

# Regulatory Policy for Broadband:

## A Response to the “ETNO Report’s” Proposal for Intervention in Europe’s Internet Ecosystem

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## Executive Summary

Achieving the European Union’s (EU’s) ambitious 2030 connectivity targets enshrined in the proposed *Path to the Digital Decade*<sup>2</sup> program will require significant additional investment, and most of that investment will be provided by a complex array of for-profit enterprises funded by private investment capital. There will also be a need for public subsidies to address digital divides and ensure adequate access to network services, including last-mile broadband access, for users where private provisioning of such services is uneconomic. Addressing those challenges will require focused regulatory interventions to provide targeted subsidies. Additionally, regulatory oversight will be needed to ensure efficient operation of EU digital infrastructure without any abuse of market power among the diverse players engaged at diverse points of the value chain. Pursuing those goals is wholly consistent with the design of light-handed regulatory regimes: frameworks that rely first on market processes to direct behavior and only secondarily on regulatory interventions to address problems.

In May 2022, Axon Partners Group Consulting published a report commissioned by the European Telecommunications Network Operators’ Association (ETNO)<sup>3</sup> (hereafter: “ETNO Report”). The ETNO Report proposes (among other measures) the introduction of a new interconnection regime to ensure “a fairer balance between tech giants and telecom operators”, thus advocating for a strong change in the direction of regulatory policy in the EU. The ETNO Report embraces the EU’s 2030 connectivity targets but argues that those goals and the benefits they promise will be put at risk if a subset of large, primarily U.S. OTTs fail to contribute significant funds to pay for Internet Service Provider (ISP) investments. In building its argument, the ETNO Report utilizes a “stick/carrot” logic, suggesting that failure to act as it recommends will doom the connectivity targets.

**This paper offers a response to the ETNO Report.** We explain why the ETNO Report and the recommendations it advocates fail to make a useful contribution to important policy issues confronting policymakers in the EU (and indeed globally). In doing so, we explain how the ETNO Report is unhelpful in informing regulatory policy related to provisioning the infrastructure needed for businesses and citizens in the EU to fully participate in the digital economy. Proposing an alternative solution is beyond the remit of this paper. It would also dignify the overly simplistic approach that is the ETNO Report’s fundamental flaw, thereby detracting from more meaningful consideration of policy options and evidence-based contributions.

The ETNO Report **oversimplifies the environments for infrastructure investment, interconnection, and content delivery.** We show how the ETNO Report’s “stick/carrot” narrative is flawed at multiple levels.

- *First*, the ETNO Report **fails to clearly identify a regulatory problem.**
- *Second*, **the analysis of the effects of regulatory action (or inaction) is fatally flawed.**
- *Third*, and finally, **the evaluation of the remedies proposed is likewise fatally flawed.**

We explain that each of the elements contains logical, methodological, and analytical failings that together deny justification for the ETNO Report’s aggressive regulatory recommendation.

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<sup>2</sup> For example, Article 4(1)(2)(a) proposes the following digital target: “all European households are covered by a Gigabit network, with all populated areas covered by 5G” (EC, 2021, p. 24).

<sup>3</sup> Axon Partners Group (2022). Available here: <https://etno.eu/library/reports/105-eu-internet-ecosystem.html>

Although the ETNO Report superficially addresses important issues confronting EU policymakers that we and other scholars, analysts, policymakers, and industry stakeholders are actively engaged in discussing, the **ETNO Report's analysis of the forces and changes confronting the Internet ecosystem is overly simplistic and fails to make a helpful contribution to identifying sound policy options.** It does not provide the necessary evidence to justify the drastic policies it advocates. Furthermore, it fails to provide evidence of harmful asymmetry and of market failure from alleged excessive OTT bargaining power, which would be required to justify the proposed substantial change in regulatory policy direction.

An analysis of regulatory options needs to account for the fact that the future of the digital economy will be increasingly dependent on digital infrastructures and products of all kinds: broadband, clouds, AI apps, post-PC devices, and generalized automation of processes. The digital economy will be the product of the co-evolution of edge providers and ISPs and will require digital connectivity to all kinds of complementary resources, not just basic transport. However, the ETNO Report's focus is as if the only investment challenge relates to bit-transport in last-mile ISP access network facilities. This **focus is clearly a mischaracterization of the overall challenge regarding requisite network infrastructure.** It inappropriately relies on an overly narrow abstraction of the role of complementary investments and innovation by different ecosystem actors.

Even though changes in industry structure and bargaining positions have and will continue to occur, including (new) issues with regard to interconnection, **the ETNO Report neither provides useful evidence nor does it make a coherent or compelling case for the swift introduction of the proposed interconnection regulation.**

As the EU is advancing an aggressive and comprehensive agenda, the regulatory frameworks they adopt may provide a template and guidance for the rest of the world – to both those who choose to follow and those who choose another path. **In view of this responsibility for the EU and beyond, the importance of the topic under consideration, the EU should not hastily follow the overly simplistic policy change recommended by the ETNO Report.** It is widely unfounded on evidence and more likely to harm progress if adopted.

# 1. Introduction

In May 2022, Axon Partners Group Consulting published a report commissioned by the European Telecommunications Network Operators' Association (ETNO)<sup>4</sup> (hereafter: "ETNO Report") (Axon Partners Group, 2022). The ETNO Report proposes (among other measures) the introduction of a new interconnection regime to ensure "a fairer balance between tech giants and telecom operators." At its core, the ETNO Report recommends that European Union (EU) regulators adopt Internet interconnection rate regulations. ETNO recommends that regulators require a subset of large, primarily US, over-the-top providers (OTTs) of Internet content and application services pay for regulated interconnection (or termination) to Internet Service Providers (ISPs) for delivering traffic to ISP broadband Internet access service subscribers. To date, in most countries, Internet interconnection has not been subject to such access regulation. Globally the trend is for Internet interconnection arrangements to be subject to commercial negotiations resulting most often in settlement free arrangements. Hence, the ETNO Report advocates for a strong change in the direction of regulatory policy in the EU that if adopted would significantly disrupt the Internet ecosystem.<sup>5</sup> South Korea has introduced an interconnection regime and sending-party-network-pays (SPNP)-style "network use fees" that has resulted in multiple court cases and analysts have already identified a range of undesirable impacts.<sup>6</sup>

This paper offers a response to the ETNO Report. We explain why the ETNO Report and the recommendations it advocates fail to make a useful contribution to important policy considerations confronting policymakers in the EU (and indeed globally). In doing so, we explain how the ETNO Report is unhelpful in informing regulatory policy related to provisioning the infrastructure needed for businesses and citizens in the EU to fully participate in the digital economy. Proposing an alternative solution is beyond the remit of this paper. It would also dignify the overly simplistic approach that is the ETNO Report's fundamental flaw, thereby detracting from more meaningful consideration of policy options and evidence-based contributions.

The remainder of this paper is structured as follows. Section 2 discusses the growth of the Internet and its evolution that have given rise to today's policy context, providing a more realistic and nuanced portrayal of the current state and future direction in telecommunications and Internet infrastructure than underlies the ETNO Report's analysis. Section 3 focuses on identifying the failings of the ETNO Report, setting forth our high-level and more detailed criticism of the ETNO Report's deficiencies. The focus is on pointing out what is wrong with the report and why it fails to make a compelling case for the regulatory policy change it advocates. Finally, Section 4 summarizes key conclusions and offers thoughts on the appropriate regulatory policy for where the Internet ecosystem is and should be going.

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<sup>4</sup> ETNO members are mostly large (legacy) telecom operators, or as ETNO describes it on its website, "Europe's main telecom operators" (ETNO, 2022). ETNO members thus only represent a subset of European Internet Service Providers (ISPs) that offer broadband Internet access services to EU citizens and businesses. In this paper, we use the term access ISP to describe all providers of broadband Internet access services, which are a more diverse group with interests that may not be aligned with those of ETNO members.

<sup>5</sup> To the extent policymakers have sought to regulate Internet interconnection, the focus has been on prohibiting some forms of selective and mandatory payments for content delivery as part of so-called network neutrality regulatory frameworks, intended to protect the open Internet and non-affiliated third-party content and application providers against potential abuses of market power by access ISPs that might manifest as harmful traffic and/or price discrimination practices (i.e., "non-neutral" traffic management). See Stocker et al. (2020) for an overview of the state of network neutrality regulation.

<sup>6</sup> For example, see Park & Nelson (2021), Gahnberg et al. (2022), and WIK (2022). See also Footnote 82.

## 2. Internet and Broadband Evolution in Context

### Highlights

- **From public utility regulation to more market-based approaches.** Legacy telephone networks were heavily regulated as public utilities. In today's Internet ecosystem, the complex and evolving mix of services, technologies, and commercial enterprises that need to interoperate renders the legacy public utility model unsuitable and inoperable. The ascension of broadband communications has given rise to a complex, dynamic, and diverse Internet ecosystem that necessitated a transformation in how digital networks and services are regulated and caused a shift toward more light-handed and market-based regulatory approaches guided by technology and service neutrality principles.
- **From siloed single-purpose telephony networks to general-purpose broadband networks.** The evolution from special-purpose telecommunications to general-purpose broadband networks has contributed to an increased variety of digital content and services distributed by a variety of players via different technologies and with diverse business models. While the ISPs are key participants in enabling the broadband Internet ecosystem, the realization of its potential and the computing and network infrastructure needed to support it depends on and is provided by many other key players that need to cooperate to ensure their products and services may interconnect and interoperate in order for end-to-end services to be feasible and customer experience to be good and stable.
- **The provision of online services is based on an amalgam of interconnected computing and communications resources.** These are owned, operated, and controlled by different entities that are often direct competitors as well as customers of each other when it comes to the exchange of traffic and the provision of Internet-based services. The amalgam of these resources is complex and constantly evolving; delivery chains and the contractual fabric of service delivery – including interconnections – are subject to ongoing change and in constant flux.
- **The way the Internet is interconnected and how content and applications are delivered have undergone seismic shifts that have changed the economics of interconnection.**
  - *First*, the Internet has become more densely meshed as networks interconnect and exchange traffic directly (among each other), at more locations, and closer to end users.
  - *Second*, data centers and highly distributed serving infrastructures bring storage and compute as well as content and applications closer to end-users, increasingly even into the networks of access ISPs.
  - *Taken together*, these developments have produced a flatter, more densely-meshed, and much more capable Internet (in terms of processing, transmission, and dynamic adaptability capabilities). They have shortened delivery chains, enhanced load balancing capabilities, and rendered network traffic more localized, thus contributing to improved network resiliency, reliability, and utilization, as well as customer experience and security. Consequently, they have tremendously expanded interconnection opportunities and options for routing and managing traffic (in a cost-efficient fashion) and, therefore, fundamentally changed the economics of interconnection.
- **In recent years, large edge providers (including OTTs) made significant efforts to expand their footprints of data centers, points of presence, highly distributed serving infrastructures, and private wide area networks.**
  - These efforts have fundamentally contributed to providing the data storage and cloud computing infrastructure that has supported the changed topology, traffic management, and data processing capabilities that characterize today's much more capable Internet.
  - As more large OTTs have deployed more servers within access ISP networks from which they serve content to requesting end users, the role of interconnection and routing within the Internet ecosystem has changed substantially.
  - Whereas OTTs have (directly or indirectly) invested in transport infrastructures, investments in large-scale private networks that combine distributed cloud infrastructures and private high-capacity links supplement legacy Internet routes and contribute to yielding more agile,

- customizable, evolvable, and cost-efficient service provision, thus facilitating meeting expanded and more QoS restrictive networking and computing demands.
- These investments and innovations have brought many benefits to businesses and citizens that rely on the Internet ecosystem by helping to reduce end-to-end overall infrastructure investment requirements and imply cost saving potentials – also for ISPs. At the same time, such developments have reduced transit revenues for many ISPs, challenging legacy business models.
  - **ISPs have adapted to these changes by expanding the range of services they offer and shifting their business models.** They have enhanced revenues, for example, by offering their own CDN and data center services, offering new IoT or home management services (e.g., security, smart home monitoring, etc.) or mobile services as well as entertainment and OTT services (thereby often partnering with large OTTs). They also provide private networking infrastructure and services to businesses.
  - **The next phase in the digitalization process will see the integration of a complex array of networked digital computing and sensor led smart services into our lives.** Quality of Service in this digital networked future enabled by 5G will depend on the cooperative investment of many different entities within a complex digital ecosystem. These will include upstream ISPs, consumer home network systems, computing hardware and software makers, cloud service providers, and the applications and content service providers.
  - **An appreciation of the more complex strategic landscape confronting last-mile access ISPs and other key providers of Internet infrastructure and services is necessary.** Only then can the infrastructure challenges on the path to our digital future be meaningfully assessed.
  - The **ETNO Report grossly oversimplifies and fails to adequately capture** (i) the current state and the evolution in the markets for interconnection, content delivery, and broadband infrastructure over the last two decades; (ii) the diversity of investment needs, the contribution made by different key providers (e.g., OTTs), and their role in meeting (and impact on) overall requisite network investment; and (iii) the co-dependent relationship between edge providers (including OTTs) and ISPs.

In this section, we provide an overview of the history and evolution of the Internet ecosystem. We describe the developments that have contributed to providing the essential infrastructure for our digital economy and explain how the ecosystem has expanded and grown more complex. This complexity is reflected in an evolving range of relevant stakeholders (e.g., network operators, providers of clouds, data centers, applications, and devices). This expanded set of stakeholders is co-dependent and jointly responsible for making the investments in infrastructure and services that are necessary for the ecosystem to produce economic value. As the technology and markets for telecommunications have grown and become more complex and integral to our digital economy, the regulatory policies needed to manage telecommunications markets have evolved toward more market-based, light-handed regulatory approaches.

## 2.1. From Telephone to Broadband Internet: The End of Heavy Regulation

The evolution from telephony to data networking has been one of expanding markets and options for delivering services: from wired to wireless, fixed to mobile, and terrestrial to space-based; from narrowband, basic telephony to general-purpose broadband data networks. This evolution was enabled by rapid technological progress in the hardware and software that enables telecommunication and computing services. Ensuring that the separate components can interconnect and work together to enable end-to-end, high-quality services is a complex technological feat that has increasingly relied on the evolution from special-purpose telecommunications hardware (i.e., switches and transmission gear) to general-purpose computing hardware supporting ever-more-capable software systems. As technological advances have



enabled expanded digital services, improved quality, and reduced costs, the markets and value chain of providers engaged in providing the digital infrastructure have grown more complex and varied. Those changes have necessitated a transformation in how digital networks and services are regulated.

### 2.1.1. Natural Monopolies and Regulation: The Telephony World

Telephone networks exhibited many features of natural monopolies: average costs fell as networks grew. Those economics were byproducts of the cost structures for building telecommunication networks that depend heavily on the deployment of fixed facilities that need to be shared to make telephony services economically viable.<sup>7</sup> Average costs per unit (as a function of traffic) fall significantly because of scale and scope economies. Moreover, because most of the costs are fixed (i.e., associated with the capacity of the network) and *not* traffic-sensitive, the incremental costs of handling additional traffic are relatively small and close to zero.<sup>8</sup> These economic cost effects are most apparent for local, last-mile networks, and supported the legacy view that those local telephone networks were non-contestable natural monopolies.<sup>9</sup>

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<sup>7</sup> Telecommunication networks are designed to take advantage of statistical multiplexing opportunities that arise because end-user demand is not correlated in time (i.e., users do not generally make telephone calls to the same places simultaneously) and hence facilities can be sized to handle peak usage (i.e., the maximum amount of user traffic that needs to be carried along a network path). The requisite peak capacity – and hence the network cost – is substantially less than the aggregate traffic that the network carries since most of the user traffic is off-peak and can share the same facilities based on the statistical properties of the traffic. In a recent study commissioned by Netflix, Abecassis and Daly (2022, p. 16, Footnotes omitted) provide current numbers for UK access ISP British Telecom Plc (BT) and state: “It is important to note that, overall, peak traffic on fixed broadband networks remains very significantly below the theoretical speed and capacity of access networks. For instance, BT in the UK disclosed that average peak traffic increased to 25.5Tbps at its busiest period during 2021, up by 12% from the previous year, or two-and-a-half times the 2018 level. On a per end user basis, we estimate that this represented less than 3Mbps per customer in December 2021, significantly below the average (peak) speed of fixed broadband connections in the UK, which Ofcom estimated was just over 50Mbps in 2021.” It is noteworthy that this was during a period when we were still witnessing higher than average traffic, due to the Covid-19 pandemic; nevertheless, the network was more than able to cope. As we will explain later, in today’s Internet, edge-caching of content that does not change (e.g., most entertainment video) can significantly reduce the need for network capacity.

<sup>8</sup> For a telephone network to be able to handle its first telephone call, lots of upfront investment to install the capacity must occur first. If the service is to be provided via a fixed (typically, wired) or mobile (with wireless last-hops) network, the wires and supporting equipment (e.g., antenna sites) must pass or provide coverage for every potential home in the neighborhood that will be eligible for service before a single customer household can begin using the service and generating revenue for the service provider. Because the installation costs of outside plant facilities are significant and are subject to significant scale economies, it is economically efficient to install significant excess capacity in advance of expected demand (growth). The costs of putting up the telephone poles, preparing conduit for underground wires, and planning the network are costs that do not vary significantly with the capacity and involve a large share of one-time costs. Consequently, most of the costs associated with provisioning telecommunication networks are not traffic sensitive – they are installed up front to meet expected future peak demand. Those costs are incurred whether *any* traffic is carried.

<sup>9</sup> Digging up streets, deploying telephone poles, and installing the wired infrastructure needed to support the local portion of end-to-end telephone networks was associated with what economists call “cost subadditivity” – cost structures that made it appear as if the lowest cost solution was to have the last-mile networks deployed by a single, or monopoly, provider (see, Baumol, 1977; Sharkey & Telser, 1978; or Sharkey, 1982). Moreover, it is worth noting that in contrast to the economics of greenfield investments in telecom/broadband where the roll-out takes place in previously unconnected areas, cost economies change in brownfield scenarios where infrastructure elements already exist, (e.g., ducts and ductworks exist from legacy telecom networks or other networks like utilities like water or electricity). In Europe, the relevant challenge is mostly how to upgrade existing networks rather than provide service to unserved communities. In this context, differences in the state of network deployments (e.g., with regard to the roll-out of fiber and 5G, topologies, and the existence and upgradability of legacy networks) crucially determine the upgrading paths and costs. See, for example, Briglauer et al. (2020).

To realize the potential (economic and social) value of telecommunication networks and telephony, the local networks needed to be interconnected to (and interoperable with) other local networks to allow anywhere-to-anywhere communications. To ensure that the local monopolies interconnected their networks to provide national, and ultimately, globally interconnected telephony services, regulatory authorities sanctioned the creation of heavily regulated national monopoly providers. Whether investor-owned as in the U.S. or Public Telephone & Telegraph companies (PTTs) as in Europe and most of the rest of the world, the telephone companies were regulated as public utilities.

The classic model for public utility regulation was heavy-handed. It was typically based on cost-based regulatory approaches (e.g., Rate of Return [RoR] regulation), by which regulators set prices at levels that enabled the monopoly provider to recover its costs, including earning a fair (but not supra-competitive) return on its invested capital and ensured that end-user pricing comported with social goals. Public utility regulators played a direct role in the choice of technology, the design of service offerings, and the setting of prices and business strategies for network providers. Historically, that meant setting retail prices so that long-distance, business users, and urban users paid higher prices to facilitate government-sanctioned implicit subsidies for local, residential, and rural calling to keep the prices for local calls low and generally affordable for all citizens.

In choosing the right technologies and in matching those to changing market and business conditions in global, national, and local markets, regulatory authorities are at a distinct disadvantage. The companies developing the technologies, deploying the networks and services, and interacting daily with their customers and with other technology/service providers have access to information and can respond to changing conditions with flexibility and capabilities that are unavailable and impossible to access for government regulators. Consequently, economists have long agreed that wherever feasible, allowing firms increased scope for decision-making and relying on competitive market forces to determine technology and product choices and prices produces better and more efficient outcomes than the sort of direct regulatory control that comes with public utility regulation. The information asymmetries, bureaucratic constraints, and administrative costs of regulatory decision-making add delays, costs, and misdirected resources that may be avoided when markets are allowed to operate efficiently under an approach of regulated competition (e.g., Bauer, 2013).

When the focus of telecommunications was on providing a single service – universal telephony – via purpose-built networks, the public utility model was workable. In this environment, where the services, product markets, and key industry participants that needed to be regulated were readily identifiable and separable from unregulated services, markets, and industry participants, the inherent inefficiencies introduced by regulatory interventions into markets were considered tolerable for a long time. In today's broadband Internet and digital economy, the complex mix of services, technologies, and commercial enterprises that need to interoperate renders the legacy public utility model unsuitable and inoperable. In the newer model, regulators shift toward allowing firms greater flexibility in decision-making and increasingly rely on market forces to direct strategic choices regarding network technologies, the design of products and services, and retail pricing and product marketing strategies. Modern regulatory approaches are more focused on specific problems (e.g., significant market power), more light-handed, and guided by technology and service neutrality principles.

Regulatory reform based on the transition towards more focused market interventions traces back to the 1970s, when it was already clear that end-to-end telephone service was not a natural monopoly and that facilities-based competition was possible across multiple components of the end-to-end networks. Facilities-based competition in end-user devices (i.e., handsets, business



Private Branch eXchanges [PBXs]), network equipment, and long-haul network services was economically viable and offered significant benefits. Those benefits included enhanced incentives to innovate and invest in improved services, while at the same time driving costs out of the system and thereby enabling lower retail pricing. In Europe, fully liberalized telecommunications markets in which legal entry barriers had been abolished have been generally reported to have performed better compared to pre-liberalization when legacy PTT business models and public utility regulation prevailed by simultaneously delivering improved quality services and coverage at lower prices.<sup>10</sup>

### 2.1.2. The Rise and Evolution of Broadband Internet Services

Even more important forces that pushed for liberalization were the technological advances and the associated market changes that helped transform the single purpose, “silo” telecommunication networks into general-purpose digital service platforms. Over time, digital services for enabling distributed access to computing resources for business and consumers and much richer modalities of electronic communications have emerged as essential services for modern social and economic interactions.<sup>11</sup> In the past, television, business data communication and computing services, and telephone services were provided via separate, bespoke networks. Today all of the legacy services, as well as a host of new telecommunication and media services, can be delivered via general-purpose digital networks, of which the best known is the Internet.

End-users connect to the Internet via the broadband access networks and services provided by last-mile ISPs, sometimes referred to as access ISPs or eyeball ISPs. While the ISPs are key participants in enabling the broadband Internet ecosystem, the realization of its potential and the computing and network infrastructure needed to support it depends on and is provided by many other key players that need to cooperate to ensure their products and services may interconnect and interoperate for end-to-end services to be feasible and customer experience to be good and stable.

In addition to cooperating, many of the key industry players also increasingly compete. The changes noted above enabled the rise of intermodal competition among ISPs and other value chain participants (e.g., between legacy cable television and telephone companies, between mobile and fixed network providers, and between end-user equipment and network operators<sup>12</sup>). This has shifted the focus of ISPs toward offering an expanded array of communication and computing services that extend far beyond plain old telephony services. Today’s users of digital communication networks want access to a suite of electronic communication services (e.g., telephony, email, chat, messaging, video conferencing), media services (e.g., access to streaming music and video, online gaming, and multimedia access to Web-hosted content and services such

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<sup>10</sup> For overviews and discussions of EU telecommunications regulations, see, for example, Knieps (2001), Bauer (2013), and Cave et al. (2019).

<sup>11</sup> Whereas historically, telephony was limited to real-time, voice-only communications between parties at fixed locations; today, mobile digital communications are possible using text, voice, video over a wide array of devices, media, and applications. In addition to legacy telephony, we now have multimedia messaging, video conferencing, chat, email, and social media modalities for digital communications.

<sup>12</sup> For example, the rise of PBXs as an alternative to legacy telco provided CENTREX services was an early example of how equipment vendors and network service providers competed. In many cases, the same companies that produced PBXs were also providers of the network equipment used by telephone companies in the provision of CENTREX services. In today’s broadband world, cloud-based services run from servers accessed via the Internet on thin clients like Chrome books and browser software compete with applications running on more capable end-user devices like smartphones or personal computers. Both depend on the broadband Internet but make use of it in different ways that may simultaneously or alternately offer complementary or competing alternatives to end-user consumers and businesses that rely on digital infrastructure to interact.

as social media and eCommerce), and general data-communication services (for file transfer, application access, cloud computing and storage, etc.). These services are provided by an expanded array of business enterprises that extends far beyond the legacy telephone or cable television network providers that remain, in many locations, the primary provider of last-mile digital connectivity sources for end-users to this wider world of digital communication and computing capabilities and services. Moreover, for the majority of end-users in most markets, those last-mile providers provide a bundle of digital services. That bundle typically includes access to television, telephony, and broadband Internet access services (as well as other services such as home automation, cloud storage, and other information services). Significantly, although those services often share and are provided over the same physical facilities, they are typically provided via separate logical networks.

The content and services provided by this expanded ecosystem have given rise to various revenue models including paid services (e.g., transaction-based or subscription-based) and non-paid services (e.g., advertising-supported or various forms of alternative data monetization), as well as hybrid forms that combine different elements. The ecosystem includes digital platform service providers such as Google (Alphabet), Amazon, Apple, Microsoft, Netflix, and Facebook (Meta), as well as thousands of other large and small providers that compete with a variety of business models across diverse goods and service markets. Increasingly, for almost every offline, physical good or service market, there is a digital online alternative or complement. For example, in the world of eCommerce retail there are general-purpose retailers like Walmart or Tesco, as well as niche retailers that specialize in specific product domains like clothing, housewares, or plumbing supplies. A similarly diverse array of service providers exists if one looks more narrowly at streaming media, for which there are multi-channel/multi-program aggregators like Netflix, Amazon Prime, HBO, YouTube, or Hulu, as well as niche providers of programming content like BBC, Fox News, or ESPN. There are hundreds of thousands of providers of free or pay-per-view content offering a wide array of video content services.<sup>13</sup>

The next phase in the evolution of the digital ecosystem is shaped by digital networking infrastructure and services. It promises to continue the trend towards the integration of a complex array of networked digital computing and communication services into our social and economic lives, and our collective reliance on the services that they make possible. The transition to 5G next generation networks will provide the infrastructure needed to realize Smart-X visions – where X is any activity that may benefit from access to and augmentation from on-demand access to networked computing, communication, and storage resources. The X can be replaced with Cities (Smart Cities), Grids (Smart Grids), Supply chains (Smart supply chains), Healthcare (Smart Healthcare), etc. The Smart-X goes well beyond today's smartphones to include a world of AI-augmented virtual reality (VR) and augmented reality (AR) applications.<sup>14</sup> Enhanced VR will enable digital twins to provide extremely rich virtual worlds in which to test what-if scenarios to facilitate

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<sup>13</sup> In addition to the content provided by service providers, individual end users actively participate as prosumers, thus not only consuming content but also producing content. Hence, they contribute with user generated content to the value creation of platforms like Tik Tok, YouTube, Facebook, and other platforms on the World Wide Web. Whereas such decentralized content generation provides unprecedented means for participation and content innovation, platforms that facilitate and manage end user activity are required to provide necessary resources and manage corresponding activity.

<sup>14</sup> Some of these applications may be edge-native and edge-dependent, therefore critically requiring low latency, high bandwidth connectivity and local (cloud) computing capabilities (e.g., Wang et al., 2019; Peterson et al., 2019). Examples include applications that provide immersive user experiences like those related to the “evolving paradigm” of the metaverse (Wang et al., 2022).

better monitoring and real-time management of critical systems.<sup>15</sup> Enhanced AR will bring the power of digital technologies for computing, sensing, and information aggregation to enable better situational awareness and control for Autonomous Vehicle (AV) operation, remote surgery by robots, and Internet of Things (IoT) systems.

Realizing this digital network future will depend on the innovation and cooperative investment of many different entities within the increasingly complex digital ecosystem. For example, the last-hop connectivity for many applications and devices will need to be wireless and that will require significantly expanding the number and coverage of small cells (i.e., antenna base stations that are close to the devices they are wirelessly connecting to). That will require significant investment to deploy the small cell infrastructure needed to support more demanding and capable last-mile/edge computing and connectivity infrastructure. That investment will be undertaken by ISPs and other local infrastructure providers like third-party antenna companies (like American Tower) and business enterprises that deploy infrastructure on/in their buildings and campuses.<sup>16</sup> Significant investment also will be needed by the providers of the many services that will make use of 5G networks.

Those services will call for more capable, reliable, and flexible networks capable of accommodating the more heterogeneous Quality of Service (QoS; typically characterized by performance metrics like latency, latency variations, or packet loss ratios) requirements of Smart-X and diverse multimedia services (e.g., video-conferencing, interactive remote business applications, gaming, as well as accessing streaming video and music entertainment services like those that account for a significant share of the traffic today). Ensuring that the QoS is realized will require the cooperation of many network components along the end-to-end path from the application/content provider to the end-user. The access ISPs are only one link in a chain that will include upstream ISPs, consumer home networks and computing hardware and software, cloud service providers, and the applications and content service providers. These are sometimes referred to as edge providers, although the terminology we prefer here is Online Service Providers (OSPs), which include but are not limited to the Over-the-Top Providers (OTTs) that are the focus of the ETNO Report.

Against this background it is critical to understand that the need for 5G is driven by the next generation of enhanced communication and Smart-X services. If all that was needed was to accommodate more streaming one-way video traffic over broadband connections, of the sort that comprises most of the traffic carried today over residential broadband connections, then one does not need to invest in 5G and the total costs of meeting continued growth of such one-way streaming traffic can be best addressed by expanded edge-caching of content. As we will explain in greater detail below, such edge-caching, greatly facilitated by Content Delivery Networks (CDNs), is how the Internet managed to scale to and accommodate the exponential growth in traffic that the rapid shift to OTT video streaming has already given rise to; and in which many OTTs invest to bring content closer to the end-user.

The Internet's ability to handle significant traffic growth and even unexpected surges in traffic was shown during the Covid-19 lockdowns. Arguably, this ability was significantly due to modifications in how the Internet is provisioned and the expansion of cloud infrastructure that had taken place

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<sup>15</sup> For example, digital twins can be used to test crisis or cyberattack response scenarios and for anomaly detection. Digital twins can be used to restore state in the event of a failure in the working system.

<sup>16</sup> Real-estate companies, stadium and theater operators, and other providers or owners of the places where people work, live, and congregate are increasingly engaged in providing access and support for the deployment of last-mile digital infrastructure and the resources needed for it to operate (e.g., sites, electric power, and in many cases, end-user owned computing and other digital technology resources used to deliver end-to-end services).

before the pandemic hit. Enabling those capabilities included significant investment by third-party cloud service providers and other content and application providers (among them large OTTs), and other businesses investing in cloud and networking infrastructure that helped more efficiently deliver content and services to end-users than previously via the legacy delivery model of the public Internet. Under the legacy model, content and application providers hosted their content on servers that were remote from their client customers. They had to ensure that their content could be delivered to the access ISPs that provided the last-mile broadband access connections that their client customers (i.e., end-users) used to access the Internet. The content was delivered across the network of interconnected ISPs that collectively comprised the Internet via peering interconnections and/or transit services that connected the servers with the end-users.<sup>17</sup> That model for managing Internet traffic ceased to be adequately descriptive of how traffic was managed on the Internet by around 2005. With the rise of broadband traffic that included a significant portion of cacheable content,<sup>18</sup> including streaming media (e.g., videos or music), it became efficient to host or cache the content closer to the edge of the networks and thus end-users to improve the customer experience (since that shortens the distance from where the content is stored to where the end-user displays the content and thereby bypasses potential upstream sources of congestion or other network disruptions) and reduce the traffic load on the overall network (making the capacity available to handle other traffic, including future growth).

## 2.2. The Interconnection Ecosystem – Flattening & Trends of Traffic Localization

The Internet is often described as a network of networks. These networks are heterogeneous, diverse, and managed independently. They differ regarding their technologies, topologies, policies, and sizes (e.g., their geographical footprint and number of connected customers), but also regarding their purpose – for example, access ISP networks differ from the networks of large edge providers. For end-to-end services to be feasible, networks need to interconnect and exchange traffic to make sure that traffic can flow from its source to its destination. That traffic could be a voice telephone call, a web query, a streaming video, or any other type of traffic that may be exchanged via the Internet. The source and destination nodes could be fixed or mobile addresses corresponding to end-users or servers located anywhere in the world.

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<sup>17</sup> Bilateral or multilateral peering facilitates the direct exchange of traffic between two or more networks. Whereas the reach is limited to the interconnecting peers' customers, most peering arrangements are settlement-free. Even though settlement-free peering implies that no monetary flows are exchanged between interconnecting parties, entities incur peering costs (including transport to the exchange point, colocation fees, peering fees, and equipment cost) (Norton, 2014, ch. 5). Whereas settlement-free peering is based on a peer-to-peer relationship, other forms of interconnection are based on customer-to-provider relationships. Transit describes a commercial relationship in which a transit provider sells access to the global Internet to transit customers. Whereas customers thus gain global reach and can send and receive traffic to and from the entire Internet population (i.e., all endpoints connected to the Internet), partial transit is a commercial arrangement in which this reach is restricted to a subset of the Internet population (i.e., a cone of prefixes and a specific subset of the address space) (see also Faratin et al., 2008). A variation of peering is paid peering, which is a means to account for cost asymmetries between peering partners. Whereas cost asymmetries are typically compensated by unidirectional side payments which Dietzel (2019, p. 11) identifies as a customer-to-provider relationship, Norton (2014, ch. 4) explains that paid peering can also be based on agreements in which one peers covers more of the peering costs than the other peer.

<sup>18</sup> Cacheable content is content that can be stored since it does not change over time. Movies and recorded music are obvious examples. Video-conferencing and live sports events are not readily cacheable since the data that they relate to is continuously changing in real-time. To manage the distribution of live-content, application and service providers use other strategies. For example, video-conferencing providers like Zoom use complex distributed routing algorithms and servers distributed around the Internet to enable their service to be robustly provided and deliver a high-quality experience even in the face of fluctuating aggregate Internet traffic loads. Such services may make use of private network facilities to bypass legacy routes on the public Internet that may be more prone to congestion. Also, legacy routes may not provide OTT providers with appropriate tools with which to control QoS.

Since the commercialization of the Internet in the mid-1990s, the hierarchical structure of the interconnection ecosystem has changed fundamentally. The way the Internet is interconnected and how content and applications are delivered have undergone seismic shifts in response to market and technological forces and in the absence of intrusive interconnection regulation. Today, the provision of online services is based on an amalgam of interconnected computing and communications resources including wired and wireless links, switches and routers, and servers. These are owned, operated, and controlled by different entities that are often direct competitors as well as customers of each other when it comes to the exchange of traffic and the provision of Internet-based services. The amalgam of these resources is complex and constantly evolving; delivery chains and the contractual fabric of service delivery are subject to ongoing change and in constant flux (Stocker et al., 2020).

### 2.2.1. Flattening of the Internet

One significant development that has driven ecosystem change is the flattening of the interconnection routing topology. In the early days of the commercialized Internet, the interconnection fabric was sparsely meshed and hierarchical. A set of large and globally operating Tier-1 ISPs (which included former telecommunication service providers incumbents) played a dominant role. They exchanged traffic that was destined for termination to addresses within the recipient ISP's domain. Such traffic was typically exchanged without payment subject to bilateral peering agreements between the ISPs. Lower-tier ISPs in the vertical interconnection hierarchy – typically smaller ISPs that did not operate globally – needed to pass traffic “up” to higher-tier ISPs to ensure that traffic could be delivered globally. Lower-tier ISPs typically purchased transit services from higher-tier ISPs in order to ensure that traffic to and from end-users outside of the lower-tier ISPs' domain would be globally delivered.<sup>19</sup>

This simple model of settlement-free peering among the largest Tier-1 ISPs and a vertical hierarchy of lower-tier ISPs purchasing transit services from higher-tier ISPs was already changing and growing more complex by the late 1990s. Networks that previously relied on transit (indirect interconnection) to exchange traffic were shifting to interconnection models based on peering connections (direct interconnection). As growing numbers of networks sought to directly connect and exchange traffic among each other, often based on settlement-free peering arrangements, the interconnection fabric became denser. As transit relationships were bypassed, the interconnection ecosystem became less hierarchical, and disintermediation shortened delivery chains (i.e., the number of entities involved in end-to-end traffic delivery is reduced) (e.g., Gill et al., 2008; Dhamdhere & Dovrolis, 2010).

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<sup>19</sup> These vertical relationships between higher-tiered sellers of connectivity, so-called transit providers, and lower-tiered buyers of connectivity, so-called transit buyers, were necessary for many actors in the ecosystem to ensure global connectivity.



Whereas different forms of private<sup>20</sup> and public<sup>21</sup> and bilateral and multilateral peering strategies exist, innovations like remote peering have further expanded routing options.<sup>22</sup> Moreover, over the last couple of years, a growing number of geographically distributed interconnection facilities (e.g., colocation facilities or IXPs) has enabled a larger array of networks to meet and exchange traffic directly *and* locally, i.e., close to destination customers. This has further contributed to changing traffic matrices, the densification of the interconnection fabric, and expanded routing options (e.g., Dietzel, 2019; Arnold et al., 2020b; Stocker et al., 2021).<sup>23</sup>

One of the first large-scale studies to comprehensively document the changes occurring in the Internet's topology and interconnection landscape was conducted by Labovitz et al. (2010a, 2010b). Their analysis highlighted the consolidation of Internet traffic and content, explaining how the Internet has become flatter (i.e., less hierarchical), more densely meshed, and traffic volumes increasingly dominated by a smaller number of large entities. At the same time, the capacity and volume of traffic exchanged over peering and transit links expanded significantly, taking advantage of technological enhancements, and collectively contributing to significant reductions in the transmission costs for traffic (as measured on a per-MB basis).<sup>24</sup>

Today, large amounts of global traffic originate from the networks of large edge providers, including large OTTs. In this context, OTT-based media delivery yields strongly imbalanced

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<sup>20</sup> Private peering is typically based on a dedicated fiber cross-connect between two peers. In the course of Private Network Interconnections (PNIs), interconnecting parties privately negotiate traffic exchange agreements. Although most of these peering agreements were settlement free, new models of both paid peering and partial transit emerged (see Clark et al., 2016b).

<sup>21</sup> Public peering is based on a shared switching fabric and facilitates that a network can directly interconnect with multiple networks. The French regulator ARCEP (2022, p. 38) provides numbers on incoming (ingress) interconnection traffic for the four major French ISPs and shows that by the end of 2020, private peering traffic accounted for more than half of the relevant interconnection traffic (50.3%), while public peering accounted for only 2% of relevant interconnection traffic (with the remaining 47,7% being attributed to transit).

<sup>22</sup> With remote peering, geographically distant networks that are not directly connected can directly exchange traffic between each other. Absent the need for both interconnection partners to have a physical presence at the same interconnection facility, remote peering changes the meaning of distance and renders geographically distant networks virtually adjacent. For example, the IXPs or a partner provider may offer services to facilitate networks remote access to the IXP. Thus, these networks can interconnect at the IXP with other networks without having a physical presence at the interconnection facility (e.g., AMS-IX, 2022). Other IXPs operate grids consisting of a private wide area network (WAN) that connects geographically distributed interconnection facilities (i.e., locations). Connecting to one of the locations (e.g., Madrid) enables a network to directly interconnect with any network connected to any other location (e.g., Frankfurt or New York City) of the IXP grid (e.g., DE-CIX, 2022). For more details on remote peering, see, for example, Nomikos et al. (2018) and Giotsas et al. (2021).

<sup>23</sup> According to data by Euro-IX (2021, Table 2.1.1 at p. 5), the number of operational IXPs in Europe has increased from 144 in 2011 to 273 in 2021. To get an idea of the geographical distribution of such (carrier-neutral) third-party interconnection facilities, see TeleGeography's Internet Exchange Map (TeleGeography, 2022a). For an accessible primer on the state of interconnection, see Dietzel (2019) and Marcos et al. (2020).

<sup>24</sup> To illustrate the impact on cost due to such technological enhancements, a study by A.D. Little and Liberty Global from 2014 reported that router costs per Gbps decreased from \$47,000 to \$1,000 between 1999 and 2012, thus indicating an average annualized price decline of 24% (A.D. Little & Liberty Global, 2014, Figure D at p. 8). When it comes to transport prices, Boudreau (2022) reports for various routes a decline in weighted median monthly lease prices for 10 Gbps and 100 Gbps wavelengths for the period between 2016 (2018) and 2021. Even though average CAGR price declines vary across different geographies and technologies (10 Gbps versus 100 Gbps), which is also true for other connectivity services and highlights the need for context-specific investigations, Boudreau finds double digit declines (11% to 12%) for 100 Gbps (weighted median monthly lease prices) since 2018 for trans-Atlantic and trans-Pacific routes. Significantly, the author describes a price erosion of 100 Gbps that outpaces the price erosion for 10 Gbps, thus rendering upgrades to 100 Gbps more economical. The author further suggests that such price erosions also drive declines in respective transit prices.

in/out traffic ratios when OTT's and access ISPs exchange traffic.<sup>25</sup> The reason is simple: outbound traffic (mainly consisting of media content) traveling from OTT's to requesting end-users exceeds inbound traffic (mainly end-user requests) traveling from end-users to OTT's. Large edge providers typically seek to get access to their customers via direct and local interconnection arrangements with the access ISPs to which their customers subscribe.<sup>26</sup> Thus, they have expanded their presence at geographically distributed interconnection points, thereby increasing the number of direct interconnections with more interconnection partners, spurring the densification of the interconnection fabric, and tremendously expanding routing options.<sup>27</sup>

The flattening and densification, the technological enhancements, and the consequent localization of traffic flows have all contributed to a more competitive interconnection landscape and reduced transit prices. Table 1 illustrates how transit prices fell considerably over time. Whereas the declines varied across regions in absolute and relative terms, the rates at which transit prices decline has slowed as prices per Mbps have dropped sharply and converged toward zero.<sup>28</sup>

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<sup>25</sup> The in/out traffic ratio describes the ratio between ingress (inbound) traffic and egress (outbound) traffic. Whereas this ratio has been considered a proxy for assessing the allocation of costs related to the interconnection between ISPs, typical Internet usage by broadband subscribers leads to imbalances of upstream/downstream ratios, which is why broadband access products typically offer much higher downstream data rates than upstream data rates. Whereas this is also reflected in the design of broadband networks, it reflects the usage patterns of broadband subscribers and the traffic characteristics associated with the consumption of online services. This is particularly evident in the case of media delivery and, unsurprisingly, has been the source of conflict in the past (see also Footnotes 68 and 71).

<sup>26</sup> In contrast to the in/out traffic ratio in traditional inter-ISP interconnections for which most basic interconnection agreements were designed, interconnections between edge providers and ISPs are different – not only in the symmetry of exchanged traffic but also in the purpose of the deal. Edge providers offer content and applications that are valuable for broadband subscribers. ISPs use this content and applications as part of the value proposition to their subscribers and carry it, if requested, to their subscribers. Whereas traditional peering between ISPs focused on a rough symmetry of the cost of delivering traffic to each other's customers (also giving rise to cost avoidance strategies like hot potato routing), traffic exchange between edge providers (e.g., OTT's or CDNs) and access ISPs may (e.g., depending on the cacheability of content) look very different. While OTT-based video conferencing has many resemblances with legacy voice services (traffic ratios are relatively symmetric unless group calls are made), the delivery of OTT-based video service (on demand) delivery is typically characterized by highly imbalanced traffic ratios. However, as we will explain in the following sections, OTT providers may invest a lot in bringing servers and, thus, content and applications as close as optimal to their customers. Local server deployments and interconnections thus imply that the distance separating servers and requesting customers is shortened. Hence, traffic delivery resembles a cold potato strategy where the handover to the terminating network is moved closer to the end-users. This can be mutually beneficial: traffic control and customer experience can be optimized from the OTT perspective, and ISPs benefit from cost savings (see detailed explanations in the following sections). In contrast to one-hop scenarios in which the interconnection point is moved closer to end-users, zero-hop delivery of content and applications via servers hosted in access ISP networks completely changes the role of interconnections (see our discussion in Section 2.2.2).

<sup>27</sup> These general trends are described in the well-known studies by Weller and Woodcock (2013) and Woodcock and Frigino (2016). Referring to these studies, BEREK (2017, p. 42) states: "Since the previous report the dozen largest networks have increased the number of peering partners from a range of 700 – 2,400 in 2011 to 2,200 – 4,500 in 2016. The percentage of networks with ten or fewer peering partners declined from 62 % in 2011 to 35% in 2016. Across all networks the average number of interconnections per network rose from 77 to now 292." While we will discuss zero-hop scenarios in the next section, Takami (2021) provides interesting insights into the density of the interconnection landscape. The author explains that CDN provider Cloudflare has reached more than 10,000 direct interconnections with adjacent networks and estimates that Google has direct connections with 12,000 to 15,000 other networks. Furthermore, many of the top backbone providers directly connect to increasing numbers of ASes. Hurricane Electric has, for example increased the number of connections to other ASes from less than 2,000 before 2010 (TeleGeography, 2021, Figure 5 at p. 7) to almost 10,000 in 2022 (TeleGeography, 2022c, Figure 5 at p. 6) – and thus presumably to the large majority of global Internet users. Whereas this implies that, from the perspective of these providers a large share or even a large majority of Internet users is only one hop away, large networks often connect to large eyeball ISPs at multiple locations, thus facilitating cooperative strategies for traffic engineering and steering to improve load balancing and customer experience (e.g., Zerwas et al., 2022).

<sup>28</sup> Transit prices also have an impact on paid peering. Norton (2014, chapter 10) explains how Comcast charged companies who wanted to reach their customers based on peering via a metered service priced pretty much according

The flattening of the Internet’s topology and the concomitant densification of the interconnection fabric have disrupted traffic delivery and changed the economics of interconnection. Associated developments have spurred the evolution of content delivery modalities as well as business models. While for many end-to-end communications, only a single interconnection point (i.e., one hop) must be traversed, falling transit prices and associated monetization potentials due to the increased competition from alternative efficient traffic routing options have strained the legacy business models of Tier-1 ISPs. Shortened delivery chains have arguably reduced potential transit revenues for many ISPs, but the virtues of new delivery models are manifold. They reduce the total costs for delivering traffic to end-users and yield better (control over) performance and customer experience.

**Table 1:** Commodification of Transit and Transit Price Erosion

Time Period	Insights	Source
1998 – 2010 (2015)	<ul style="list-style-type: none"> <li>Based on data gathered via informal surveys, Norton estimates that U.S. transit prices (minimum commitment) have decreased <b>from \$1,200 per Mbps</b> in 1998 to <b>\$5.00 per Mbps</b> in 2010, thus implying an <b>annualized average decline of 61%</b>.</li> <li>The document estimates further decreases to \$0.63 per Mbps by 2015.</li> </ul>	Norton (2010)
2018 – 2021	<ul style="list-style-type: none"> <li>Whereas price declines vary considerably across different geographies, weighted median <b>10 GigE (Gigabit Ethernet) IP Transit CAGR prices declined globally (on average) at 17%</b> between 2018 and 2021.</li> </ul>	Boudreau (2022)
2018 – 2021	<ul style="list-style-type: none"> <li>(Weighted median) <b>10 GigE IP Transit prices</b>: Three-year CAGR <b>decline</b> (across major global hub cities) <b>at 18%</b> (Q2 2018 to Q2 2021)</li> <li>(Weighted median) <b>100 GigE IP Transit prices</b>: Three-year CAGR <b>decline</b> (across major global hub cities) <b>at 30%</b> (Q2 2018 to Q2 2021)</li> <li><b>Lowest 10 GigE IP Transit prices</b> reported (in Q2 2021): ca. <b>\$0.09 per Mbps</b> per month</li> <li><b>Lowest 100 GigE IP Transit prices</b> reported (in Q2 2021): <b>\$0.06 per Mbps</b> per month</li> <li><b>Price erosion</b> driven by <b>more competition</b> and <b>adoption of higher capacity technology</b> (i.e., 100 GigE and 400 GigE transit ports, perhaps even ports with 1 Tbps capacity)</li> <li><b>Expects</b> increasing volume and <b>further decreases in unit cost and price</b>.</li> </ul>	Coll (2021)

### 2.2.2. The Rise of Clouds and CDNs – Localization and the Race to the Edge

Many innovations that have become integral elements of today’s Internet ecosystem originated as responses to deficiencies of the best-effort-based legacy delivery model of the Internet to meet the growing and changing demands for content and application delivery. These deficiencies have often emerged from a lack of evolvability and limited potential for service differentiation of the legacy delivery models, complex coordination problems between competing entities (e.g., in the course of interconnections), scalability problems, and (distance-related) protocol inefficiencies (e.g., related to TCP or BGP), or security aspects (e.g., Clark et al., 2006; Leighton, 2009; Stocker et al., 2017).

One important set of such innovations is related to the emergence and rapid rise of cloud services and cloud service providers to augment, complement, and compete with the services of traditional ISPs. Cloud service providers come in many shapes and sizes and continue to evolve their infrastructures, services, and business models. They provide a range of services that complement and/or substitute for legacy services provided via the public Internet or ISPs (Lehr et al., 2019;

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to the market price for transit. In other words, from a cost perspective, third-party networks would be indifferent to reaching customers indirectly via transit or directly via paid peering with Comcast. However, Norton states that the paid peering offering was based on a good value proposition by the ISP, and several CDNs chose this option. Arguably, a direct interconnection may yield better performance and traffic control (one-hop) compared to the indirect route via a transit network (multiple-hops).

Claffy and Clark, 2014). Collectively, these providers enable multiple tiers of cloud services, offering on-demand, “plug-and-play” options for businesses that want to host their computing services in the public cloud, as well as the components needed to support businesses seeking to deploy private enterprise clouds on their premises. Hybrid cloud approaches that combine private and public cloud resources and multi-cloud approaches further broaden the scope of cloud deployments of which businesses can avail themselves. In the early days, cloud services were categorized into three service tiers: software as a service (SaaS), platform as a service (PaaS), and Infrastructure as a Service (IaaS).<sup>29</sup> Today, the range of cloud services and Internet ecosystem service providers has expanded, offering versions of these is making it feasible to get on-demand access to almost anything or Everything-as-a-Service (XaaS).<sup>30</sup>

The growing demand for on-demand access to computing and data storage resources by Internet users helped drive the growth of large public cloud computing service providers (sometimes referred to as hyperscalers) that operate large data centers with server farms that pool compute and storage resources. The scale and scope economies associated with the provisioning and management of large data centers has helped drive industry consolidation so that today a few large cloud providers account for most of the traffic. To meet the growing demands for cloud computing, cloud providers have invested heavily in expanding their infrastructures.

In this context, three developments are particularly worth considering as they indicate the scale and scope of the investments made by large cloud providers. *First*, cloud providers have expanded their footprints by building more large data centers to bring relevant capabilities closer to customers (see Figure 1 below). *Second*, cloud providers have extended their footprints based on more distributed computing approaches and strategically deploy smaller facilities (with fewer servers) even closer to customers (see Figure 2 below). *Third*, cloud providers have built private wide area networks (WANs), purpose-built and high-capacity backbone networks that connect strategically important locations like data centers or points of presence<sup>31</sup> (see Section 2.2.3).

These three developments bring many benefits. The first two developments describe strategies for the expansion of the cloud footprint. By bringing networked cloud resources closer to customers, the distance between cloud capabilities and customers is reduced. As workflows can be processed more locally, security and performance-relevant metrics like data rates and latencies can be improved. The third development further expands options for bypassing legacy routes in portions of the public Internet, rendering the provision of cloud services more capable and cost efficient (Stocker et al., 2020, 2021).

The activity of the three leading cloud service providers Amazon (AWS), Google/Alphabet (Google Cloud) and Microsoft (Microsoft Azure) shows a trend towards more data center investment in Europe. All of the three companies have expanded their cloud footprints in Europe and have already announced the opening of new cloud regions. The relevant investment activity can be illustrated by a few examples. As Morgan (2022) reports, AWS’s capital investment was around \$6.71B in Q2 2022, thus about 40% of Amazon’s total capital investment in that period.

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<sup>29</sup> See Armbrust et al. (2009) or Rimal et al. (2010) for earlier discussions of the SaaS/PaaS/IaaS typology of cloud computing. Microsoft Office and Google Apps are examples of SaaS; Microsoft’s Azure and Google App Engine are examples of PaaS; and Amazon’s Elastic Cloud (EC2), Rackspace, and IBM Computing on Demand are examples of IaaS offerings.

<sup>30</sup> See Ashtari (2022), Duan et al. (2015), or Ganapathy (2020) for discussions of XaaS as the model for cloud computing and its implications for businesses migrating services to the networked cloud information and communications technology resources.

<sup>31</sup> Put simply, points of presence are access points to and from the networks of these cloud providers.



The same article reports that, since it was founded, AWS has spent around \$120B. The company has heavily invested in expanding its European data center footprint. For example, it recently announced data center-related investments of €2.5B over ten years in Spain (Torres, 2021). Google has also expanded its European data center footprint. In a study commissioned by Google, Basalisco et al. (2019) comprehensively explore the company's cloud and network infrastructures in Europe, relevant investments, and benefits. The study states that by 2021 (since 2007; as announced by August 2019), Google's investments in data centers and related infrastructures<sup>32</sup> in Europe will be around €11.9B – with €5.0B committed investment between 2019 and 2021 (Basalisco et al., 2019, p. 4). The study further reports that investments in network connectivity (e.g., network infrastructure and equipment expenditures related to relevant subsea cables, metro-to-metro links, points of presence and caching equipment, etc.) have increased over time and will amount to €2.9B by 2020 (since 2007; including committed investments) (Basalisco et al., 2019, Figure 22 at p. 41). Microsoft has also invested heavily in data centers in Europe. While in 2016, Microsoft had already invested over \$3B in European cloud deployments (DeMaria, 2016), the company has expanded its European cloud footprint. As of September 2022, several new cloud regions have been announced (e.g., in Austria, Greece, Italy, and Poland) (Microsoft, 2022). For example, comprehensive investment plans of \$1B in Poland (Microsoft, 2020a) and \$1.5B in Italy (Microsoft, 2020b) include the development of cloud regions in respective countries that will soon be opened.

In a study commissioned by Google, Abecassis et al. (2018) adopts a more comprehensive perspective. The authors provide detailed insights into the strongly growing direct and indirect investment activities by Online Service Providers (OSPs) across different regions and investment categories (hosting in data centers, transport via terrestrial fiber and submarine cables, and traffic delivery via CDN nodes, public and private peering points).<sup>33</sup> Average annual investments in Europe by OSPs have amounted to \$17.9B between 2014 and 2017 which implies an increase by 68% as compared to \$10.7B between 2011 and 2013 (Abecassis et al., 2018, Fig. 1.3 at p. 3).<sup>34</sup>

Focusing on the time period between 2018 and 2022 (and capturing the announced plans for future build-outs), Figure 1 illustrates the trend towards more data center investment in Europe by the three leading cloud service providers Amazon, Google/Alphabet and Microsoft. These providers have expanded their cloud presence and footprint in Europe, establishing more geographically distributed cloud regions and availability zones. Such an aggressive footprint expansion requires investments but also brings many benefits for European businesses and citizens. For example, access to cloud-based services proved critical during the Covid-19 pandemic.<sup>35</sup> Moreover, more localized cloud capabilities are critical for enabling a new generation of applications and use cases. With more data centers being deployed closer to end-users, desired resources are typically only a

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<sup>32</sup> These investments include the following three types of investments: “Construction, civil engineering and restoration of the data centre sites”; “Ongoing data centres’ operation, including site reliability engineering and all support functions”; and “Connectivity links serving the EU and related networking assets” (Basalisco et al., 2019, p. 3).

<sup>33</sup> Note that OTTs are a subset of OSPs. Abecassis et al. (2018, p. 13) describe such indirect investments by the example of OSPs having leasing agreements that are so significant that they drive “dedicated” investment by third-party providers of colocation data centers to expand capacities according to the OSP demand. In the same context, the report emphasizes the role of partnerships between different entities.

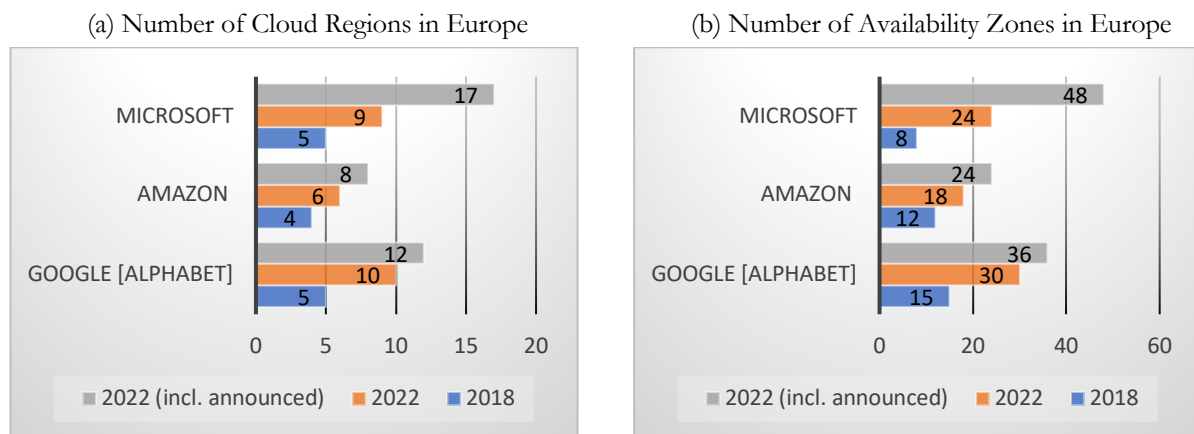
<sup>34</sup> Moreover, the authors report increases in annualized R&D spending for major OSPs from \$27.2B in 2013 to \$59.6B in 2017, an increase of 119% (Abecassis et al., 2018, p. 5).

<sup>35</sup> Feldmann et al. (2020) explain the increased role of cloud-based services during the Covid-19 pandemic. Another example is the partnership between AWS and Netflix. As Barr (2020) states, AWS has supported Netflix to quickly scale their services to meet the unexpected increases in customer demands during the first wave of the Covid-19 pandemic.



few tens of milliseconds or less away from those seeking access to cloud capabilities in Europe (e.g., Corneo et al., 2021a, 2021b; Hjembo, 2022).

**Figure 1:** Expanding Cloud Presence of the Big Three in Europe



Source: Based on data by Abecassis et al. (2018, p. 27) and company websites (last accessed: 21 August 2022).

**Note:** Microsoft = Microsoft Azure; Amazon = Amazon Web Services; Google [Alphabet] = Google Cloud; Cloud regions typically contain multiple availability zones; if availability zones were not specified for announced cloud regions, we assumed the standard case of three availability zones per cloud region.

Content Delivery Networks (CDNs) are an example of a special class of cloud service providers that emerged in the late 1990s to add capacity and capabilities to the Internet ecosystem. Many businesses worldwide rely on CDNs to deliver their content and applications and purchase content delivery services from third-party CDN providers like Akamai, Fastly, or Cloudflare. While many OTTs rely on third-party CDN services, some leading OTTs have built their own CDNs, which they use to deliver their own content, sometimes also offering content delivery services to other third-parties.<sup>36</sup> CDNs have a strong value proposition for multiple ecosystem actors as they contribute to reducing total costs of traffic delivery while enhancing overall efficiency, functionality, scalability, and also security. Service delivery via CDN relies on (highly) distributed serving infrastructures. By strategically deploying geographically distributed servers (increasingly even within access ISP networks via intra-ISP caches), CDNs bring storage and computing resources and workflows closer to end-users. Instead of sending multiple copies from distant servers to each subscriber who requests a copy of the content, CDNs store copies of the content close to the edge, thereby obviating the need to use scarce upstream capacity. Edge caching also reduces latency which improves the performance or responsiveness of interactive applications and facilitates increased end-user data rates (Leighton, 2009). By reducing the vulnerability to upstream routing problems and congestion and also increasing the available capacity along those routes that are no longer needed, they support the cost-effective delivery of other traffic (Stocker et al., 2017).<sup>37</sup>

<sup>36</sup> CDNs present a multifaceted proposition and come in different forms and sizes. For a typology of CDNs and a comprehensive overview of the variety of CDN architectures, approaches, service characteristics, and business models, see Stocker et al. (2017). While ISP-CDN collaborations may be built upon licensed CDN solutions, many leading OTTs have their own CDNs. For example, Netflix has its Open Connect CDN, a highly distributed, special-purpose CDN the company uses to deliver their media content (Netflix, 2022a). Google/Alphabet has its highly distributed Google Global Cache CDN (Google, n.d.), and Amazon has Amazon CloudFront, which the company uses for the delivery of their Amazon Prime Video content and also to offer CDN services to third-party customers like Hulu (video streaming) or Slack (API acceleration) (Amazon Web Services, 2022).

<sup>37</sup> Delivering content and applications from servers that are close to requesting end-users means that upstream parts of networks have less traffic to carry. This translates into a reduced need for network upgrades in these upstream parts of the network and interconnection links, improved cost efficiency (e.g., through state-of-the-art coding and compression techniques and load balancing), and cost savings – for edge providers and ISPs. While these benefits

The CDN approach is especially valuable in addressing the OTT traffic that the ETNO Report focuses on because so much of the consumer Internet traffic consists of cacheable entertainment content (e.g., streaming video or music). Today, most consumer Internet traffic is delivered via CDNs. According to his measurements study, Labovitz (2019, p. 6) reports that even as far back as 2018, about 90% of global consumer traffic was already delivered via CDNs. The same study also reports that increasing numbers of CDN servers are not only caching content but also have compute capabilities. Finally, given the large share of traffic delivered via CDNs, Labovitz reports that the nature of traffic has changed. This is because most CDNs utilize dynamic rate adaptations for the delivery of their content. Based on measurements of current network conditions, sending rates are dynamically adjusted to optimize customer experience as well as to mitigate states of network congestion.<sup>38</sup> On top of that, CDNs employ sophisticated algorithms that use collected real-time information on network and server conditions to intelligently redirect end-user requests for a piece of content to those servers that are best suited to deliver the requested content. Beyond optimizing the customer experience, CDNs thus help to improve load balancing and network utilization (see Stocker et al., 2017).

In addition to reducing end-to-end infrastructure investment requirements that would have been needed before adopting the innovations that CDNs and other topology/routing changes have wrought, these changes help reduce end-to-end coordination (transaction) costs by shortening delivery chains and reducing the number of independent entities that need to be coordinated to facilitate end-to-end service delivery.<sup>39</sup> These changes that have expanded the Internet ecosystem by adding new sorts of players such as cloud providers or CDNs and private networking by edge providers, have also contributed significantly to the growth and success of the Internet in being

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depend on the decision where servers are deployed (e.g., at an IXP outside the borders of the access ISPs or at various locations within the access ISP network), Abecassis and Daly (2022) estimate that the Netflix CDN model helped save ISPs worldwide more than \$1B of costs in 2021 based on the deployment of cache servers within ISP networks and the adoption of new (more efficient) codecs. Hosting the desired content or application closer to end-users and within the networks of access ISPs means that in many cases, communications that determine customer experience become independent from interconnections between different autonomous systems (ASes), i.e., the independently operated networks of entities like ISPs or large content or cloud providers. Significantly, local (or intra-ISP) server deployments are necessary to ensure that future latency-critical use cases can be realized since the physical limitations of signal transmission render it inevitable that endpoints are sufficiently close to each other and networked computing resources are deployed locally.

<sup>38</sup> A good example is video content delivery. OTT-based video services process the content they offer and typically create different versions or representations of the content at different qualities (e.g., regarding video resolution, frame rates, etc.) by employing compression and encoding techniques. Different representations require different bit rates (i.e., connection speeds) from the networks that deliver the content, thus facilitating rate adaptations (with higher quality generally requiring higher bit rates). Netflix, for example, currently recommends the following connection speeds (per video stream): 15 Mbps for ultra-high definition (UHD) resolution, 5Mbps for 1080p and 3 Mbps for 720p for high definition (HD) resolutions and 1 Mbps for standard definition (SD) (Netflix, 2022b). Depending on measurements (and assessments) of current (and expected) network conditions, adaptive bit rate algorithms determine the “best” version offering the best customer experience – bit rates are adapted by dynamically switching between different representations. While such approaches are used by the most significant OTT platforms for video delivery and help to optimize resource utilization, insightful overviews of adaptive streaming approaches are provided in Seufert et al. (2015) and Begen and Timmerer (2017). Advances in coding help reduce the bit rates and network resources required to deliver a piece of content at a specific quality (as perceived by end-users) (see also Weinberger, 2022). As we explained before, such improved efficiencies reduce network loads and yield cost saving potentials – for CDNs and ISPs (see Abecassis & Daly, 2022).

<sup>39</sup> Additionally, for many end-users that previously received their content via cable television or other non-broadband Internet transmission paths, the shift to OTT access freed up network infrastructure investment (e.g., RF bandwidth on a cable network) for redeployment to support broadband traffic growth; however, to most effectively make use of such capacity, other changes in the network architecture were needed since traditional models for video distribution relied on broadcast technology where a bundle of programming is sent to all homes along a cable network, whereas OTT-based video delivery relies on unicast.

able to scale to meet growing traffic while offering improved performance and reduced costs per MB of traffic.<sup>40</sup>

Without these changes, the Internet would not have been able to handle the surge in traffic associated with the Covid-19 pandemic in the spring of 2020, and the Internet would not be positioned to support the more demanding Smart-X applications that are expected to deliver digital economy benefits in the future.<sup>41</sup> More specifically, local cloud capabilities will be needed with even greater capabilities for resource sharing to support the multiaccess (or mobile) edge computing (MEC) needed to meet the performance goals targeted for 5G networks which calls for ultra-low latencies and other performance enhancements (ITU-R, 2015). Many of those applications and use cases are expected to emerge in the context of the Internet of Things, the tactile Internet and in general are spurred by 5G and 6G networking.

In recent years, large CDNs, cloud, and edge application and content providers made significant efforts to expand their footprints of data centers and highly distributed serving infrastructures. Papers by Trevisan et al. (2020), Corneo et al. (2021a, 2021b), and Gigis et al. (2021) document these efforts that have fundamentally contributed to provide the data storage and cloud computing infrastructure that has supported the changed topology, traffic management, and data processing capabilities that characterize today's much more capable Internet. While the efforts further give rise to more localized traffic flows, much of the relevant investment has been coordinated with ISPs, and much of the associated equipment is located within the networks of the access ISPs.<sup>42</sup> Moreover, large OTTs that seek global content distribution – even if they have their own serving infrastructures – may pursue multi-CDN strategies, thus purchasing CDN services from third-

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<sup>40</sup> Similar to the development described above regarding transit prices, Rayburn (2019, 2020a, 2020b) provides insights into CDN pricing. Based on bi-annual surveys of CDN media delivery service customers, Rayburn identifies relevant industry trends regarding usage, pricing, firm strategies, etc. Regarding pricing, he reports a decline in the lowest reported CDN prices over time (likely for large customers that have benefitted from bulk discounts), falling from \$0.002 per GB delivered in 2017 to \$0.0006 per GB delivered in 2020 (Rayburn, 2020a). In a presentation held in November 2020, Rayburn (2020b) further reports that CDN prices (again in \$ per GB delivered) in the U.S. had decreased by around 20-25 % (year-on-year; 2019 vs. 2020) for the largest customers. He explains that the multi-CDN strategies of large customers and these price levels and low margins imply that many third-party CDNs pass on delivering traffic at such prices and that this might further incentivize do-it-yourself initiatives by content providers (Rayburn, 2020a).

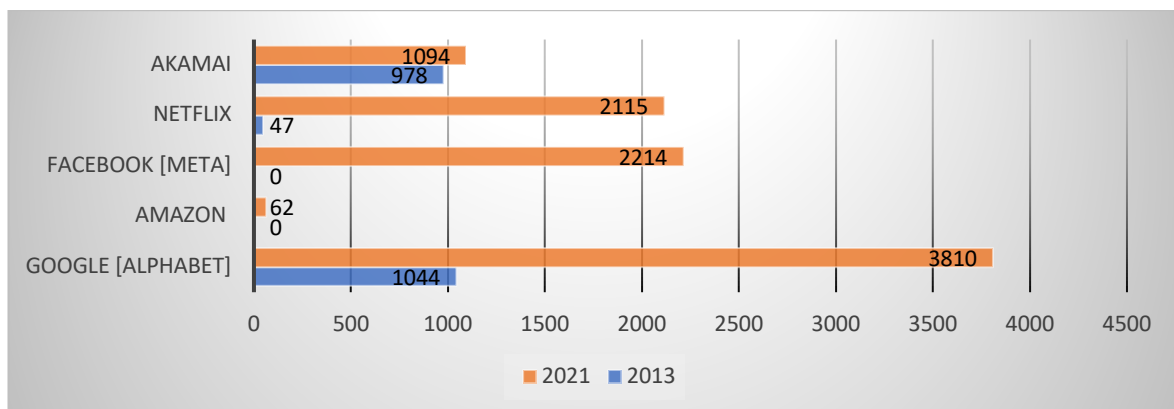
<sup>41</sup> Eurostat (2021, pp. 9-10) highlights the importance of cloud computing and the many economic benefits as follows: "Cloud computing is one of the strategic digital technologies considered important enablers for productivity and better services. Enterprises use cloud computing to optimise resource utilisation and build business models and market strategies that will enable them to grow, innovate and become more competitive. The Digital Services Act and European data strategy aim to enable and facilitate a faster adoption of cloud computing across all sectors of the economy; this can cut ICT costs and, when combined with new digital business practices, boost productivity, growth and jobs." More recently, a comprehensive study by Public First (2022) commissioned by AWS emphasized the role of cloud computing for achieving the EU's Digital Decade targets and its benefits (e.g., related to supporting cloud adoption of businesses, digital government services, or improving digital skills). Interestingly, the study states: "The EU looks likely to meet its Digital Decade targets for internet connectivity, with 59% households already covered by fixed Very High Capacity Networks (VHCN). More work is needed to support the development of low-latency solutions, such as edge computing, which enables data processing, analysis and storage closer to the source of the data" (Public First, 2022, Executive Summary section).

<sup>42</sup> Whereas different approaches exist as to where servers are positioned within an ISP network, the closer the servers are deployed to the end-users, the shorter the distance data packets need to travel via ISP networks. Deploying more distributed cloud or serving infrastructures, however, is costly. The required investments, though, contribute not only to improved customer experience and facilitate innovation, they also enable better load balancing of the ISP network based on the intelligent redirection of end-user requests for content or compute to those servers that are best able to provide the requested service (by time, location, network conditions, and capacity availability). With regard to CDN investments, Keck (2021) provides insights into the Netflix CDN and reports: "Netflix says it's invested roughly \$1 billion in Open Connect since its creation a decade ago."

party providers. This means that content from a single OTT is (dynamically) spread over multiple CDNs that each directly or indirectly interconnect with access ISPs.<sup>43</sup>

To give an idea and sense of the recency, pace, and scale of the footprint expansion of some large edge providers, Figure 2 visualizes data from Gigis et al. (2021) on the expansion and state of highly distributed serving infrastructures as measured by the number of ASes in which these providers have deployed their “off-net servers”.<sup>44</sup> On the one hand, this development shows a move towards a zero-hop Internet. Gigis et al. (2021, p. 525) explain that, for example, Google (Alphabet) can reach 77.5% of the European user population via their off-net servers, Facebook (Meta) 39.8%. On the other hand, the development shows an evolved form of collaboration between ISPs and relevant edge providers and also an ongoing localization of network resources and traffic that immediately impacts on the role of interconnections.<sup>45</sup>

**Figure 2:** Expansion of Edge Providers’ “Off-Net” Footprints



Source: Based on data by Gigis et al. (2021, Table 3 at p. 521)

In today’s flatter, more densely-meshed, and much more capable Internet (in terms of processing, transmission, and dynamic adaptability capabilities) there are more distributed computing and storage resources collocated in the edge networks operated by access ISPs and others (including end-user customers such as businesses). These changes blur the boundaries between end-user networks and those of service providers and the public Internet, but all contribute to enabling more capable and robust digital infrastructure. Today, there are many more options for routing and managing traffic. This diversity of options contributes to network resiliency and reliability and improved network utilization and customer experience. This is not only important from the perspective of individual end-users accessing the Internet via residential broadband access networks but also for business enterprise customers that access cloud capabilities via dedicated connectivity products which are increasingly being integrated into core business models and processes. Those solutions are provided and supported by a complex and evolving range of

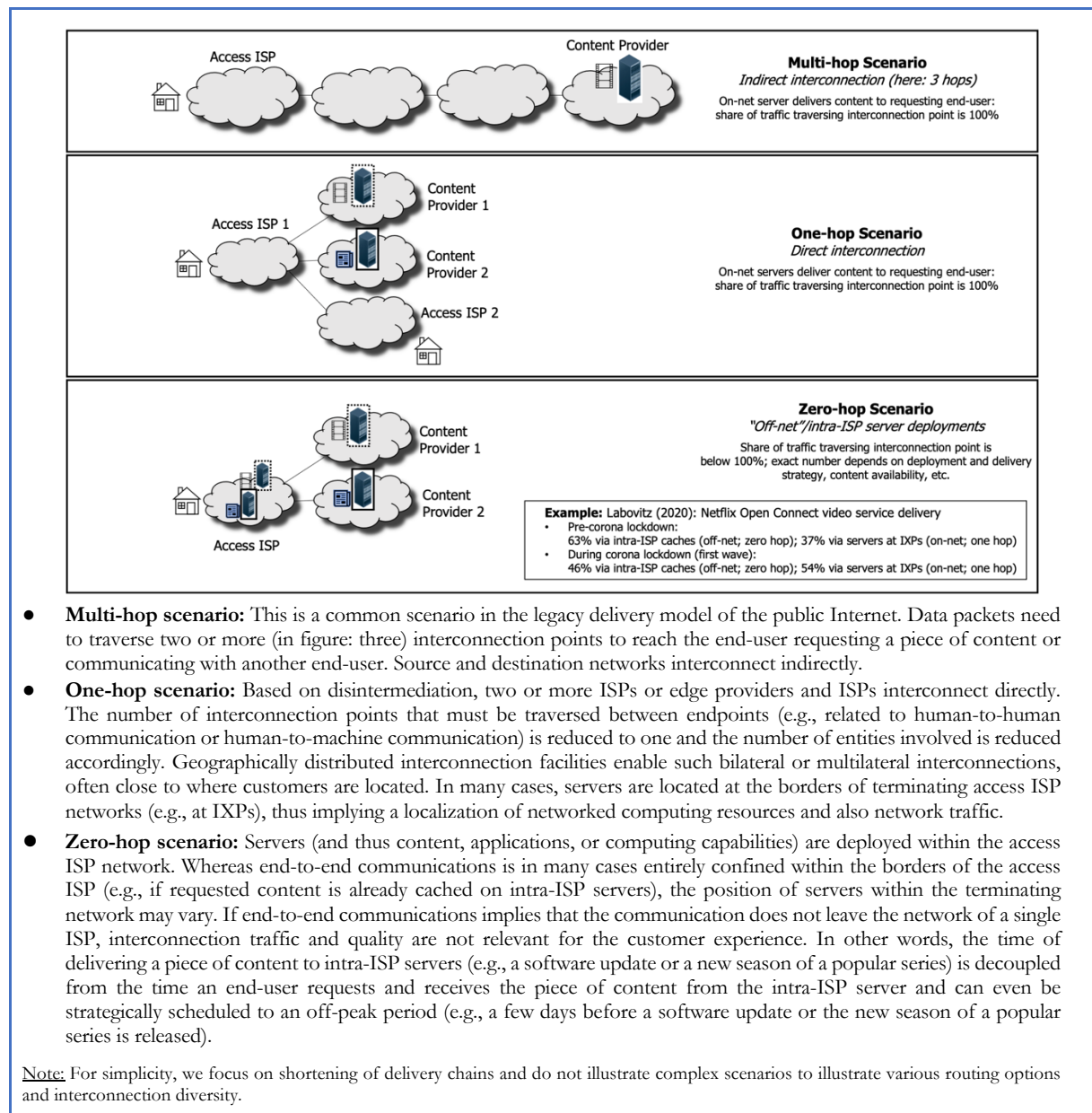
<sup>43</sup> For example, Amazon is known to use not only their own Amazon CloudFront CDN to deliver Amazon Prime video content but to use multiple CDNs (Souk, 2020). See Stocker et al. (2017) for detailed explanations on the economics and evolution of the CDN ecosystem and descriptions of different CDN approaches.

<sup>44</sup> As Gigis et al (2021, p. 516) explain, hypergiants “operate their own networks and datacenters, with servers assigned IP addresses from their own ASes.” However, in addition to such on-net servers, they “also install servers inside eyeball or other networks, to serve users in those networks or their customers”. As the authors describe, such off-net “servers are assigned IP addresses of the hosting network” (Gigis et al., 2021, p. 516).

<sup>45</sup> For a discussion of CDN-ISP collaborations, see, for example, Stocker et al. (2017) or Zerwas et al. (2022).

connectivity providers that include but are not limited to ISPs.<sup>46</sup> Figure 3 provides a visualized and stylized summary of the localization of traffic and direct interconnections.

**Figure 3:** A Stylized & Schematic Illustration of Traffic Localization



Source: authors

### 2.2.3. Non-ISP Service Providers and Large-scale Private Networks

In today's ecosystem, non-ISP providers of ancillary services and infrastructure have become more important. These providers offer a variety of digital infrastructure service options that allow customers to obtain customized networking and computing solutions that may bypass legacy public Internet routes and public cloud services. Service options include a range of managed connectivity services offered by colocation and connectivity providers via private links and even private and proprietarily managed backbone networks (so-called wide area networks, WANs).

<sup>46</sup> The share of companies in the EU that integrate cloud solutions is growing and expected to continue to do so. See Eurostat (2021).



These managed connectivity services may, for example, offer direct cloud access or connectivity between points of presence of respective WANs (e.g., Marcos et al., 2020, p. 12).<sup>47</sup> Such private connectivity may support private network traffic of enterprises and service providers, offering alternative routing paths to those available via the legacy and public Internet and reflecting heterogeneous demands for connectivity.<sup>48</sup>

When considering activity of large OTTs in this sphere, we can observe that several large content providers like Amazon, Microsoft, Facebook (Meta), and Google (Alphabet) have invested and developed their own private and proprietarily managed, high-capacity, purpose-built backbones. These are used by the companies to connect their data centers and/or other important network locations like points of presence where they interconnect and exchange traffic with other networks (including content providers and access ISPs) or connect with enterprises via direct cloud connectivity services (Clark et al., 2016a; Hong et al., 2018; Stocker et al., 2021; Salamatian et al. 2022). Whereas private managed links help to bypass the public Internet and its deficiencies for parts or the entire distance data packets travel between endpoints, respective backbones typically comprise virtual or physical links, typically terrestrial and submarine cables, that are built, purchased, or leased (e.g., TeleGeography, 2022b). Significantly, the providers that operate such backbones (directly or indirectly) invest in transport infrastructures.<sup>49</sup> Developments toward large-scale private networks that combine distributed cloud infrastructures and private high-capacity links are said to yield more agile, customizable, evolvable, and cost-efficient service provision; they have enhanced capabilities to accommodate and facilitate innovation and improve customer experience. More investment in backbones and distributed server footprints, and an increased presence at interconnection facilities close to end-users expands the capacity and spatial footprint of such networks. In addition to this expansion, complementary investments in the deployment of servers within access ISP networks (i.e., “off-net” from the viewpoint of the edge provider) further helps to bring content and compute even closer to end-users (Stocker et al., 2021; Balakrishnan et al., 2021; Arnold et al., 2020a).

So how have ISPs responded to these changes in the ecosystem, or more precisely, the role of non-ISP service providers, their investments in transport and server infrastructures, and role as carriers? We observe a general trend among ISPs to adapt to these changes by expanding the range of services they offer and shifting their business models. To lower costs, many ISPs have moved to increased reliance on diverse routing (to avoid costly transit payments) and to shifting the

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<sup>47</sup> An important driver of the agile (on-demand) provision of scalable and customized connectivity services is the trend toward moving functionality out of specialized hardware and into software (enabling the use of lower-cost, general-purpose hardware). This trend has facilitated virtualization which enables more complex and dynamic sharing arrangements of (complementary) network resources and across end-users and network providers. Softwarization and virtualization have also produced new means for business customers to reach the clouds of large providers directly via dedicated and managed (purpose-built) connectivity services, facilitating better end-to-end cost management and service control.

<sup>48</sup> For example, large IXPs may operate grids of geographically distributed interconnection locations connected via private backbones, thus facilitating remote peering (see explanations above).

<sup>49</sup> Abecassis et al. (2018, p. 33) report that OSPs’ average annual transport-related (direct and indirect) investments in Europe have increased from \$0.9B between 2011 and 2013 to \$1.0B between 2014 and 2017. More recently, investment by large content providers in submarine sea cables has increased significantly. As Stronge (2022) reports, the share of CAPEX investments in new submarine cables covered by large content providers has increased to more than 80% between 2020-2023 for Trans-Atlantic cables and around 70% for Trans-Pacific cables. Furthermore, as of August 2022, the websites of Google Cloud, AWS and Microsoft Azure impressively show the current state and future plans to expand their global backbone infrastructures consisting of both terrestrial and submarine sea cables. For example, the AWS private backbone network connects “all AWS Regions, CloudFront PoPs. and Direct Connect locations” (Vaganov & Ghiya, 2021, Figure 3). Since none of the large OTTs are currently offering broadband Internet access services to citizens in Europe, we do not further mention initiatives like Google Fiber in this paper.

burden for hosting and managing distributed edge servers to edge providers and private network services. To enhance revenues and make up for reduced revenues from transit services and other legacy services (like non-OTT video), ISPs are branching into other services. Some are offering their own CDN and data center services (e.g., Stocker et al., 2017). Some are offering new IoT or home management services (e.g., security, smart home monitoring, etc.). Many are offering mobile services as well as entertainment and OTT services.<sup>50</sup> And, when traffic is routed via non-broadband Internet access services or non-legacy Internet routes, often the ISPs are the ones providing the private networking infrastructure that is used. On the one hand, this shows that many ISPs have found ways to monetize access to the clouds beyond pure “public Internet” services like broadband Internet access. On the other hand, it reveals a facet of cooperation and integration between ISPs and third-party edge providers that provide further examples of how the ETNO Report grossly over-simplifies how service providers are interconnecting and responding to changing market and traffic conditions.<sup>51</sup>

### 2.3. Summing Up and Contextualizing the ETNO Report

The Internet ecosystem has changed significantly over the last two decades. Legacy telephone companies have morphed into broadband network operators (or access ISPs) and are key participants in an expanded and more complex ecosystem of interconnected and co-dependent providers of information technology products and services. The Internet ecosystem has become richer and more capable, offering end-user mass-market consumers and businesses across all sectors of the economy access to a globally connected pool of digital computing and communication capabilities. These developments have also affected ISPs that are confronting a greatly expanded and increasingly complex marketplace, which has created opportunity for and helped propel the growth of a multitude of providers and services. Third-party infrastructure and service providers made significant investments and innovation, and offer a diverse array of cloud computing and digital connectivity solutions. Edge providers offer content, applications, and ancillary equipment and services that are necessary to utilize the expanded capabilities productively.

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<sup>50</sup> Several European ISPs have recognized the value of video content to their subscribers and offer IPTV and OTT services via their entertainment platforms to their subscribers and sometimes also to customers of other ISPs. Currently, large access ISPs offer highly innovative IP-based video packages that include linear and non-linear TV (i.e., legacy broadcast TV channels and live and on-demand content), exclusive content (e.g., original content or live streaming of major sports events [recently, European OTT provider DAZN has attracted much attention for delivering soccer matches in Spain (La Liga) and Italy (Serie A)]), bundled subscriptions with popular third-party OTT services like Netflix or Disney+, and also integrating other third-party OTT services like Amazon Prime Video. These packages constitute IP-based substitutes for legacy TV offerings, thus increasing network traffic by shifting content and associated traffic from legacy non-Internet delivery models to broadband. For example, Deutsche Telekom offers MagentaTV (Telekom Deutschland, 2022; Donegan, 2021) and Telefónica offers Movistar Plus (Telefónica, 2018, 2020; Hopewell & Lang, 2022). Based on numbers from 2019, the Netflix option which Telefónica offered has been reported to be chosen by 35% of the customer base, thus indicating Netflix’s popularity and potentially hinting at a positive impact on Telefónica’s subscriber growth (Hopewell, 2019).

<sup>51</sup> A few aspects are interesting to mention in this context. First, ISPs sell direct cloud access products (e.g., Orange Business Services, 2022a), sometimes even advertising such products as helping business to become more sustainable (e.g., T-Systems and Google Cloud) (T-Systems, 2022a). Second, ISPs partner with cloud providers to help businesses to innovate and transform (e.g., Orange Business Services, 2022b) or to offer sovereign cloud products in compliance with GAIA-X (e.g., T-Systems, 2022b). Third, ISPs may collaborate with cloud providers in the context of 5G edge capabilities (e.g., Telefónica and Google Cloud) (Google Cloud, 2020). Fourth, large access ISPs offer innovative IP-based entertainment platform services, thus emphasizing the role of “access + content”-based value propositions of ISPs (see Footnote 50). Fifth, in the past, European ISPs marketed zero rating deals to their mobile customers in which they granted access to the applications of partner providers without counting respective usage against subscribers’ monthly data caps. Especially the latter two aspects suggest that ISPs – in their pursuit of strengthening their value proposition – have made efforts to attract OTT content and incentivize their usage, thereby deliberately encouraging heavier network usage and growing traffic loads in their networks.

Access ISPs are part of a transformed and continuously evolving Internet infrastructure and service provider landscape that has given rise to greatly expanding technical and business model options for embedding and accessing digital information technology resources. Dominant trends have contributed to improved service quality (data rates, usability, customizability, reliability, etc.) and reduced total costs, which, in turn, act as critical drivers of growth in demand and create opportunities for innovation and entry into the expanding Internet ecosystem.

This more complicated landscape requires participants to adapt – they must simultaneously cooperate (to ensure that their services interconnect and interoperate) and compete with those same service providers. Managing and routing traffic in today’s Internet and considering the needs of future Smart-X applications calls for expanded access to edge (cloud) computing and storage (caching) resources that are needed to reduce overall network costs, enhance performance (reduce latency and improve data rates), and facilitate that future demands can be accommodated. Responding to this need has helped propel the transformation of the Internet routing topology and the rise of cloud service providers, including CDNs. It has also changed the ways in which edge providers deliver their services and how they interconnect and interact with ISPs and other Internet ecosystem providers.

The ETNO Report grossly oversimplifies and fails to adequately capture how the markets for interconnection, content delivery, and providing Internet broadband infrastructure have changed over the last two decades. As this section has underscored, an appreciation of the more complex strategic landscape confronting last-mile access ISPs and other key providers of Internet infrastructure and services is necessary to meaningfully and holistically assess the networking infrastructure challenges that need to be addressed on the path to our digital future, both with respect to the diversity of investment needs and the contribution by different providers. Among the key providers in the ecosystem are the OTT providers who are the subset of edge providers that are the focus of the ETNO Report’s analysis.

### 3. The ETNO Report Fails to Make a Useful Contribution

#### Highlights

- The **ETNO Report fails to clearly identify a regulatory problem**
  - It fails to demonstrate that OTT traffic growth is a problem in need of a solution.
  - It ignores how ISPs and OTTs have adjusted to accommodate exponential traffic growth.
  - It asserts without adequate evidence that OTTs have superior bargaining positions that precludes market-based solution to the alleged problem.
  - The assertion of “unfair” OTT contribution to infrastructure ignores the OTTs’ complementary investments and innovations.
  - The alleged funding shortfall for future infrastructure investment is not demonstrated.
  - The simplistic comparison of metrics like stock market performance of large OTTs versus European ISPs provides little relevant insight.
- The ETNO Report’s **analysis of the effects of regulatory action (or inaction) is flawed**
  - The argument that access ISPs will fail to invest without an OTT financial contribution is unsubstantiated and contrary to historical experience.
  - The ETNO Report ignores strong incentives that ISPs have to embrace new business opportunities that investment in 5G will enable, as well as the resulting traffic growth.
  - The ETNO Report fails to consider the importance of complementary investments and complex coopeition incentives requiring OTTs, ISPs, and other key stakeholders to jointly contribute to the realization of the Next-Generation 5G infrastructure.
- The ETNO Report’s **evaluation of suggested remedies is flawed**
  - Even if one assumes (contrary to the available evidence) that a funding shortfall or unfair allocation of cost burdens is likely to exist, the ETNO Report jumps to recommending a selective and excessively strong form of regulatory intervention.
  - This recommendation is offered without adequate support at any point, and without adequately considering simpler, less-intrusive, and less-market-distorting alternative regulatory approaches.
  - Mandating financial contributions from a handful of large U.S. OTTs to ISPs without adequate foundation adds noise to regulatory policy discussions, without making a useful contribution.

In this section, we set forth our high-level and more detailed criticism of the ETNO Report’s deficiencies. Even though the ETNO Report embraces the Internet’s progress and growth that has been encouraged by the regulatory policy trajectory over decades, the report fails to acknowledge and adequately reflect key features of today’s Internet ecosystem. In the following, we summarize the ETNO Report’s key arguments, then address the major flaws and weaknesses in the ETNO Report that explain why the ETNO Report fails to make a useful contribution for policymaking consideration.

#### 3.1. Summary of ETNO Report Arguments

The central point of the ETNO Report is that it recommends the adoption of mandatory (traffic-based) interconnection payments from OTTs to access ISPs to ensure their contribution to usage costs of traffic. While pointing to the large share of OTT-related traffic in the overall Internet traffic mix,<sup>52</sup> the ETNO Report builds its argument as follows. Section 4 of the ETNO Report

<sup>52</sup> The ETNO Report uses data on global Internet traffic shares provided in the Global Internet Phenomena Report by Sandvine (2022). Sandvine’s report offers a comprehensive overview of broadband consumer networks and related Internet usage including detailed insights into the mobile traffic mix (Sandvine, 2022, p. 16) and the traffic mix for the EMEA region (Sandvine, 2022, p. 21). However, the ETNO Report does not refer to these insights. Moreover, even though emphasizing broadband-related benefits to GDP, employment, etc., the ETNO Report’s narrative focuses somewhat narrowly on the consumer Internet, thus failing to capture the scope of the EU’s digital targets for 2030, including the “digitalization of businesses” as one of their cardinal points (EC, 2021, p. 2). Similarly, the Explanatory Memorandum of the proposal for the “Path to the Digital Decade” program highlights “[t]he EU’s ambition ... to

justifies its recommendation by arguing that such an intervention would be feasible and easy to do since (according to ETNO) it is apparently compatible with existing regulatory principles requiring “fair and proportionate contribution to the costs of public goods, services, and infrastructures” as stated in the European Declaration on Digital Rights and Principles for the Digital Decade (EC, 2022a, p. 3). The concept of fair compensation is similarly included in the EU’s Digital Markets Act (DMA). Section 2 of the ETNO Report argues that its recommended intervention is necessary because access ISPs are in an inferior position to large OTTs. Three claims are made. First, access ISPs are not in the position to negotiate interconnection payments (because of excessive OTT bargaining power) that would allow them to recover the incremental traffic-related costs of carrying OTT traffic.<sup>53</sup> Second, there is no other alternative for recovering those costs. Third, cost recovery of the traffic-related costs is necessary to enable ISPs to invest to meet the EU’s 2030 connectivity targets.

In building its argument, the ETNO Report utilizes a “stick/carrot” logic, suggesting that failure to act as they recommend will doom the EU 2030 connectivity targets and the (range of) benefits that those are anticipated to deliver. In Section 2, the ETNO Report argues that access ISPs cannot meet investment needs, which presents the “stick”. In Section 3, the ETNO Report introduces the “carrot” as it goes on to argue that the adoption of the ETNO Report’s proposed scheme will increase investment in broadband, thus not only helping to achieve the EU 2030 connectivity targets but also delivering significant incremental gains in GDP, jobs, innovation, and sustainability.

While we acknowledge the importance of the topic and debate, in the following sections, we will explain that this stick/carrot narrative is overly simplistic. More importantly, it fails to consider the state and economics of interconnection and content delivery as described in Section 2 of this paper and completely fails to justify the preemptive, overly hasty, and arguably radical departure in the direction of regulatory policy the ETNO Report advocates. Before undertaking a significant intervention that would effectively reverse the trajectory of regulatory policy that has contributed to the growth and success of the Internet, it should be clear that a problem even exists. Undertaking an intervention that leaves many less disruptive and less risky regulatory strategies unexamined and is based on the ETNO Report’s characterization of a problem that may be completely illusory would put at risk the successes realized to date. It would further imperil the future that the ETNO Report claims is at risk if its recommendations are not followed.

Our analysis shows that moving ahead with any such drastic change in regulatory policy ought to be subject to serious evaluation before being adopted. We demonstrate that the ETNO Report fails to provide a holistic evidentiary review to substantiate either its characterization that any problem requiring regulatory intervention even exists or its recommendation. Despite the importance of the issue at hand as regulators worldwide grapple with similar questions, the ETNO Report fails to make a meaningful contribution for policy reform consideration.

### 3.2. ETNO Report Failures Summarized

In this section, we will demonstrate how the ETNO Report fails at three levels. *First*, it fails to clearly identify a regulatory problem (below in Section 3.2.1). *Second*, the analysis of the effects of

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pursue digital policies that empower people and businesses to seize a human centred, sustainable and more prosperous digital future” (EC, 2021, p. 1).

<sup>53</sup> The ETNO Report states: “EU Telcos are placed at serious disadvantage in negotiating their legitimate commercial interests when these are at odds against those of OTT providers. The situation tilts the scale radically towards the benefit of OTTs and does not allow network operators to negotiate fair terms with regard to their network costs” (Axon Partners Group, 2022, pp. 19-20, Footnote omitted).



regulatory action (or inaction) is flawed (below in Section 3.2.2). *Third*, the evaluation of suggested remedies is flawed (below in Section 3.2.3). Whereas all three constitute necessary elements to justify sound regulatory policy interventions and thus also the ETNO Report's aggressive regulatory recommendation, we explain logical, methodological, and analytical failings related to each of these three elements.

### 3.2.1. ETNO Report's Failure to Identify Problem Requiring Regulatory Intervention

#### Highlights

- The ETNO Report **fails to show OTT traffic growth is a problem in need of a solution.**
  - Double digit growth rates for Internet traffic have been the norm and have been accommodated by investments in infrastructure and adjustments in traffic management practices by ISPs and OTTs that have accommodated exponential traffic growth without dramatic increases in the annualized costs for network upgrades by access ISPs.
  - Next-Generation 5G investments are not driven by the growth in OTT video-traffic, but by the desire to enable a much richer set of applications and services, requiring cooperative and complementary investments by multiple value chain participants to enable Smart-X applications to become a reality.
  - If all that was needed was to manage continued growth in content-streaming services, much less investment in 5G infrastructure would be required.
- The ETNO Report **fails to demonstrate that OTTs have a superior bargaining position relative to ISPs.**
  - OTTs and ISPs are mutually co-dependent. Just as ISPs need valuable content to attract broadband subscribers, OTTs depend on ISPs for last-mile access to reach their customers.
  - OTTs compete intensely with each other and with other contenders for OTT customer attention, whereas many broadband subscribers have limited options for last-mile broadband services.
  - Although ISPs have strong incentives to be able to offer their subscribers attractive OTT content, there is no evidence that any particular content is essential for ISPs to have a viable broadband service.
  - The ETNO Report fails to acknowledge the strong shared incentive that OTTs and access ISPs have in reaching individually and mutually efficient traffic management arrangements that enable good customer experience and future market growth and revenue.
  - Any assessment of so-called "fair contribution" must account for OTT investment in complementary infrastructure and strategies that reduce the costs of network build-out as well as OTTs' investments in content and attractive services.
- The ETNO Report **relies on irrelevant data to substantiate its claim that ISPs are facing a funding crisis that requires strong regulatory intervention.**
  - The simplistic comparison of stock market performance of large OTTs versus ISPs provides little relevant insight into bargaining positions for interconnection agreements between ISPs and OTTs or an inability to fund investments.
  - It presents a static picture of competition and fails to take account of the dynamic nature of markets, including the impact of new regulation such as the EU's Digital Markets Act (DMA).
- The ETNO Report's argument **does not provide the careful analysis and relevant evidence to be seriously considered as making a meaningful contribution to an important topic and debate.**

A fundamental weakness of the ETNO Report is that it fails to clearly identify and describe a problem that would justify the proposed regulatory remedy which it advocates. This lack of a problem statement renders the discussion of adequate remedies inherently meaningless. In the

following, we focus our discussion on two aspects. *First*, the claim that data traffic growth is the problem. *Second*, the claim that OTTs have excessive market power due to asymmetric bargaining positions.

### 3.2.1.1. *The ETNO Report suggests that data traffic growth is the problem*

The transition from legacy silo-based telecom networks with limited capabilities to deliver a closed set of services to today's general-purpose broadband platforms that can support an open and evolving set of more capable and diverse services at a lower total cost (per unit of traffic) is a hallmark of success – not a “problem” as the ETNO Report suggests. It is the result of organic market growth and a by-product of virtuous investment and innovation cycles. Traffic growth reflects application innovation and success on the one hand, and end-user adoption on the other. As we will explain, it also strengthens the value proposition access ISPs can offer to their customers.

The Covid-19 pandemic has arguably reinforced pre-pandemic investment and innovation cycles, shifting more social and commercial activity online, and amplifying the consensus view of the importance of the broadband Internet for society and the economy. Expanding capabilities of broadband access expand the scope for participation<sup>54</sup> and present a key driver of growing end-user demand for broadband services, the development and adoption of online and cloud services, and traffic growth for end-user consumers and business enterprises across Europe and the world.

Broadband connectivity is necessary but it is not sufficient for productive participation in the digital economy (e.g., Stocker & Whalley, 2018). Facilitating and broadening the scope for participation of end-users (citizens and businesses) is the result of collective efforts – innovations and investments made by multiple actors across the Internet ecosystem as discussed already in Section 2. It is the joint efforts of all of these Internet ecosystem participants that create the value proposition that drives end-users to become broadband subscribers of access ISPs and to use relevant services to access valuable Internet content and services that, in turn, results in increased traffic flows.

Internet traffic growth is good and normal. In fact, double digit average annual aggregate traffic growth rates of about 30% have been normal for years (e.g., Feldmann et al., 2020; Leighton, 2020). Accommodating that growth and addressing the market opportunity it represents has justifiably motivated access ISPs and the entire ecosystem (which depends on continued investment in the Internet and its associated infrastructures) to make significant investments in upgrading and expanding their networks. ISPs have long been accustomed to expanding the capacity of their networks in anticipation of the expected growth. When ISPs invest in capacity expansion, they do so in anticipation of the future traffic they expect to handle during peak periods which is a function of the services they expect to offer.<sup>55</sup>

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<sup>54</sup> While enterprises may, for example, innovate their services based on the integration of an ever-expanding range of cloud services, citizens may act as innovators (e.g., as app developers), consumers (e.g., streaming videos, playing games, or reading blogs), or content producers (e.g., as bloggers, educators, influencers on social media, or content creators on video platforms).

<sup>55</sup> As explained in Section 2, capacity expansions are made based on expected peak traffic growth. However, the relationship between more aggregate daily traffic and peak traffic and thus the need for network upgrades is complex. If, as during the pandemic, citizens work and educate themselves from home and use their residential broadband connections instead of their school, university or workplace environments to access online services, this leads to changed usage patterns, traffic matrices, symmetry of data traffic (i.e., upstream/downstream ratios), and probably dramatically increasing aggregate traffic. However, if this means that additional traffic is exclusively increasing utilization levels in periods that are normally off-peak, traffic peaks (that usually occur in the evenings) may be completely left unchanged. Chief Technology and Information Officer at BT, Howard Watson, reported the following

ISP network costs are mostly fixed (and in many cases sunk) and they occur in anticipation of expected peak traffic needs. Once the infrastructure is in place, costs do not vary significantly with the amount of traffic that may actually be carried over the infrastructure. There are many ways that OTT providers and access ISPs can manage traffic cooperatively and many ways to design applications and services to reduce, adapt, or balance traffic loads that can help reduce network costs. As discussed in Section 2, edge providers like OTTs and access ISPs have a shared incentive in ensuring broadband subscribers have a good customer experience. Together and separately, OTTs and access ISPs have available a range of complementary strategies to reduce the costs for managing growing aggregate traffic loads.<sup>56</sup>

For example, network topology and routing optimizations, the strategic deployment of servers close to customers (e.g., at IXPs or within access ISP networks), employing modern compression and dynamic bitrate adaptations (in response to current network conditions), (cooperative) traffic engineering and the intelligent redirection of end-user requests, and oversubscription ratios are technical tools that ISPs and OTT providers can tweak to reduce the total costs for provisioning for peak network capacity. Strategically scheduling the delivery of specific (cacheable) content to off-peak periods can vastly expand the aggregate volume of traffic that can be carried without significantly increasing total ISP network costs.<sup>57</sup>

As this suggests, accommodating the traffic growth has been feasible because of the significant technological progress and cost savings enabled by the complementary investments and cooperative involvement in traffic delivery discussed earlier by edge content and application providers, providers of ancillary services, and by end-users. Those complementary ecosystem investments and evolved forms of coordination between ISP and OTTs have made it feasible to accommodate exponential traffic growth without dramatic increases in the annualized costs for network upgrades by access ISPs.<sup>58</sup>

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during the first wave of the pandemic: “Since Tuesday this week, as people started to work from home more extensively, we’ve seen weekday daytime traffic increase 35-60% compared with similar days on the fixed network, peaking at 7.5Tb/s. This is still only around half the average evening peak, and nowhere near the 17.5 Tb/s we have proved the network can handle” (Watson, 2020). See also Stocker et al. (forthcoming).

<sup>56</sup> ISP costs consist of much more than just their network-related costs, the vast majority of which are capacity-related and do not vary with actual traffic levels. They also include their general overhead and sales and marketing related costs (e.g., costs of acquiring and retaining new subscribers, service design and pricing, etc.). The outcome of ISP and OTT negotiations will impact not just the network-related costs but also other costs potentially that are not the focus of the ETNO Report. Furthermore, ISP fixed costs vary significantly across and within countries depending on a host of factors including the state of broadband deployment and the upgradability of deployed technologies, population density, and topographical characteristics (e.g., Briglauer et al., 2020).

<sup>57</sup> Von Bornstaedt (2019, p. 201) provides an example of how Netflix voluntarily shifts traffic to off-peak times: “Netflix can predict with high accuracy what their members will watch at what time of day. This enables Netflix to use non-peak bandwidth to update their servers, which is appreciated by eyeball ISPs.”

<sup>58</sup> For example, Abecassis and Daly (2022, Figure 5 at p. 8) explore the cost saving potentials of the Netflix CDN called Open Connect. Their report suggests that total core and backhaul network costs for ISPs make about 10-20% of the total annualized network costs (with 80-90% of network costs associated with the access network) that are expected to remain rather constant. The report states (Abecassis & Daly, 2022, p. 8): “We find that traffic-sensitive costs are relatively stable over time: transmission capacity between existing nodes can be upgraded very cost-efficiently as demand increases (from 1 to 10 to 100Gbps, and beyond), and the cost of high-capacity transmission equipment keeps falling. In addition, Open Connect and other similar partnerships between content providers and ISPs (e.g. Google Global Cache) ensure that growing demand from end users can be handled effectively through deep caching and compression without growing costs over time.” In the same context, von Bornstaedt (2019, p. 200) explains: “Better coordination can save network costs. For a large network, 3% higher utilisation can yield several million Euro in cost savings. If the consumer ISP can run its core network at 33% average load after coordinating with the OTT, compared to 30% load at the same quality level as before, significant network cost savings can be realized.”

The resiliency and capabilities of today's Internet to respond swiftly to significant and unexpected increases in traffic were illustrated in the first wave of the Covid-19 pandemic. In the spring of 2020, nations around the globe enacted Covid-19 responses that required a massive and unexpected shift from physical to online and remote activity. To give an idea of the magnitude of the change during the pandemic's first wave: a year's worth of traffic growth had to be accommodated within 4 to 6 weeks (Feldmann et al., 2020). Moreover, since the primary location of Internet access (e.g., due to remote work or learning) was shifted to the homes of many European citizens, broadband usage patterns, as well as traffic matrices, changed. Flexible network management, new and upgraded (local) interconnections and links, and the use of cloud services helped to keep networks up and running and maintain customer experience at high levels. As we now know, the Internet coped rather well with the unexpected increases in data traffic growth and the changing usage patterns. In Europe, digital infrastructures, in particular the Internet, proved resilient enough to provide a lifeline for many during the pandemic (e.g., Briglauer & Stocker, 2020; Rexford, 2021; Feldmann et al., 2021; Cloudflare, 2021).<sup>59</sup> The Internet came under pressure but did not reveal systematic, structural, or persistent problems and European ISPs coped relatively well (Stocker & Whalley, 2021; BEREC, 2021). The Internet helped cushion the adverse social and economic effects of the crisis.

Looking ahead, neither the EU's 2030 connectivity targets for significant improvements in broadband network capabilities nor the hopes of ISPs to participate in the digital future are premised on the prospect of being able to deliver ever more streaming video and music entertainment to end-users (EC, 2021, 2022a, 2022b). Were that the ultimate goal, the right architecture would be to construct a broadcast network with asymmetric capacity optimized for downstream delivery (and hence only limited upstream bandwidth for selecting the content to be streamed). That is not the network that is being built.

The network that is being built must be capable of flexibly and adaptively scaling to and otherwise accommodating the heterogeneous demands of an evolving (and not yet known) range of applications and services provided by a variety of actors. In fact, it must enable 5G+ network services needed for Smart-X applications which will offer a wide array of heterogeneous services with vastly diverse QoS requirements. To deliver such an evolving variety of services to citizens and businesses and unleash the tremendous innovation potentials emanating from these networks, connectivity is necessary but not sufficient. Instead, facilitating and migrating to this digital future in a cost-efficient way places an emphasis on the criticality and complementary roles of connectivity and (local) clouds. This is recognized by the EU in their "Path to the Digital Decade" policy program (EC, 2021), which explicitly recognizes the role of cloud infrastructures and sets targets for cloud deployments,<sup>60</sup> and also in the Digital Economy and Society Index (EC, 2022b, p. 52). In this context, the ETNO Report is narrowly construed and fails to mention or account for the benefits associated with cloud infrastructures in terms of ICT cost savings, GDP, or employment.<sup>61</sup>

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<sup>59</sup> More detailed accounts of the changes in traffic across different ISPs and the demands for edge providers and their responses to cushion the negative effects and often joint efforts of different providers of the ecosystem are provided in Stocker et al. (forthcoming).

<sup>60</sup> The targets state that "by 2030 at least 75% of European enterprises should have taken up cloud computing services, big data and Artificial Intelligence" (EC, 2021, p. 3) and that "at least 10 000 climate neutral highly secure "edge nodes" are deployed in the Union, distributed in a way that guarantees access to data services with low latency (few milliseconds) wherever businesses are located" (EC, 2021, p. 24).

<sup>61</sup> See also Footnote 41.

The ETNO Report's narrative entirely neglects the Internet ecosystem's ability to accommodate significant expected and even unexpected and sudden surges in traffic growth, the investments and innovations made and tactics and strategies that were voluntarily employed<sup>62</sup> across a wide range of ecosystem participants – edge providers, ISPs, and others – for managing future traffic growth.<sup>63</sup> It also fails to mention the business strategies of large access ISPs that incentivize the usage of OTT services thus willingly increasing traffic and network loads. On the one hand, this can be observed by ISPs' entertainment platforms and their partnerships with large U.S. OTTs like Netflix or Disney+ and European OTTs like DAZN (which has been reported to cause much traffic related to the delivery of major sports events; e.g., Luciani, 2022) to strengthen their value proposition (see Section 2). On the other hand, zero rating offers incentivized the usage of OTT services by exempting them from subscribers' monthly data caps. Both strategies imply traffic growth, put additional strain on networks, and may involve partnerships with OTTs the ETNO Report would like to see charged for traffic.

### *3.2.1.2. The ETNO Report claims that OTTs have dominant bargaining positions*

First, it is worth noting that in spite of the many changes that have occurred over time, OTTs still do not own last mile networks in Europe. Hence, OTTs are wholly dependent on being able to negotiate wholesale relationships with (last-mile) connectivity providers in order to connect to their customers. Since customer experience is a key value proposition for many OTT providers, bringing content and applications close to their customers and delivering content locally via direct interconnections (one-hop) or intra-ISP servers (zero-hop) are preferred over indirect, multi-hop options (e.g., via transit). Depending on their service model and infrastructure situation, the first best option for many OTTs is to negotiate corresponding interconnection and hosting agreements with last-mile access ISPs or purchase relevant CDN services from third-party providers to deliver their services. In the context of cloud services for enterprise customers, managed cloud connectivity services may be preferred to get direct access to enterprise customers.

Bringing content and applications closer to their customers requires investments from edge providers. These investments not only reduce the distance data packets need to travel via the access ISP network but also yields cost savings for ISPs as noted earlier. Whereas different interconnection and hosting options imply different forms of cost sharing between OTTs and ISPs, expanded options for broadband subscribers to access OTT content provides OTTs with some measure of flexibility in the business models and technical options for how they get their content to their customers. OTT providers may, for example, have more flexibility in the pricing and service arrangements that they may separately negotiate with their customers and other revenue providers (e.g., advertisers). The set of options available to OTTs for reaching their

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<sup>62</sup> That is, the design, choice, and adoption decisions of traffic management and service provisioning practices by ISPs, OTTs, and other industry participants occurred within a light-handed regulatory framework that left detailed decision-making to market participants, but did not engage in the sort of strong decision-making interventions characteristic of legacy Public Utility regulation.

<sup>63</sup> Reflecting “traffic over internet bandwidth connected across international borders”, TeleGeography (2022c) provides insights into average and peak utilization levels in different Internet regions (per year). The data they provide (TeleGeography, 2022c, Figure 3 at p. 4) show that between 2018 and 2022 (and this includes the pandemic effects), average utilization levels in Europe have remained relatively stable at levels between 24% and 26% (with 24% in 2022). Similarly, peak utilization levels in Europe have remained rather stable between 40% and 44% (with 42% in 2022) over the same time period. These numbers indicate that those parts of the networks considered here have scaled and coped well in recent years.



customers also factors into their bargaining position when seeking to negotiate direct interconnection with a last-mile access ISPs.

However, the flexibility of OTT providers in how they sell and distribute their services to OTT customers is significantly limited by technological and competition forces. Many OTTs compete aggressively against each other for subscriber attention and dollars. For example, the large OTT providers (Google/YouTube, Amazon Prime Video, Disney+, Netflix, Hulu, HBO, Apple, etc.) compete aggressively among each other as evidenced by data on the high rates of customer churn experienced by OTTs.<sup>64</sup> They also compete with OTT offerings from legacy entertainment providers (e.g., cable television and satellite broadcasting providers) and a large and continuously changing array of niche content and application providers. In addition to competing with lots of alternative sources of programming content, the OTT providers that the ETNO Report focuses on also have to compete with other online and offline providers of products and services that compete for a share of consumer leisure activity expenditures. Those include games, education, live entertainment, and a host of other personal services – all of which have both online and offline offerings. This competition occurs both in the battle for subscribers and their attention, as well as in the quest to (i) facilitate the production of user-generated content, and/or (ii) secure the rights to valuable content (programming).<sup>65</sup> In short, as user attention and activity is critical for their success and to stay abreast of their competitors, large OTTs compete fiercely for end-users and thus broadband subscribers – and to retain those subscribers, OTT providers are continuously pushed to ensure that their services deliver a high-quality broadband Internet customer experience. This ensures that OTTs have a strong vested interest in ensuring that the access ISPs that OTTs depend on are economically viable and incentivized to continue to invest in enhancing the quality of broadband access networks.

Conversely, the value proposition of access ISPs critically hinges on the range of content and application services their subscribers can access (and the customer experience they support).<sup>66</sup> The ability of an access ISP to sell fast (higher-priced) broadband services to their subscribers depends on the ISP's ability to enable its broadband subscribers to access popular content and applications. The ETNO Report implicitly relies on this fact to justify its claim that it is not an option for access ISPs to fail to negotiate direct interconnection agreements with OTTs. However, the ETNO Report goes further, implying without any relevant supporting evidence that access ISPs are

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<sup>64</sup> Although most broadband subscribers are also subscribers to paid subscription services offered by OTTs like Netflix, Amazon Prime, HBO, and others, many OTT subscribers change the mix of services they subscribe to, resulting in high churn rates (i.e., usually reported as the percentage of customers who terminate or suspend their service during the billing period). For example, “OTT subscriber churn in the US hit 44% in Q1” of 2021 according to Thomson (2022) referring to data from Parks Associates. More recent data by Parks Associates on OTT churn in the U.S. underscores this. On the one hand, their data underlines the role of multi-homing: while 80% of U.S. broadband households have one or more OTT subscriptions, 49% have at least four OTT subscriptions. On the other hand, OTT consumer churn has been measured at an all-time high in Q3 of 2021 at 45% (Streaming Media, 2022).

<sup>65</sup> While competition between streaming platforms has due to its high intensity been referred to as “streaming wars” (e.g., Mouriquand, 2022), in 2017, Netflix CEO Reed Hastings explained that basically everything that draws attention from their services is competition, even sleep. In this context, Hastings was reported to have said: “but think about if you didn’t watch Netflix last night: What did you do? There’s such a broad range of things that you did to relax and unwind, hang out, and connect—and we compete with all of that” (Raphael, 2017). That being said, preferences for OTT services can change over time. A recent survey by Pew Research (2022) showed that the usage of OTT services by U.S. teenagers aged between 13 and 17 has changed dramatically. For example, while Internet usage in general has increased, 95% of the teenagers ever use YouTube (with 19% almost constantly visiting/using it) and 67% use TikTok. While the use of Instagram has increased from 52% in 2014/2015 to 62%, the use of Facebook has plummeted to 32% – a dramatic drop from 71% in 2014/2015 – with 2% using it almost constantly (Pew Research, 2022, pp. 3-4).

<sup>66</sup> High levels of customer experience is a common denominator for OTTs and ISPs and arguably a key factor incentivizing partnerships and cooperation.

compelled by business necessity to carry the traffic of all of the large OTT services – even if OTTs fail to pay ISPs anything, and even if carrying such traffic imposes incremental costs on ISPs that threaten an ISP’s ability to recover its variable costs of operations.

The ETNO Report fails to address both the state of the interconnection ecosystem and the strong shared interest that OTT service providers and ISPs have to negotiate mutually economically viable interconnection agreements. Moreover, the ETNO Report fails to consider the other business strategies that ISPs are availing themselves of to address the challenges and opportunities posed by OTT traffic. The ETNO Report fails to mention that access ISPs are increasingly competing directly with OTT providers by offering their own OTT services to complement their non-OTT multimedia services (e.g., IPTV offerings) and bundling access ISP video services with other valuable consumer services (e.g., with telephony and other new services – bundles which OTT providers do not offer), raising opportunities for cross-service subsidization and improving access ISPs’ abilities to retain broadband subscribers.<sup>67</sup> In other cases, access ISPs are negotiating agreements for the distribution of OTT content as part of access ISP programming options.

Thus, contrary to the simplistic presentation in the ETNO Report, both OTTs and access ISPs have strong technical and market options that provide them with some flexibility and bargaining power, but both are constrained by competitive forces. What the ETNO Report fails to demonstrate or even seriously investigate is whether OTTs’ or access ISPs’ bargaining power is superior (let alone so dominant as to enable one party to fully dictate the terms of traffic exchange). More importantly, the ETNO Report fails to acknowledge the strong shared incentive OTTs and access ISPs have in reaching individually and mutually efficient traffic management arrangements that reduce total costs and thereby enable the future market growth in demand and revenue potential that both ISPs and OTTs are counting on.

In addition to failing to properly characterize the negotiating challenge confronting OTTs and ISPs, the ETNO Report relies on irrelevant data to substantiate its claim that ISPs are facing a funding crisis that requires strong regulatory intervention. To substantiate the claim that OTTs have a dominant bargaining position, the ETNO Report merely points to the large market capitalization values associated with some of the largest OTTs relative to the legacy ISPs. As explained above, the largest of the OTTs are global players with business ecosystems spanning many geographic and product market segments (often also offline and hardware). While many of the ISPs are also engaged across many product markets, the simplistic comparison of stock market performance of large OTTs versus ISPs provides little relevant insight into bargaining positions for interconnection agreements between ISPs and OTTs. The fact that the largest OTTs have grown rapidly and are valuable companies only means that they have likely generated a lot of value, have lots at stake (i.e., need to retain satisfied and engaged subscribers), and potentially have resources available to negotiate with other large players, which certainly includes the access ISPs which are in a “gatekeeper” position between OTTs and their subscriber base.<sup>68</sup> The market

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<sup>67</sup> ISPs have explored new ways of offering multimedia services (e.g., linear and non-linear TV offers as well as their own/exclusive content) and also bundling subscriptions of IPTV services with offers of third-party OTT providers like Netflix and Disney+. Again, integrating such offers and delivering them on an IP basis increases network traffic.

<sup>68</sup> Again, OTTs neither own last mile networks nor offer broadband access services in Europe. As Norton (2014, ch. 10) explains, this creates a gatekeeper position for access ISPs, leading to what he refers to as “access power peering”. He describes the scenario of interconnection tussles between access ISPs and video streaming providers (i.e., OTTs) in the context of the well-known Comcast/Netflix tussle that finally led to a paid peering agreement. Anticipating conflicts in the sphere of interconnection in the context of Internet-based video delivery, Norton explains that video content leads to in/out traffic ratios that violate standard peering requirements of ISPs. OTT video providers must reach their customers either directly (via peering) or indirectly (via transit or third-party CDN services) via the access ISP. As transit may not offer the same performance (more router hops, higher latency) and customer experience as

capitalization and size of OTTs does not allow one to infer – without proper, sound economic analysis – (i) whether or how the current situation is problematic,<sup>69</sup> (ii) more problematic than in the past when similar calls for payments by telco ISPs were rejected by EU regulators (e.g., Kroes, 2014; BEREC, 2017), or (iii) whether it would be economically viable for OTTs to make the significant mandatory traffic payments to access ISPs as recommended by the ETNO Report. In short, the ETNO Report’s superficial juxtaposition of irrelevant market statistics does not allow one to identify the excess profits that the report presumes (without evidence) exist in the OTTs’ revenues that could be transferred to ISPs.

Instead of providing evidence and informed analysis to clearly identify a problem and elucidate its precise nature, the ETNO Report waves a wand at OTTs, failing to recognize that the OTTs compete intensively for end-user attention and are highly differentiated, instead treating them as if the OTTs were a singular monolithic entity with obvious bargaining advantages in the context of direct interconnections.<sup>70</sup> Specific examinations of relative changes in bargaining positions between relevant actors over the last couple of years and the many partnerships that exist between OTTs and ISPs as explained in Section 2 above are missing in the ETNO Report. Moreover, existing paid (direct) interconnections that reflect the ability and willingness of (some) ISPs to charge OTTs are not mentioned.<sup>71</sup> Paid interconnections are obvious market-based mechanisms

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peering, Norton foresees that OTT providers will bring their content as close as possible to their customers and enter paid peering agreements with access ISPs.

<sup>69</sup> The meaningfulness of market capitalization comparisons is questionable for the issue at hand. At the same time, the dramatic losses in market capitalization experienced by OTT providers like Netflix (stock prices have decreased from a 52-week-maximum of \$700.99 to \$235.38 on September 15th, 2022 [at close, according to Yahoo! Finance]) can hardly indicate a loss in bargaining power against ISPs. Neither do we consider the recent positive financial results of companies like Deutsche Telekom, Telefónica, Vodafone, or Orange as a leading indicator of an improved bargaining position. Generally, when assessing market capitalizations, one needs to consider that the business models of ISPs and OTTs differ vastly between and within these categories. And so does value creation. As Van Alstyne and Parker (2021) explain, many of the large OTTs like Google (Alphabet), Facebook (Meta), Amazon, or Microsoft orchestrate platform ecosystems and have adopted platform-based business models based on organizational structures known as ‘inverted firm.’ In a nutshell, these organizational structures emphasize the role of external partners (e.g., complementors like third-party content creators or app developers and end users) in how firms create value. Instead of creating value via their employees and production, firms act as facilitators, orchestrating and coordinating the activity of and transactions between platform participants and the resources these bring in. Firms can thus nurture and participate in ‘external’ value creation, firm valuations are driven to a larger extent by intangible assets, and ratios of market capitalization per employee are high.

<sup>70</sup> The ETNO Report somewhat infers from the market capitalization of large U.S. OTTs and the current regulatory stance in the EU with regard to OTT content and service provision (particularly in the context of the DMA) that the same providers have an unfair advantage against ISPs in the interconnection sphere. Even though this narrative may sound appealing as it is familiar from DMA-related contexts and other ongoing legislative processes in the EU, the U.S., and beyond, this unfair advantage in the specific context of interconnection is not supported or proven by the ETNO Report.

<sup>71</sup> WIK (2022) and ARCEP (2022) explain that transit and paid peering (which in some circumstances sometimes also is referred to as “transit”) agreements currently exist. WIK (2022, p. 43), for example, reports that Deutsche Telekom routinely charges content providers while not admitting intra-ISP server deployments from third-party CDN providers or the OTTs’ own CDNs (WIK, 2022, p. 44). Even though data on relevant contracts, their numbers and the payments involved, as well as conflicts, is generally scant due to non-disclosure agreements, the reports by ACM (2021), ARCEP (2021, 2022), BEREC (2022) and WIK (2022) neither conclude nor suggest that regulatory intervention of the sort proposed and advocated by the ETNO Report is necessary or inevitable at this point. In the political arena, the topic remains contested: even though strong opposition against the regulation has formed among MEPs (Bertuzzi, 2022a) and several NRAs warned against overly hasty decision (Bertuzzi, 2022b), other EU Member States have supported similar interventions as those suggested in the ETNO Report (Pollina and Fonte, 2022). More recently, MVNO Europe, an association of European Mobile Virtual Network Operators (MVNOs) that comprise businesses providing IoT, M2M or public sector related business models, has cautioned against the introduction of the proposed interconnection regulation. While they state that this would imply that large telecom providers would be paid three times (i.e., by their subscribers, OTTs, and alternative operators like MVNOs), they conclude with the following

that ISPs could avail themselves of without requiring the preemptive and strong interference by EU regulators into previously unregulated interconnection markets as advocated by the ETNO Report.<sup>72</sup>

Building upon the unsupported claim that OTTs have insurmountable bargaining advantages, the ETNO Report asserts without evidence that OTTs are not currently making a “fair contribution” to support the costs of infrastructure build-out. We have already explained that OTTs invest in complementary infrastructure (e.g., transport and clouds), employ strategies to reduce the costs of network build-out, and that OTT traffic likely contributes little in the form of traffic-sensitive incremental costs since most of the network costs are fixed and do not vary with the actual traffic that networks are called upon to carry. Of course, one might argue that OTTs ought to contribute to recovery of the total costs of access ISPs which includes the fixed costs. Even if one recognizes that as an argument worth considering, in view of the ecosystem’s complexity and diversity, the ETNO Report’s overly simplistic analyses does more damage than good. In addition to more carefully characterizing the nature of the perceived problem, any analysis of remedies that might require OTTs to contribute (if indeed a problem requiring such a contribution were found to exist, which the ETNO Report fails to demonstrate), should consider their capacity for contributing and options for how to obtain that contribution that are less disruptive and distortive ought to be examined first.

When assessing the contribution of OTTs, it is clear that considerable resources and significant investments by OTTs are required to provide and distribute OTT content and services that, as we explained, significantly contribute to the value proposition of ISPs. Assessing the exact investments per OTT is non-trivial because of the complexity and diversity of their business and revenue models and the types and variety of (digital and non-digital) products and services they offer – investment needs differ vastly between different OTTs.

Whereas access to valuable content and services (at good customer experience) is a central part of the value proposition of broadband access services (although how valuable different content and services are to different customers can vary significantly), valuable content and applications can potentially be acquired via other access means (e.g., not depending on OTT broadband delivery). It is thus unsurprising that several large access ISPs invest in the development, creation, and acquisition of valuable content and services which attests both to the economic viability and reasonableness of such a strategy.

Moreover, the most logical strategy for addressing any shortage of funding for local access infrastructure (once one has explored and adopted all efficient strategies for ensuring those costs are no larger than necessary<sup>73</sup>) is to charge the subscribers for that service – and who request the content provided by OTTs – directly. That is, to raise broadband subscription prices or change the terms of broadband pricing (e.g., to time-of-day pricing or to differentiated tier pricing – both of which are consistent with network neutrality and other existing regulatory permissions) to address those funding shortfalls. If higher broadband prices threaten subscribership, the entire

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drastic statement: “All in all, the ‘theory’ of ‘fair sharing’ seems essentially a claim advanced by a small group of large telecom operators who, losing their historically inherited centrality in the system, react by demanding compensation from the players who have taken better advantage of the technological changes” (MVNO Europe, 2022).

<sup>72</sup> Note that according to Norton’s (2014) litmus test for paid peering, non-monetary elements that cause asymmetric peering costs may qualify as paid peerings. See also our discussion in Section 2.

<sup>73</sup> For example, employing edge caching and other routing and traffic management strategies such as those documented earlier to lower the costs of handling growing traffic loads.

ecosystem has an incentive to offset those outcomes, possibly by increasing content quality or reducing the fees charged to access OTT services (if, indeed, such options are economically viable).

### 3.2.1.3. *Summary*

Despite the ETNO Report's claims, traffic growth is not a problem that threatens the future of network investment but a mark of the success of the ecosystem in providing sufficiently compelling valuable services to consumers. This success warrants continued spending by broadband subscribers and service providers across the ecosystem. Additional investments are needed in the last-mile networks, ancillary cloud and data center infrastructure, and edge provider content and services that end users demand. Access ISP business models have grown more complex and they confront more competition in capturing the value created by the ecosystem. However, the ETNO Report provides no evidence to lead one to conclude that access ISPs are failing to recover their costs or are in danger of that happening in the future. The ETNO Report does not demonstrate that ISPs confront a funding problem. However, even if one were to accept that such a problem exists (contrary to the available evidence), the ETNO Report also fails to show how any such funding problem is due to the current interconnection arrangements with a handful of large U.S. OTTs.

The ETNO Report lacks coherence and fails to clearly identify a problem requiring regulatory intervention. The analysis is incomplete and one-sided, commingling different aspects and selectively listing a range of (alleged) problems, thus obfuscating their main argument, problem, and root cause, they seek to be addressed via their proposed recommendation.<sup>74</sup> Whereas this provides the basis for establishing the stick/carrot narrative, the ETNO Report's argument does not provide the careful analysis and relevant evidence to be seriously considered as making a meaningful contribution to an important topic and debate.

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<sup>74</sup> On the one hand, the ETNO Report identifies market power and asymmetric bargaining power as key arguments (which they do not support by necessary evidence). On the other hand, the report introduces a range of arguments related to externalities (e.g., GDP, employment, innovation, and sustainability) and what a fair contribution to the roll-out of next generation gigabit or 5G-based network infrastructures should be.



### 3.2.2. ETNO Report's flawed analysis of effects of regulatory action (or inaction)

#### Highlights

- The **argument that ISP providers will fail to invest without significant funds by OTTs to pay for ISP investments is unsubstantiated and contrary to historical experience of the sector.**
- In simply asserting, without evidence, that the ISPs will fail to be able to continue to invest, the ETNO Report **neglects to consider the fact that the ISPs expect to be able to expand the range of services and revenue-generating opportunities that 5G will unlock.**
- The ETNO Report's **focus is clearly a mischaracterization of the overall investment challenge regarding requisite network infrastructure** (and the role of complementary investments and innovation by different ecosystem actors).
  - Enabling the Next-Generation 5G infrastructure will require more complex and complementary investments by multiple stakeholders involving much more than basic bit transport network infrastructure and ISP-driven investment.
- The ETNO Report's **assertion of the need for mandatory financial support from OTTs for ISP investments fails to adequately consider more natural, less intrusive and distorting market-based or regulatory interventions** to the alleged funding shortfall.

In addition to its failure to state a problem requiring regulatory intervention, the ETNO Report's analysis of the economic implications of its recommended intervention is fatally flawed.

The ETNO Report simply claims without evidence that a failure by EU regulators to act aggressively as they recommend will doom the EU's 2030 connectivity targets and the economic benefits that the next stage of growth are expected to bring. The ETNO Report simply asserts that the investment that they estimate is required to realize fiber and 5G deployment targets will not happen without direct contributions from a (selected) handful of the largest providers of digital content and services via the mechanisms they propose. Even though this is the "stick" the ETNO Report suggests, it rests solely on unproven assumptions. Prior evidence suggests that this is not credible: access ISPs have invested significantly and continuously in the past even in the face of margin pressure and increased demand for capital-intensive infrastructure. The history of the growth of the Internet and of information technology more generally is one of continuously expanding capabilities, falling costs and prices, and growth. The number of connected devices, the traffic per device, and diversity of traffic types and sources, and of course, the aggregate traffic carried over the Internet have all increased over time. Despite (slightly) declining industry per unit revenues (that is, as measured by such common metrics such as Average Revenue per Unit (ARPU) or \$/MB), the ISPs that provide last-mile mobile and fixed networks have continued to invest and successfully accommodate exponential traffic growth for years. The ETNO Report documents this history of capital investment by the industry.

Moreover, we explained in previous sections that ISPs were not the only entities that needed to and did invest significantly in expanding the capabilities of digital computing and communications networks. End-user enterprises and home users, cloud (service) providers, and content and application providers have also been investing significantly. The collection of all of these parties investing in expanding their capabilities to access and make use of ever-more-resource intensive and rich multi-media services is what has enabled the markets for digital services and the associated traffic to grow. The truth of this was demonstrated during the worst of the Covid-19 crisis when ISPs and OTT providers proactively took steps to ensure the Internet continued to operate and

avoided major problems even in the face of unforeseen and dramatic surge in traffic loads (see also Section 3.2.1.1 above).

The growth in digital markets and traffic has changed the demand and costs for provisioning next generation digital infrastructure. On the one hand, there is a much greater need for capabilities to support increasingly digital resource intensive applications (i.e., for connectivity *and* computing capabilities) with much more locally-variable, “on-demand” availability.<sup>75</sup> On the other hand, ensuring that this need is met most efficiently and at lowest possible cost requires the coordinated activity of many industry participants and is not addressable solely via increased investment by access ISPs. Enabling the efficient (cost-minimizing) delivery of increasingly resource-demanding and complex products and services shifts cost structures and value chain interactions, thus motivating industry participants to adapt and restructure their business models and interactions to better respond to these changes. In this context, adaptive capacity emerges as a chief advantage of market processes. The rise and role of clouds and CDNs as a way to flexibly address the challenges of meeting growing demand for cacheable content and services and the trend toward local edge-caching and computing are obvious examples for this.

On top of that, other new business models and strategies are likely to be needed for managing the increased last-mile costs of deploying 5G small cell infrastructure. These may include expanded decoupling of passive/active components and restructuring of how different resources or assets are provided. Passive resources like conduit, outside poles and antenna sites are already being provided by third-party antenna companies like Crown Castle and American Antenna that helped reduce the costs of deploying earlier 1G-4G networks by avoiding the need for excessive duplication of antenna site locations: the antennas were shared. These companies and other new entrants are investigating how best to meet the 5G need for many more small cell antenna sites. Like with WiFi hotspots, many of the small cell deployments are likely to be deployed by end-users and be located on end-user premises. Even if the software and control of the sites is managed by the ISP, the power, site rental, and other resources needed to enable the small cell to operate will be provided by the end-user.

In simply asserting, without evidence, that the ISPs will fail to be able to continue to invest as they did in the past to meet the market opportunities, the ETNO Report neglects to consider the fact that the ISPs expect to be able to expand the range of services and revenue-generating opportunities that 5G will unlock. One example is to expand ISPs’ own OTT offerings that compete with the OTT offerings that threaten to cannibalize their legacy video or voice services. By offering OTT access as an alternative way for ISP video customers to access ISP provided content, ISPs make their service more valuable and hence competitive with OTT offers. ISP OTT access makes it easier for some users to access their ISP content when away from home, or even in the home but via a device that is not connected to the legacy TV service.<sup>76</sup> In another development, OTTs and ISPs with their own content offerings are entering into cooperative distribution agreements that benefit subscribers and make it easier for end-users to select more

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<sup>75</sup> That is, the upper-tail of performance (QoS) required by the most demanding applications that are expected to be supported by our communications infrastructure is increasing and those upper-tail performance requirements differ across applications. For example, streaming video is typically less sensitive to latency than is video-conferencing; streaming video is also typically less vulnerable to bit-error-rates than are other forms of data transfers, like for example, control signal data. In addition to differences in the QoS requirements across applications, the applications that users need to use during the peak will vary across users, locations, and time.

<sup>76</sup> Such OTT access by large access ISPs is common for broadband providers in the US, especially legacy cable-based, but also for telco-based that offer entertainment video. We offered examples of European access ISPs that offer similar services above in Section 2.2.3.

easily and seamlessly among the expanding universe of content available online via the Internet or otherwise.

Another example is for ISPs to expand into markets for Smart-X services that are yet to develop but which are key drivers for the investment in 5G networks. Examples of services that exist today and which are expected to expand in the future include consumer cloud storage and home automation support services. The range of IoT-related services that may become important in future digitally-enhanced homes include better management of HVAC (heating, ventilation, and air conditioning), lighting, and home security systems; enabling home appliances to be online for continuous monitoring and software upgrades; and other services both in-the-home and around-the-community that ISPs may provide either directly to consumers or indirectly to other businesses interested in augmenting their services with Smart-X networked capabilities.

Finally, the ETNO Report does not describe the state of gigabit and 5G deployment in European countries and associated heterogeneous investment needs and fails to explain why ISPs will (systematically and inevitably) be unable to invest in fiber or 5G to reach the 2030 connectivity targets. The ETNO Report completely ignores the more obvious responses that ISPs have available and that regulatory authorities may be expected to rely on if additional or a faster pace of investment is deemed more socially desirable than ISPs are economically capable of supporting.

The most obvious response would be for ISPs to raise prices for broadband access, or if peak-usage traffic is the concern, shift to usage-sensitive non-linear pricing that will provide a signal to end-users to shift their demand off-peak and thereby help ISPs better manage their network capacity investments.

A second option would be for policymakers to use targeted public subsidies to address gaps in fiber or 5G investments, especially in high-cost or low-revenue-potential locales to help meet universal service goals.<sup>77</sup> Such targeted (universal service) subsidies that are focused on specific local needs (which will vary by community demographics, location, and availability of options for meeting infrastructure needs on a local level) offer a minimally distorting way for governments to actively engage in addressing such market failures as may exist in delivering advanced digital computing and connectivity capabilities to underserved communities.

More options exist, but the ETNO Report discusses none of them.

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<sup>77</sup> Several funding mechanisms have been available at the EU level for several years to support the roll-out of high-capacity broadband. These were, for example, driven by EU documents laying out a vision of a European gigabit society (EC, 2016a) and an EU action plan for 5G (EC, 2016b). These documents were published in 2016, and their goals are reflected in the EU's 2030 connectivity targets. Whereas these targets by far exceed the universal (safety net) broadband connectivity targets specified in the European Electronic Communications Code (EECC) (EU, 2018, Annex V), more recently, in responding to the Covid-19 pandemic, the EU established a novel instrument – the Recovery and Resilience Facility (RRF) – to support the recovery from the pandemic and the twin (i.e., digital and sustainable) transition. EU countries have submitted individual recovery and resiliency plans, thus signaling investment needs in a diverse set of areas such as connectivity, cloud capacities, or the digitalization of public administration and services. Darvas et al. (2022) provide an accessible overview of the national plans and the allocation of funds to the different areas. They show that grants and loans in the flagship area “Connect (Roll-out of rapid broadband services)” total up to €33.54B. While Italy's plan earmarks €12.73B in this area, Germany earmarks €2.20B and France €0.24B. As a comparison, for the flagship area “Scale-Up (Data cloud capacities and sustainable processors),” grants and loans across all national recovery plans add up to €5.30B.

### 3.2.3. ETNO Report's flawed analysis of remedies

#### Highlights

- The ETNO Report **does not provide an evidentiary review of the state of interconnections and content delivery in Europe.**
- The ETNO Report **does not demonstrate that a state of unfairness exists** and that edge providers (i.e., OTTs) should contribute more than they already contribute to recover the cost of (last-mile) network infrastructure via the regime the ETNO Report recommends.
- The ETNO Report's **recommended regulatory approach is...**
  - overly intrusive and distortionary;
  - inconsistent with decades-long traditions in regulatory reform;
  - selective and asymmetric, provider-specific, and application-specific; and
  - ought to be examined only after other more market-friendly and less intrusive options are considered.
- **Alternative options** to facilitate the provision of **next generation digital services include:**
  - A *first set of options* relates to facilitating more flexible architecture for end-to-end approaches involving edge, connectivity, and other players.
  - A *second set of options* relates to removing regulatory impediments that restrict ISPs' commercial arrangements and may call for other regulatory policies, such as Universal Service Fund (USF)-type subsidies.
  - A *'last resort' set of options* relates to reinstating some form of retail or wholesale direct price regulation (of the sort recommended by the ETNO Report).
- Any proposal for regulatory reform **ought to be supported by a comprehensive analysis of the sector to examine the likely policy impacts.**
- The ETNO Report **fails to make even a minimal effort to address that obvious standard for sound policy-making.**

Before considering regulatory interventions, the ETNO Report ought to demonstrate – instead of simply asserting without evidence – that a state of unfairness exists and market-based alternatives, voluntarily adopted by industry participants, are insufficient to arrive at efficient allocations of the relevant investment burdens associated with realizing the digital infrastructure goals that are in the mutual best interests of both ISPs and OSPs (including OTTs). However, the ETNO Report does not provide an evidentiary review of the state of interconnections and content delivery in Europe. As a consequence, it fails to demonstrate that the change in the direction of regulatory policy it advocates is warranted and that its proposed regime, which requires that edge providers (i.e., OTTs) should contribute more than they already contribute in order to recover the costs of (last-mile) ISP network infrastructure, is appropriate. We explained this in previous sections.

However, even if one assumes that edge providers ought to be contributing more than they already contribute to the recovery of the costs of (last-mile) infrastructure, the solution recommended by the ETNO Report is among the last options that ought to be considered. If regulatory options are called for, they should focus first on removing impediments to market-based solutions and opt for the least intrusive and distortionary intervention feasible to avoid causing more harm by the intervention than is necessary.

**The first obvious set of options relates to architecture adjustment impediments.** Exploiting opportunities to interconnect and deploy edge caches locally is among the first obvious set of options to (i) enhance the reliability and performance of service delivery, (ii) improve the customer experience of accessing the OTT content and services that comprises the vast majority of the traffic that the ETNO Report finds problematic, and (iii) reduce the traffic on upstream parts of

the networks, thereby yielding cost savings and reducing investment requirements. At their core, such strategies imply a modification of the cost-sharing between edge providers and ISPs based on complementary investments. A natural line of regulatory investigation would thus be to focus on why expanded use of these options is not being more fully exploited. Impediments to such approaches should be investigated, especially those due to business strategy, for example, whether ISPs deny intra-ISP servers of third-party edge providers within their networks on a per se or selective (i.e., provider- or application-specific) basis.<sup>78</sup> This first set of options is important since innovative approaches and architectures that combine high-capacity and low-latency connectivity with (local) computing capabilities are slated to play an ever more critical role in facilitating ecosystem innovation and paving the way to our digital future. They provide the infrastructural basis capable of efficiently accommodating emerging demands from new applications and use cases (e.g., those related to the IoT, AR/VR, etc.).<sup>79</sup> Such a future will be characterized by evolving, flexible architectures and end-to-end delivery approaches, emphasizing complex and diverse value chains and the need for evolving forms of collaboration and coordination between connectivity, edge, and other providers.

**A second set of options relates to business contracting and interconnection negotiation impediments.** The ETNO Report mentions the highly regulated environment in which ISPs in the EU operate. Regulatory impediments to optimal pricing, which may include modified end-user pricing (including higher flat rates, usage-sensitive pricing, changed service tiering) and/or negotiation of win-win value creation interconnection arrangements (including paid peering or other routing arrangements, of which there are many) ought to be investigated. Such investigations may include looking at regulatory constraints that hamper the ISPs' ability to negotiate (e.g., due to network neutrality regulations) and may call for other regulatory policies, such as Universal Service Fund (USF)-type subsidies to address end-user/digital divide affordability gaps when end-user prices are set efficiently.<sup>80</sup>

**Direct price regulation of the sort recommended by the ETNO Report should be considered only as a last resort option, and if considered, ought to investigate both wholesale and retail rate settings.** Any such intervention is heavy-handed. It is costly from a direct regulatory perspective and indirectly costly because of its potential for adverse impacts on competition, innovation, and the healthy functioning of markets across the EU and internationally. Serious consideration of any such strong regulatory intervention should require a thorough and holistic evidentiary review to identify the need for such interventions and include a well-supported and more detailed analysis of the problem, the proposed remedy, and its likely implications. Only then can a compelling case for the need for such intervention be made and a suitable, focused remedy be designed and implemented. In this context, it should be noted that direct price regulations are out of step with the broad move to minimally invasive light-touch regulation in

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<sup>78</sup> In this context, one could imagine that regulated interconnection prices as advocated by the ETNO Report could lead to undesirable (and perhaps unintended) distortions and inefficiencies as such prices might disincentivize ISPs to opt for the deployment of intra-ISP caches. If content is deployed via intra-ISP caches (deep) within access ISPs, zero-hop content delivery implies that (significant portions of) content is delivered to requesting end-users without traversing interconnection points (see Figure 3 in Section 2.2.2). This confronts eyeball ISPs with a trade-off: cost savings (and other benefits) due to zero-hop delivery are weighed against losses in interconnection revenues as this reduces interconnection traffic charged at regulated interconnection prices. Strategic considerations like a (perceived) loss of control may further complicate the trade-off and may ensue in economically inefficient and perhaps even discriminatory outcomes. These are complex issues that market participants will need flexibility to resolve.

<sup>79</sup> See also Footnote 14.

<sup>80</sup> For example, a similar discussion in the U.S. (where strict network neutrality regulations are presently not in place) currently explores ways to expand the contribution base to a USF solution to make big tech companies contribute to infrastructure investments (e.g., Dano, 2022).



which such interventions are generally considered as a “last resort” policy tool. If the price regulation involves a mandate for cost contribution, then it must also mandate cost monitoring and some form of rate-of-return (or mark-up) regulation which is in itself fraught with difficulty.<sup>81</sup> Such an approach would imply a return to utility-style regulation tolerable in the telecommunications era but utterly unsuitable for complex, diverse, and dynamically changing environments characterized by an evolving range of co-evolving ecosystem providers. It is unsuitable for the current and desired future for advanced information technology infrastructure needed by Europe and other digitally advanced economies today and in the future.<sup>82</sup>

From a high-level perspective, the ETNO Report proposes and advocates remedies without a careful and holistic evidentiary review that would be required to demonstrate the need for intervention and the suitability of the proposed remedies. Instead, the ETNO Report provides no coherent guidance on an appropriate standard. Neither the claims nor the conclusions the report makes are obvious or proven. Instead, it relies on hand-waving and claims of obvious “inference,” thus building the simplistic stick/carrot narrative predicated on axiomatic arguments. Questions about the exact problem, what a “fair,” “reasonable,” or “proportionate” contribution by OTTs might be, and how to reliably assess this remain widely unsupported and underexplored by the ETNO Report. The evidence the ETNO Report provides in this context is a report by Frontier Economics (2022) commissioned by Deutsche Telekom, Orange, Telefónica, and Vodafone. Whereas aspects of cost causality were discussed above in Section 3.2.2, the Frontier Economics report itself states that their “estimates are illustrative of the relevant costs and cannot be construed as indicative of a hypothetical amount of recovery by Telcos from OTTs” (Frontier Economics, 2022, Footnote 13 at p. 8).

The evaluation and analysis of recommended remedies, particularly the recommended interconnection pricing regime (“direct”) but also more “indirect” remedies, are overly simplistic and incomplete. In the ETNO Report, the direct link to the actual regulatory problem is unclear, and so are the problem-solving abilities of the suggested remedies. Whereas this is, as we described above, in many ways a result of the fact that the problem statement is unclear and the analysis of the effects flawed, the ETNO Report dismisses alternatives to the proposed remedies without any real consideration or analysis, but solely based on the (unproven) assertion that these are “complex”. Finally, the proposed regime focuses on a subset of edge providers and applications

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<sup>81</sup> Traditionally, cost-based price regulations have been found to give rise to a series of problems such as information problems (e.g., what are cost of efficient service delivery? How to resolve cost allocation issues in presence of joint costs/common costs?) and incentive problems (how to ensure efficiency and incentives to innovate?). In dynamic and complex systems, topologies, technologies, and delivery approaches (which are, in turn, dependent on non-orchestrated but often complementary investments by different ecosystem actors) vary greatly within the networks of single providers (e.g., across different geographies) and also across providers, thus further adding to the complexity of determining adequate costs and rendering regulated prices that are static inherently distortive.

<sup>82</sup> South Korea has introduced an interconnection regime and sending-party-pays-style “network use fees” that have been compared to the regime proposed in the ETNO Report. While a detailed discussion is beyond the remit of this paper, several articles/reports have discussed the South Korean approach (e.g., Park & Nelson, 2021; Gahnberg et al., 2022; and WIK, 2022, pp. 36-38). Whereas the publications report that South Korean rules effectively establish traffic-based charging among relevant entities based on sending-party-pays-principles, the rules initially applied to traffic exchange between South Korean ISPs. Amendments and proposed bills have or intend to expand the scope to arrangements between South Korean ISPs and national and international edge providers (above a certain size threshold). According to Gahnberg et al. (2022), current efforts reveal trends towards installing “increasingly prescriptive mandatory rules”. Furthermore, the three articles/reports have pointed to interconnection disputes and court cases (e.g., by Netflix and Facebook) and reported or cautioned against negative impacts such as unusually high reliance on transit, high cost for connectivity, impaired consumer choice and content quality (QoS), and reduced network investments (Park & Nelson, 2021, pp. 73-75; Gahnberg et al., 2022; WIK, 2022, pp. 36-38, 54).

delivered via the Internet, thus implying a selective and asymmetric, provider-specific, and application-specific regulatory regime.

## 4. Summing Up & Future Directions

Achieving the European Union's (EU's) ambitious 2030 connectivity targets ("all European households are covered by a Gigabit network, with all populated areas covered by 5G") enshrined in the proposed *Path to the Digital Decade* program will require significant additional investment, and most of that investment will be provided by a complex array of for-profit enterprises funded by private investment capital. There will also be a need for public subsidies to address digital divides and ensure adequate access to network services, including last-mile broadband access, for users where private provisioning of such services is uneconomic. Addressing those challenges will require focused regulatory interventions to provide targeted subsidies. Additionally, regulatory oversight to ensure that the diverse players engaged in ensuring that EU digital infrastructures operate efficiently and are free from market power abuses by industry participants at any point in the value chain will be needed for markets for digital services and for the provision of digital infrastructure to operate efficiently. Pursuing those goals is wholly consistent with the design of light-handed regulatory regimes: frameworks that rely first on market processes to direct behavior and only secondarily on regulatory interventions to address problems.

The ETNO Report embraces the EU's connectivity targets but argues that those goals and the benefits they promise will be put at risk if a subset of large, primarily U.S. OTT service providers like Netflix, Amazon, or Google (Alphabet), fail to contribute significant funds to help pay for infrastructure investment by access ISPs including legacy telecommunication operators (telcos) such as Deutsche Telekom, Telefónica, or Orange. In building its argument, the ETNO Report utilizes a "stick/carrot" logic, suggesting that failure to act as it recommends will doom the connectivity targets.

We have shown that the ETNO Report's "stick/carrot" narrative is oversimplified and flawed at multiple levels.

- *First*, the ETNO Report **fails to clearly identify a regulatory problem**.
- *Second*, the **analysis of the effects of regulatory action (or inaction) is fatally flawed**.
- *Third*, and finally, the **evaluation of the remedies proposed is likewise fatally flawed**.

Although all three constitute necessary elements to justify sound regulatory policy interventions and thus also the ETNO Report's aggressive regulatory recommendation, we explained that each of the elements contains logical, methodological, and analytical failings.

At a very basic level, the ETNO Report fails to make a coherent and reasonable case for why access ISPs require additional external subsidies to fund the desired investments. Without a funding shortfall – which the ETNO Report has failed to demonstrate is likely to occur – there is no problem that would justify the strong regulatory intervention and reversal of the regulatory trajectory that has proved successful in promoting the growth of the Internet thus far. The ETNO Report merely asserts that large OTTs do not presently pay enough (or anything) to ISPs to deliver OTT traffic and that ISPs lack any market alternative to negotiate with OTTs to obtain the desired funding.

The following **five points** sum up and distill **major insights** of our analysis:

- **First, the most obvious way to address a funding challenge is to adopt solutions based on architectures and technologies that reduce funding needs.** Ample evidence that such activities have taken place and that those have been accomplished by significant complementary investments and innovation by a more complex array of Internet ecosystem participants is ignored by the ETNO Report. There is a diverse array of so-called Online Service Providers (OSPs) that provide complementary infrastructure services that are part of the fabric that make the rich collection of Internet-accessible products and services feasible. For example, investments and innovation by cloud and CDN providers and by end-users that have enabled expanded digital infrastructure and service capabilities in a cost-efficient fashion are not mentioned in the ETNO Report. OTT providers represent an important subset of OSPs and are responsible for infrastructure investments that have allowed the Internet to scale efficiently. Such OSP investments and their implications for the management of total costs (which are ignored by the ETNO Report) surely ought to be included in any consideration of what different industry participants are contributing to support the EU digital future and reach the various digital targets set forth in the proposed *Path to the Digital Decade* program (EC, 2021).
- **Second, the question of how to fund investment shortfalls needs to consider other options that the ETNO Report simply dismisses or ignores.** An obvious option is for ISPs and edge providers to negotiate different traffic management arrangements, including alternative interconnection agreements that extend beyond the legacy-style peering and transit agreements that characterized the landscape for Internet interconnection before, say, 2005. The evolution of Internet interconnection economics and traffic management strategies that emerged in response to the rise of new participants and changing market dynamics has substantially changed and become more complex to include a much richer set of market-based contractual arrangements for bilateral or multilateral traffic exchange without necessitating strong regulatory interventions.
- **Third, the ETNO Report relies on an overly simplistic and outmoded characterization of the traffic management challenge confronting access ISPs in addressing the traffic growth from OTTs and other sources.** Without any economic justification, the ETNO Report simply assumes that settlement-free peering between access ISPs and OTTs is inefficient and “unfair”, and that OTTs should be *required* to pay ISPs. Without further consideration of the total costs required to provide jointly the infrastructure and services that make the infrastructure valuable (and hence worth providing) and the optimal allocation of those costs between different industry participants, it is not possible to determine whether settlement free interconnection is fair or efficient, or if not, in which direction payments should flow.
- **Fourth, the ETNO Report claims without any valid support that the OTTs’ negotiating position is so superior to access ISPs that OTTs can simply mandate the terms of interconnection** (e.g., settlement-free peering) and foreclose any alternative market-based mechanism for access ISPs to recover their network infrastructure costs. The claim that (even large) access ISPs are in an inferior bargaining position which has caused an existential funding crisis that requires strong regulatory intervention is not substantiated by valid evidence, but is justified by pointers to metrics like the size and market value of large U.S. OTTs relative to European ISPs. Both ISPs and OTTs have a strong incentive to negotiate toward efficient and sustainable agreements that ensure both parties remain economically viable. Both confront competitive pressures that limit their negotiating flexibility and bargaining power. While the ETNO Report implicitly recognizes that ISPs have limited hope of being able to sell broadband services to their subscribers without OTT content and services being available, it fails to recognize that there are many competing OTT providers. While each OTT is wholly dependent on being able to negotiate wholesale relationships with (last-mile) connectivity providers in order to connect to its customers, one could argue that an access ISP only needs

to have sufficient OTT content for ISP broadband subscribers to be willing to subscribe to broadband services. While it may be the case that the largest OTTs have more bargaining power than many other edge providers, this is not demonstrative of the presumed asymmetry and market failure that the ETNO Report alludes to. **Neither does the ETNO Report provide evidence that access ISPs are in a systematically weaker position than OTTs, nor is this obvious.**

- *Fifth*, even if one assumes that access ISPs are not adequately recovering the costs they incur from carrying their subscribers' broadband traffic (an assumption we do not adopt but note here for purposes of discussion), then **requiring OTTs to help make up that shortfall via direct transfers is not the most natural or obvious approach for addressing such a funding gap.** A more logical, simpler and direct approach is for access ISPs to change their subscriber pricing to address the deficit and provide a direct signal to end-users of the cost implications of their usage behavior. And, if policymakers felt public subsidies were needed to offset perceived inequities in retail pricing, then a poll tax or end-user VAT on all digital activity might be explored as a way to collect additional funds in a way that would be minimally distorting on market competition and incentives for private network and technology investments. The ETNO Report has not made a case for either of those sorts of interventions and this paper is not arguing here for those either, but merely points to those regulatory alternatives to highlight the selectiveness and general failures of the ETNO Report's analysis.

The future of the digital economy will be increasingly dependent on digital infrastructures of all kinds: broadband, clouds, AI apps, post-PC devices, and automation in business and society. Whereas this digital future is characterized by a co-evolution of edge providers and ISPs, their business models, services, and infrastructures, as well as relevant co-dependencies, it must be acknowledged that digital connectivity to all kinds of complementary resources, not just basic transport, is required. However, the ETNO Report's focus is as if the only investment challenge relates to bit-transport in last-mile access network facilities. This focus is clearly a mischaracterization of the overall challenge regarding requisite network infrastructure (and the role of complementary investments and innovation by different ecosystem actors) or even of telecoms. **A comprehensive, holistic, and evidentiary review of different options is necessary to arrive at meaningful regulatory policy.**

Although the ETNO Report superficially addresses important issues confronting EU policymakers that we and other scholars, analysts, policymakers, and industry stakeholders are actively engaged in discussing, the ETNO Report's analysis of the forces and changes confronting the Internet ecosystem is overly simplistic and fails to make a helpful contribution to identifying sound policy options. It **does not provide the necessary evidence to justify the drastic policies it advocates and fails to provide evidence of harmful asymmetry and market failure due to excessive OTT bargaining power that would be required to justify the proposed substantial change in regulatory policy direction.**

In conclusion, the ETNO Report fails fundamentally at multiple levels, thus creating noise rather than meaningfully contributing to the current debate. Even though changes in industry structure and bargaining positions have and will continue to occur, including (new) issues with regard to interconnection, the **ETNO Report neither provides useful evidence nor does it make a coherent or compelling case for the swift introduction of the proposed interconnection regulation.**

As the EU is advancing an aggressive and comprehensive agenda, the regulatory frameworks they adopt will provide a template and guidance for the rest of the world – to both those who choose to follow and those who choose another path. In view of this responsibility for the EU and beyond,



and the importance of the topic under consideration, **the EU should not hastily follow the overly simplistic policy change recommended by the ETNO Report.** It is widely unfounded on evidence and more likely to harm progress if adopted.

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