although the adoption by ECN/S providers of AI systems is still in an early stage, telecom market players expect that the use of AI systems in the operational procedures will become a norm approximately in the next six to ten years.

AI systems may impact ECN in terms of new hardware requirements, integration of different hardware and software components or the deployment of edge infrastructures. It may also require additional network capacity investments. The draft report signals as well that AI systems require a number of key enablers for fully exploiting the potential of AI, such as connectivity, access to (large amounts of) reliable data, adequate capacity to store and process this data, and, in some cases, edge computing capacity. Among those, connectivity provided by ECNs will not only make AI more accessible, but it is also

[36]Draft Report on challenges and benefits of Artificial Intelligence (AI) solutions in the telecommunications sector (including use cases) BoR (22) 191 https://www.berec.europa.eu/en/document-categories/berec/reports/draft-report-on-challenges-and-benefits-of-artificial-intelligence-ai-solutions-in-the-telecommunications-sector-including-use-cases Public consultation draft. Final report to be published in June 2023.

necessary to enhance its performance. In addition, standardisation will be of capital importance to help decrease time to market and development costs. It will furthermore play an important role in enhancing a level playing field, furthering interoperability and innovation, enabling market surveillance and mitigating potential lock-in effects. However, BEREC also signals the risk that in case of barriers to access to and use one or more AI enablers may imply imbalances between different players in developing and adopting AI.

The impact of AI systems can be profound in the context of ECN: the use of AI systems may necessitate significant investment in data or physical infrastructure, while the resource requirements for developing AI systems may exceed the capacities of even large ECN/S providers, leading to an increasing reliance on external providers.

Transformation is not only taking place in the last mile

The most recent EU legislation, including the DMA and the DSA, addresses emerging challenges taking place at the edge of the network. Nevertheless, developments are not taking place only regarding how digital services are provided to end users.

In addition to the developments regarding networks deployments by new players network architectures are also evolving. The Internet of today could not be able to offer the speed and latency which it currently allows for without infrastructures developed within the network such as CDNs. Along the same lines, the Internet of tomorrow will most likely require additional infrastructure investments to underpin upcoming developments (e.g., investments in cloud and edge nodes). The core of networks will also require investment as well as strategic commercial and technical developments.

Furthermore, as BEREC has illustrated in the Report on the Internet Ecosystem, large platforms ecosystems encompass not only a broad portfolio of interlinked digital services but are also present all across the internet ecosystem, including core networks. At the same time, competition concerns also often relate to structural features of the markets. Entry barriers, for example, are often (but not always) independent of being active in one or several markets of internet access, interpersonal communication services, interconnection, cloud or AI, etc.

Many of those concerns are addressed by the EECC, the DMA and, in the future, the Data Act. These legislations reflect how standardisation, common, accessible and industry-wide standards, as well as interoperability play an important role for market contestability. Indeed, they are essential requirements and/or enablers for data portability, in a global context where data transfers and data are one of the most competitive intangible assets for the digital society and its productive models (e.g., Smart society, Industry 4.0) or data processing services switching and facilitating multi-cloud adoption. In line with a holistic perspective, BEREC believes these developments of the network infrastructure require close monitoring of their competitive but their environmental impacts.

New technologies require access to inputs concentrated in few enterprises

Considering the fundamental role played by data, skills related to data, as well as the services helping to store and process (cloud) or utilise data (AI), it is important to take into account that access to and use of these resources is not ubiquitous. Instead, these

vital inputs for the digital ecosystem are more often than not distributed unequally, and those lacking these resources need to negotiate access.

At this moment, agreements are reached on a commercial basis. However, vertical and horizontal integration trends may change the incentives to conclude agreements and may thus impact these dynamics in the future. In such a scenario, new bottlenecks in the provision of ECN may arise. This could be the case if, for instance, hyperscalers [37] leverage their market power into the ECN. Recent studies such as the published by ACM[38] or OFCOM[39] have found grounds of concern in the functioning of cloud services.

Within this context and taking into consideration the relevance of these services in the provision of ECN/S and, in general, for the internet ecosystem, the BEREC 2023 Work Programme envisages several work streams related to the provision of data processing services:

- As part of the work related to BEREC's input to the EU institutions on the Data Act, a possible preliminary assessment on the implementation of switching between data processing services measures and a workshop on data processing services switching.
- BEREC Report on cloud services and edge computing.
- BEREC External study on the trends and policy/regulatory challenges of cloudification, virtualisation and softwarisation in telecommunications.
- BEREC Report on the entry of large content and application providers into the markets for electronic communications networks and services.

Other implications of the technological development

Dependencies on a few enterprises may also have implications not only in terms of competition but on users' rights, EU sovereignty, security, sustainability, and network resilience.

With regard to users' rights, BEREC has noted [40] that the open access to, as well as the open provision of, services and applications could potentially be affected in practice by developments further up or along the internet value chain to which the Open Internet Regulation does not apply. BEREC concluded that this subject should be kept under scrutiny at European level for further consideration in ongoing and future regulatory developments.

[37] The term hyperscalers refers to three leading cloud providers (Amazon, Microsoft and Google).
[38] ACM Market Study Cloud services https://www.acm.nl/system/files/documents/market-study-def-public.pdf
[39] https://www.ofcom.org.uk/news-centre/2023/ofcom-proposes-to-refer-uk-cloud-market-for-investigation
[40] See BEREC Opinion for the evaluation of the application of Regulation (EU) 2015/2120 and the BEREC Net Neutrality Guidelines BoR (18) 244 https://www.berec.europa.eu/en/document-categories/berec/opinions/berec-opinion-for-the-evaluation-of-the-application-of-regulation-eu-20152120-and-the-berec-net-neutrality-guidelines

New technologies such as the ones mentioned in the questionnaire[41], aim to reach the entire productive fabric and all kinds of services including those necessary for social integration and the well-being of citizens such as health, education or access to information. This raises the need to use and access these technologies while avoiding dependence on a few companies. It is necessary to establish rules and develop frameworks that allow to promote competition and avoid or mitigate the adverse effects of such concentration.

These effects have been acknowledged by EU legislation such as the General Data Protection Regulation (GDPR) and ePrivacy Directive, the DMA (to ensure fair and contestable markets in the digital sector) and the DSA, the Data Governance Act as well as the future Data Act (introducing measures for a fair and innovative data economy) and AI Act that are currently debated at legislative level. BEREC has contributed with its expertise and experience in the development of some of these legislations and is committed to continue working together with the EU institutions and other relevant authorities for their implementation for the benefit of all EU citizens.

Relevance of technological developments (question 1)

The questionnaire asks to rank new technologies[42] in consideration to their impact on the electronic communications in the next ten years. BEREC emphasises that such predictions are challenging due to the complexity of the telecommunications sector.

A ten-year window is considered to be a long span when making predictions for technological developments. A number of factors may affect and influence these developments, reaching from circumstances that impact the supply chain to changing preferences and needs of end-users. Competition within a market, for example the content/application market, may also have a strong impact on how electronic communications develop in ways which cannot always be foreseen.

At the same time, it is evident that most of these technologies entail increased demand for bandwidth, capacity, and higher performance in terms of QoS. In this sense, VHCN and in particular fibre rollout is a necessary precondition of most technological developments to be implemented and further developed.

Another open question relates to how these developments will impact the environmental footprint of the telecommunications sector, since some developments promise to reduce the impact of the environment both within the telecommunications sector and in other sectors, while others may lead to increased land usage, water consumption or resource extraction.

In addition to the above aspects, other issues need to be factored in when considering the importance of future technologies:

[41] Network virtualization; Open networks / network disaggregation and cloud RAN; Edge cloud; Artificial intelligence; Terahertz communications (6G); Low orbit satellite communications; Super precise geo-location; Blockchain technology; Quantum encryption; Longer lasting battery technology; Non cellular technologies

[42] ibid

- *Interdependencies among technologies*

Interdependencies, or synergies, may exist among the various technologies. These operate on different layers of the Internet ecosystem. For instance, edge and cloud computing are relevant enablers for some AI solutions and VHCN for all of them. Thus, these enablers are the key to allowing other technologies to reach their full potential. Concurrently, AI may, in turn, be very relevant as an enabler of cloud/edge solutions and other network developments related to 6G.[43] Other example is how Open RAN networks, fibre and cellular technology provide the infrastructure for applications such as AI, blockchain, encryption.

Moreover, different technologies may need to share the same resources, mostly bandwidth and network capacity, which in some cases affects how these technologies can be used (e.g., in the case of a shared medium). As a result, the uptake of technological developments is indirectly influenced by their availability. Lastly, fixed and mobile networks may need to be differentiated in some cases . These two types of technologies are used in distinctly different ways while also being interdependent (i.e., mobile networks still require fixed backhaul, and the majority of international connectivity is provided via submarine cables).

- *Some of the technologies partially overlap*

Cloud RAN may be envisaged as a form of network virtualization. Other types of edge cloud, including NaaS solutions, may also be considered a subset of network virtualization.

- *The technologies listed in the questionnaire serve different purposes*

The listed technologies serve different purposes. They are, in many of the cases, complementary to each other. Furthermore, their importance varies depending on the specific use case. 6G, for example, is expected to facilitate enhanced QoS and other technical features that will pave the way for more innovative products. Conversely, LEO satellite communications may, in some circumstances, be used to ensure connectivity in remote areas and bridge the digital divide in terms of access.[44] So, the weight assigned to a particular technology varies depending on the specific use.

Opportunities of these technologies for ECS (questions 2 and 12)

New technologies may unleash the following advantages for ECN/S providers:

- New innovative products and use cases increase the demand for enhanced connectivity;
- New opportunities for differentiated offers and new products, moving from bundled products to customized services
- Evolution towards an ecosystem:

[43] See, for instances, https://digital-strategy.ec.europa.eu/en/news/europe-launches-second-phase-its-6g-research-and-innovation-programme

[44] See, for instance, BEREC Report on Satellite Connectivity for Universal Service. https://www.berec.europa.eu/en/document-categories/berec/public-consultations/draft-berec-report-on-satellite-connectivity-for-universal-service

  - unleash potential to develop their own generative capacity towards a diversified and integrated offer at both wholesale and retail level;
  - potentiate their role as enablers of IT and data processing based services;
  - develop a business strategy more innovation driven and agile;
- CAPEX/OPEX reduction enabled by some of these technologies.

Besides the general enhancement of QoS promised by new access technologies, which could help create a market for premium access offers, the deployment of standalone 5G comes with the availability to provide access with more specific QoS parameters and more quality guarantees for services and end-users. These features are likely to develop a market for tailored offers that might induce new revenue sources. Such revenues are likely to be found in specific markets for verticals and professional users but could also arise from consumer use cases (e.g., AR, gaming, entertainment).

However, this transformation also signifies the market entry of new actors in the vendor business (mainly hyperscalers). These new actors could also become challengers for some revenue lines of the operators, as they are active in several parts of the ecosystem where telecom operators are active. In turn, telecom operators could also use their newly acquired cloud infrastructure or partner with cloud providers to spread out into new segments of the ecosystem. From a general perspective, it could lead to a shift in the internet ecosystem with actors that will be able to integrate infrastructural and applicative part of the networks. BEREC expects that the question as to which regulation will be relevant for these actors is still open and deserves further analysis in the years to come.

There are also developments which affect the costs incurred by operators and thus have an impact on their business models. For instance, the development of network virtualisation promises to offer a better cost efficiency than traditional networks. Network virtualisation enables the hosting of different network functions or parts (e.g., core networks but also access parts like RAN and Edge) on a cloud platform, which comes at a lower cost than setting up a fully-fledged network. Such a development also means a gradual shift away from a very capital-intensive business model to a more OPEX-centric cost base. This transformation also enhances the possibilities of network sharing between operators, which is another potential area for cost optimisation. However, the costs and processes for this transition are uncertain and may be challenging.

AI systems could also have a big influence on making networks more efficient. BEREC has showcased several use cases which use AI systems to optimise QoS, plan networks, allow for dynamic spectrum sharing or handle customer queries. As mentioned further above, AI adoption by ECN/S providers it is still in an early stage and these providers expect AI systems to be used in their operations at large scale in the next six to ten years.

Challenges and urgent problems to unleash the ECS potential (questions 2, 3 and 12)

In Europe, digital infrastructure for connectivity and environmental sustainability are intertwined goals. Digital infrastructure is among the objectives set out by the 2030 EU

Digital Compass[45] and it is also essential to achieve the mission set out by the European Green Deal.[46]

Significant investments will be required to meet these policy objectives and enable the development and implementation of new technologies (AI/ML based solutions, cloud and edge services, digital twins, AR/VR, etc.) in Europe supported by VHCN for the benefit of businesses, citizens, and society in general. Those investments may be challenged by several factors of different nature: economic, technical and competition related ones.

Economic factors

- *Macroeconomic context*

The current macroeconomic context features uncertainties related to energy shock and record high inflation that have slowed down the European recovery after the pandemic crisis. The EU Winter 2023 Economic Forecast[47] foresees that "*monetary tightening is therefore set to continue, exerting a drag on investment. Weakness in consumption is set to persist in the near term as inflation keeps outpacing nominal wage growth*." The digital sector is not alien to these general developments. The increase of cost of capital entails additional efforts compared to previous years.

Technological investment has very complex character, since it depends not only on research and technological progress, but also on a global and local economy and general situation in the world. According to the European Investment Bank Report,[48] in the last two years a series of shocks have battered the European economy, which include COVID-19, inflation, increase in energy prices, and the war in Ukraine. This all impacted investments and research capabilities of firms. Nevertheless, the conclusions of the Report are optimistic in as much as digital firms generally perform better overall than non-digital firms, tending to be more innovative and productive.

- *Return on investment (ROI) and demand uncertainties*

Investments in new services and technologies may face additional uncertainty regarding the return on investment compared to other types of investments. Although their potential is not questioned, the concrete use cases enabled by future technologies are still to be developed. However, fully developing and implementing those use cases require that the investments are made beforehand while investments are, in turn, justified by the range of use cases that enables. Therefore, the roll out of new technologies require that this is done concomitantly with the development and uptake of the use cases.

Moreover, once this "chicken and egg dilemma" is solved, networks are deployed and innovative products are commercialized, there is a risk that those might not find the expected user demand. This may be not only because those new products have not been tested in the market before, but also because the uptake of complex digital products

[45] BEREC Press Release BEREC will continue promoting full connectivity to strengthen Europe's digital sovereignty https://www.berec.europa.eu/en/document-categories/berec/berec-press-releases/press-release-berec-will-continue-promoting-full-connectivity-to-strengthen-europes-digital-sovereignty

[46] BEREC Report on sustainability in https://www.berec.europa.eu/system/files/2022-07/10282-berec-report-on-sustainability-assessing_0_3.pdf

[47] https://economy-finance.ec.europa.eu/economic-forecast-and-surveys/economic-forecasts/winter-2023-economic-forecast-eu-economy-set-avoid-recession-headwinds-persist_es

[48] https://www.eib.org/attachments/lucalli/20220211_economic_investment_report_2022_2023_en.pdf

depends on the willingness of the users to invest in digital transformation in addition to the right understanding of the users' needs on the providers' side. BEREC's Report on the 5G Ecosystem develops on these two issues in relation to verticals.

- *Uncertainty regarding investments capitalization*

In its 5G Ecosystem Report, BEREC underlines the role of traditional market players in the rollout of 5G networks and in fostering the demand of verticals for 5G based products. However, the convergence of IT and telecommunications competences needed for the delivery of 5G products may entail new roles, which could also be undertaken by new players as 5G evolves and reaches maturity. These new roles in the 5G ecosystem include new equipment suppliers, system integrators and managed service providers (MSPs), cloud network providers and 5G verticals. In such a scenario, a possible outcome could be that new players may specialize in the provision of platform operation as traditional players undertake the network domain operation. Additionally, the design of specialized products for verticals is expected to lead to different combinations of partnerships among all players. Such scenario may lead to uncertainty regarding how investments will be capitalized on and who will be able to capitalise on them, and, ultimately, increase investment uncertainties overall.[49]

- *State Aid*

Public support plays a very important role for reducing the digital divide where commercial operators have no incentives to invest. In the current context, the EU is committed to a twin digital and green transition to mitigate the impact in the economy of the COVID pandemic and aims and has foreseen that 20% of the Resilience and Recovery Facility will be dedicated to digital objectives. However, this is a last resort instrument to address market failure and needs to be carefully designed to avoid negative impact in competition[50] and ensure the best management of public funds. As BEREC has repeatedly stated, competition drives investment.[51] Therefore, a healthy competitive ecosystem must be ensured and prioritized to, among other public interest objectives, promote the required investments in networks and innovation.

Technical factors

Technical factors relate to the need of new inputs and expertise (IT, data analysis, AI, etc.) to benefit from the technological developments. In particular, the convergence of the IT sector with electronic communications infrastructure and services entails new specific competencies and skills of the personnel of the traditional ECN/S stakeholders. For instance, data scientists or software developers are increasingly becoming indispensable for ECN/S providers in areas as diverse as network management and customer insights. A new working culture may be required, which is challenging for

[49] See the 5G Ecosystem Report for further development on this matter.
[50] See, for instance, BEREC response to the public consultation on the draft revised European Commission Guidelines on State aid for broadband networks https://www.berec.europa.eu/en/document-categories/berec/others/berec-response-to-the-public-consultation-on-the-draft-revised-european-commission-guidelines-on-state-aid-for-broadband-networks
[51] https://www.berec.europa.eu/en/document-categories/berec/berec-press-releases/press-release-on-berec-papers-on-the-review

incumbent actors. In addition, the availability of assets other than connectivity are required for some of these technologies as, for example, the reliable data for AI.

Competition factors

- *Big tech companies[52] can challenge the openness and contestability of the internet ecosystem*

Digital infrastructures enable a series of structural changes which affect both network architecture and services and are also driving developments in the data economy. Big tech companies offering a variety of different services, including core enabling services (cloud, app store, search engine, online advertising, ...), are the main actors in this transition. The services they develop are based on data processing and require connectivity as a basic resource to reach users. As shown in BEREC Report on the ex-ante regulation of digital gatekeepers[53] and in BEREC Report on the Internet Ecosystem,[54] these big tech companies can act as gatekeepers or bottlenecks and have the ability to affect openness and contestability of the internet ecosystem.

The EU legislators have recently took action to address some of these concerns. Namely, the DMA was adopted to ensure fair and contestable markets in the digital sector and the Data Act was proposed to introduce measures for a fair and innovative data economy.

Moreover, the BEREC Report on the Internet Ecosystem identified potential bottlenecks in terms of applications and services, and also discussed the risks which exist in this value chain for any actor at the levels of access and/or provision of content and applications. BEREC's assessment revealed that big tech companies have traditionally provided services on the client and server sides of the internet ecosystem, and, in recent years, have entered into the internet infrastructure-related elements. The analysis of the competition dynamics of the internet ecosystem's elements showed that there are several issues and potential bottlenecks especially concerning CDNs, cloud computing, enabling and discovery elements, devices, attention-intensive applications, e-commerce, instant messaging and the Internet of Things (IoT).

- *Large CAPs are present across the Internet ecosystem*

BEREC emphasises that the regulatory action on specific digital platforms should ensure that digital environments are open, allowing them to develop as an engine of innovation, and that users are sufficiently empowered. This includes ensuring that the ability of end-users to access and/or provide content and applications is not hampered on the application layers where these digital platforms operate. Furthermore, the BEREC Report on the Internet Ecosystem underlined the investments made by some large CAPs in network infrastructures described above. As a result, big tech companies enlarged their provider-specific ecosystem and are present across practically all of the elements in the internet environment, so that they can often leverage their position among different services and products, e.g., partnering with ECN and ECS providers, but also directly competing with them (e.g., providing NI-ICS).

[52] Alphabet, Apple, Meta, Amazon and Microsoft
[53] BEREC Report on the ex ante regulation of digital gatekeepers
[54] Cfr. BEREC Report on the Internet Ecosystem

- *The Internet ecosystem's elements are largely dominated by few players organised in provider-specific ecosystems*

The analysis also shows that some of the Internet ecosystem's elements are largely dominated by few players organised in provider-specific ecosystems. While such companies were initially providing services/products complementary to telecom operators, their entry into ECN/S markets and the impact on the current regulatory framework deserves to be further analysed. Moreover, the analysis of the evolution of CDN and IP interconnection markets also appears to be crucial and closely connected with ECN/S markets. A small number of digital platforms have reached a position allowing them to shape and restrict both the competition dynamics on different elements of the Internet ecosystem and the relative openness under which content, services and information can be accessed and shared.

- *Different regulatory frameworks*

Sectoral electronic communications regulation has proven to be a model of success. It has brought up competition while ensuring investments and innovation, opening the European markets and ensuring end users' rights. During the last 30 years, electronic communications regulation has evolved, and NRAs have gained experience and developed a deep knowledge of the sector due to constant monitoring and in-depth exchange with all the stakeholders and within BEREC. Electronic communications regulation is a mature and developed regulatory framework that has proven its ability to adapt to market developments. Obligations on ECN/S providers encompasses not only a well experienced ex-ante competition set of rules but also the guarantee universal coverage, end user rights, open internet related measures, international roaming, etc.

As mentioned above, regulation both at national an EU level is currently being developed to tackle the emerging issues identified with regard to the provision of other digital services (e.g., DMA, DSA, Data Act, etc.). All of these regulatory instruments are extremely relevant and provide an important tool for addressing some of the challenges posed by the digital ecosystem. However, it will require years until this new framework reaches maturity. BEREC has supported the objectives of these regulatory initiatives and is fully committed to contributing to their successful implementation.

Impact on the Single Market (question 32)

The questionnaire includes a question regarding the technological developments that could further promote the digital single market.

- *Services are increasingly global*

BEREC notes that technological developments are usually not only favouring the European single market for services but impact on a global scale, like OTTs and apps. That is, services provided over the Internet are global by nature.

It is also worth mentioning that AI systems may have an impact on the single market, in that the functionalities they enable could promote closer integration. For instance, the advances in natural language processing may facilitate communication not only between end-users, but in particular between public sector organisations and end-users who do not (yet) speak the local language(s). As noted in the BEREC Report on AI, this offers an opportunity to improve the services provided by the public sector and make them more accessible for people from any part of the EEA at little additional cost.

- *Providers decide not to provide EU services based on commercial reasons (not due to technical or regulatory circumstances)*

Although networks, with the exception of satellite communication, still have a national footprint (or even, in many cases, subnational), this is not an obstacle for the provision of cross-border services. Even if operators do not have full EEA coverage, the currently available regulatory and/or commercial options are fit for purpose and allow building EEA offers. Importantly, even at national level it is not necessary for an ECN/S provider to have full coverage in order to be successful.

The reasons not to provide EU offers are not technical or regulatory but rather commercial: they relate to different telcos' business strategies in the Member States or the uncertainty of the demand for such services, cultural differences, etc... That is, differences across Member States are mainly due to the diverse market circumstances, not to technical, legal or regulatory barriers. In this context, the establishment of homogenous wholesale access products on SMP operators would be neither suitable nor justifiable. BEREC provides a more effective and realistic way for the EU convergence duly considering national circumstances by means of soft law and delivering common positions, exchange of best practices and issuing common definitions for instance, in the context of roaming regulation.

- *Some technical developments can contribute to bridging the digital divide*

From the technical perspective, interoperability and deployment of connectivity based on heterogenous networks may support the Single Market. BEREC strongly supports all measures aiming to reduce or eliminate the digital divide. For this reason, technological developments to this effect should be supported. In this respect, BEREC notes that satellite connectivity may play a role in improving coverage in remote areas, in particular because more satellite networks are expected in the coming years. In 2022, BEREC published its Report on satellite connectivity for universal service,[55] where it discusses the suitability of satellite connectivity for universal service provision as well as expected developments. The potential advantages and existing challenges of satellite communications, in particular Low Earth Orbit satellite networks, were recently discussed by stakeholders at a BEREC workshop (summary to be published at P3).[56] Apart from satellite communications, other measures can contribute to reducing the digital divide, as explored in the study commissioned by BEREC[57] and during the workshop hosted by BEREC.[58]

According to information published by stakeholder[59], recently standardized 5G non-terrestrial networks (NTN) modem technology for direct communication between smartphones and satellites, can also contribute to communication across the EU -

[55] https://www.berec.europa.eu/en/document-categories/berec/reports/report-on-satellite-connectivity-for-universal-service
[56] https://www.berec.europa.eu/en/events/berec-events-2023/berec-workshop-on-secure-and-reliable-connectivity-from-leo-satellite-fleets
[57] https://www.berec.europa.eu/en/document-categories/berec/reports/study-on-post-covid-measures-to-close-the-digital-divide
[58] https://www.berec.europa.eu/en/document-categories/berec/reports/summary-report-on-the-berec-workshop-on-digital-divide-8-june-2022
[59] https://news.samsung.com/global/samsung-electronics-introduces-standardized-5g-ntn-modem-technology-to-power-smartphone-satellite-communication

especially in remote areas. As a result, over the next few years we might expect more flexible use of network resources, and the promise of use cases for 5G and (maybe also) 6G being realised using a heterogenous or mix of networks, so long as the principles of technical sovereignty, security and reliability are maintained for the benefit of the Single Market.