A FRAMEWORK FOR RESPONSIBLE USE OF NETWORKS

A Framework For Responsible Use of Networks

Europe stands on the brink of a new era in connectivity. But an investment gap in Europe's digital infrastructure threatens this future.

The challenge is a 'tragedy of the commons' in the sector. Networks are treated as an infinite resource, creating inefficiencies and waste in their usage.

Europe needs a Framework for Responsible Use of Networks to ensure they are used more efficiently.

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A FRAMEWORK FOR RESPONSIBLE USE OF NETWORKS

EXECUTIVE SUMMARY

EUROPE'S DIGITAL POTENTIAL

Europe stands on the brink of a new era in connectivity. Across every industrial sector – from smart factories to immersive healthcare, advanced logistics and greater energy efficiency – improved connectivity in combination with AI and cloudification can help to drive Europe's next wave of growth, productivity and innovation. Investing in next-generation networks is therefore key to boosting European competitiveness.

THE CHALLENGE: THE 'TRAGEDY OF THE COMMONS' IN THE DIGITAL COMMUNICATIONS SECTOR

However, progress towards this new digital era is at risk. As recent reports by Mario Draghi, Enrico Letta and the European Commission highlight, Europe's investment gap in digital infrastructure – especially in advanced 5G technologies – already sees it lag behind other countries in North America and Asia. Addressing this situation requires a broad reset of Europe's digital single market, telecom regulations and competition policy.

At the core of this challenge is what economists call the 'tragedy of the commons': a situation where the overconsumption of a valuable and finite common resource – in this case, telecommunications networks – leads to its degradation and depletion. While the challenge of a growing traffic demand is present globally, it is particularly pronounced in Europe due to the policy environment, which places real constraints on the expansion and management of networks to address increasing demand.

There are three key drivers of this tragedy of the commons in Europe:

1. **Content providers, who do not bear the cost of using networks, lack the incentive to use them in a responsible manner**

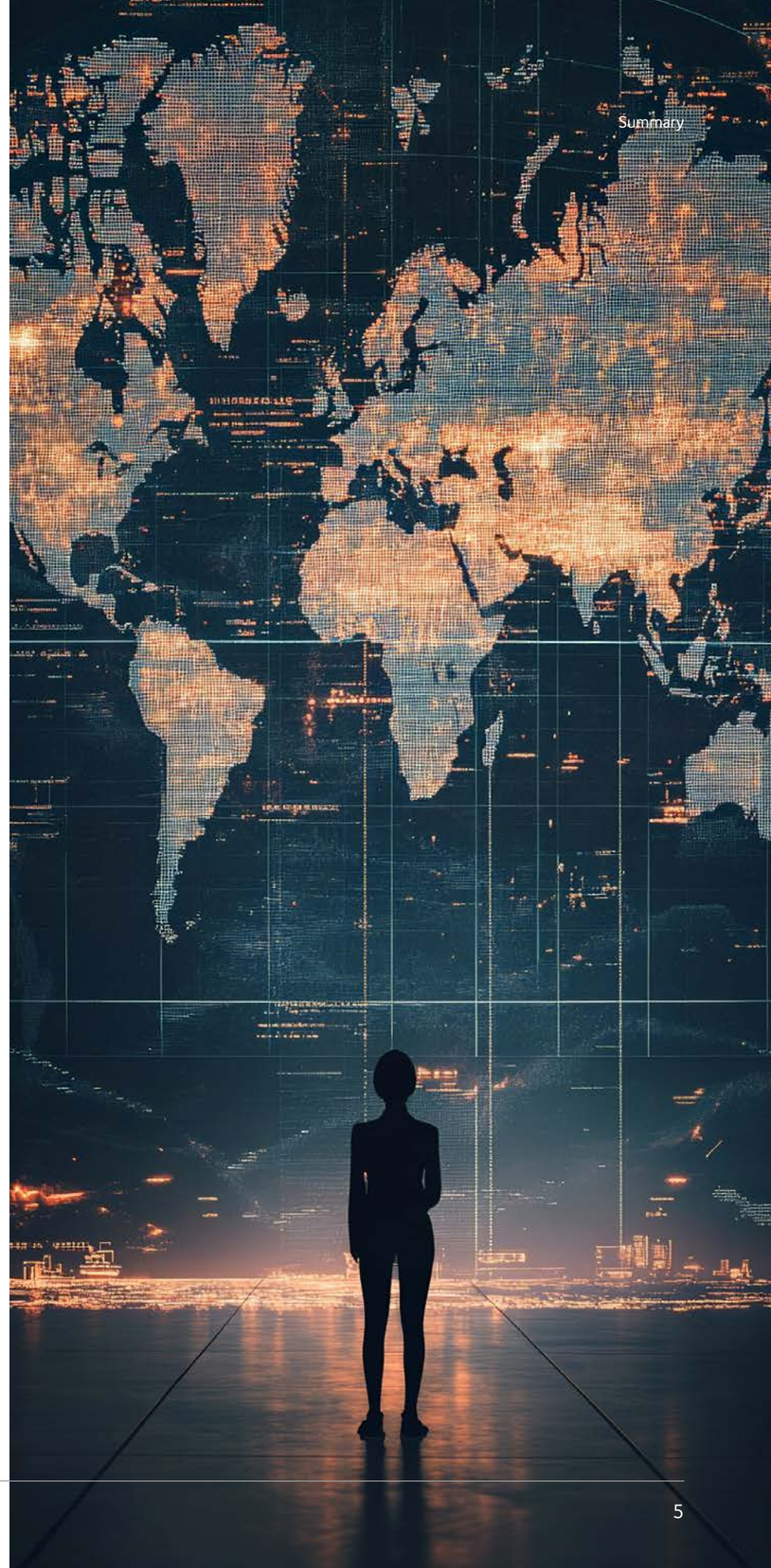
Content providers view network infrastructure as a free and infinite resource. They are therefore at liberty to maximise profits by growing traffic, regardless of the consequences for networks. Their business models are driven by constantly increasing engagement with their content, for example, through service design decisions that encourage end-users to consume more traffic with features such as autoplay, infinite scroll and pre-fetching of content. Providers also push ever-higher quality as a means of differentiation against competitors, shifting to Ultra-High Definition streaming – which come with almost ten times the demand of standard definition.

In parallel, an increasing number of digital business models are based on advertising, which now represents a significant portion of all content consumed online. A recent test on Vodafone's network revealed that at least a third of an average YouTube video experience is advertisements.

This has led to ballooning traffic volumes: in the last 10 years, traffic has increased by more than 25-fold on the Vodafone UK network, while on Vodafone Germany's mobile network, it has grown by 27% in the last year alone. Peak traffic demand – which networks must be able to handle without succumbing to congestion – has also accelerated even more at around 30% year-on-year.

This growth is occurring despite the existence of technologies which could make traffic delivery more efficient, including video algorithms, codecs and other forms of compression. Modern codecs, for example, have the ability to reduce traffic impact by over 20%. Design features that drive endless consumption could also be reconfigured, or quality of content tailored to the device over which it is being consumed.

A number of service providers are exploring collaborative and pragmatic steps, including integrating technical traffic mitigation measures into their service design and delivery, to address some of the challenges associated with traffic growth. Vodafone has welcomed the opportunity to work with our partners on these initiatives.



However, there is currently neither a requirement nor an effective incentive to make use of these mechanisms. This means that their adoption by content developers, network operators or device manufacturers is not as widespread as it should be.

2. **Network operators face difficulties in effectively expanding the 'common' of network infrastructure to address this traffic growth, particularly in last mile access networks**

To date, network operators have largely been able to avoid significant congestion and maintain a good quality of experience for end-users, despite the increase in traffic. They have done this by continuously investing in expanding capacity. Currently, Vodafone dedicates over a third of its capex budget to this task.

But this comes with trade-offs. The allocation of limited available capital into continuous capacity expansion has come at the cost of investing in other, more transformational activities that would benefit European citizens, such as rural deployment and 5G acceleration.

And, looking ahead, it is far from guaranteed that networks will remain in a position to sustainably invest to keep ahead of traffic demand. The European policy environment creates complexities and hurdles to expanding and improving networks, including:

- Practical and technical restrictions in upgrading and expanding networks, such as slow and fragmented release of new spectrum bands, inconsistent approaches to electromagnetic field (EMF) limits and inconsistent rules on physical infrastructure, such as maximum mast heights across Europe.

- Fragmented supply and a lack of scale, driven by competition policy that favours new entrants/restricts market consolidation, coupled with highly intrusive and inconsistent rules creating significant regulatory cost burdens. This has damaged the financial strength and investment capacity of the sector.

3. **Network operators are unable to effectively manage their network infrastructure**

Europe's telecoms policies directly restrict the ability of operators to manage the impact of traffic and minimise inefficiencies on their networks. A prime example of this is the highly prescriptive application of the Open Internet rules, which only allows traffic management in exceptional circumstances.

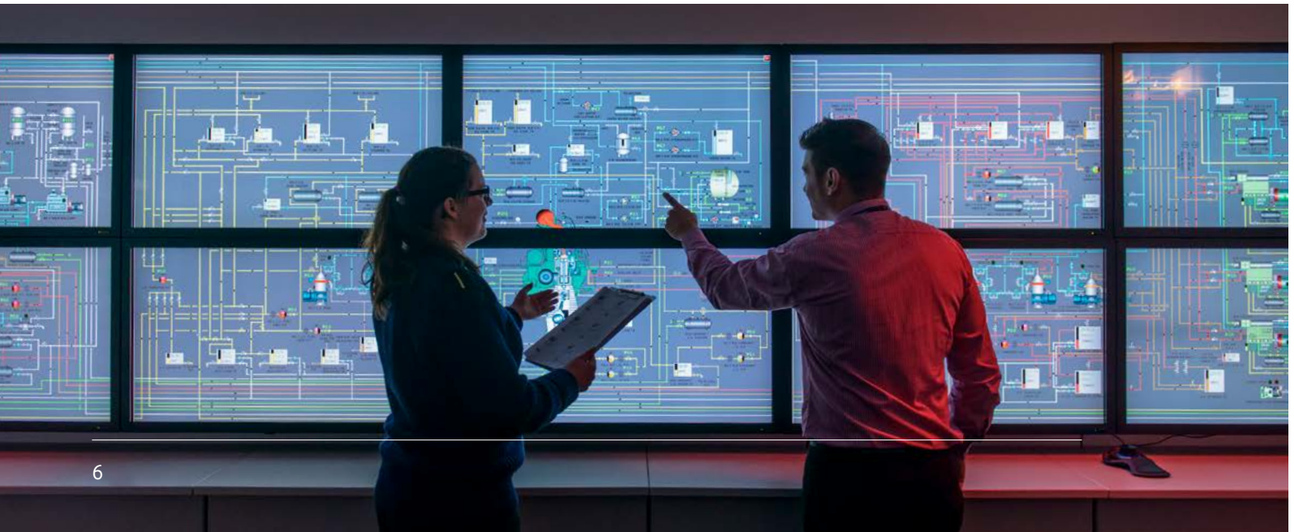
Operators are also restricted commercially. On the content side of the market, operators are unable to reach fair commercial agreements with digital service providers for the consumption of network resource, meaning these providers do not need to internalise the cost of pushing vast quantities of internet traffic onto telecoms networks.

Operators are also restricted in their flexibility to offer consumers tailored tariffs – for example, by restricting unlimited offers to certain types of traffic – that would more effectively address individual capacity needs and protect against the inefficient use of fully 'unlimited' offers.

EUROPE IS AT RISK OF REACHING ITS TRAGEDY OF THE COMMONS TIPPING POINT

Europe has already faced the precipice of a tragedy of the commons in digital communications. At the onset of COVID-19, the sudden surge in traffic required urgent action on all sides to ensure that networks were not congested to the point of failure. Network operators made significant and unplanned additional investment in their networks (in some cases using up annual capital expenditure budgets in a matter of weeks). The European Commission encouraged content providers to deliver digital services more efficiently, which they duly complied with.

Since then, Europe has returned to complacency, ignoring the risks posed by continued traffic demand. **It now runs the risk of sleepwalking into another situation of a genuine capacity crunch.**



The challenge of traffic growth and the demands on Europe's digital infrastructure will only intensify:

- The shift towards the **digitisation of previously 'analogue' activities** continues at pace. For instance, the recent and accelerating trend of major live events shifting to online streaming platforms is a significant driver of volatile growth in peak demand.

- Even in its nascent stages, **the AI revolution** is creating new demands on networks. Research shows that most traffic growth this decade will come either from new AI applications or AI-upgraded applications. This trend will continue as AI is increasingly integrated into handsets, wearables, digital services, and the digital economy more widely.

- **Cloudification** continues, with increases in data centre capacity allowing users to store their entire 'digital lives' online in the cloud and across multiple devices.

These trends also impact our planet. Ever-growing consumption of digital content places greater, and more intensive, demands on energy and critical materials, driving up the overall carbon footprint of the digital ecosystem. Yet today, digital service providers have limited incentive to account for the impact of delivering more traffic on the environment.

THE OPPORTUNITY LOSS FOR EUROPE

The manifestation of the tragedy of the commons in the digital communications sector will have real consequences. Beyond the immediate risk of a capacity crunch, the continued focus on capacity upgrades over transformational capabilities will have a significant impact on Europe's innovation and economic growth potential. Without investment in the necessary foundation of best-in-class connectivity, Europe will not benefit from the next wave of digital advancements in the new 5G, AI and cloud-enabled world.

A FRAMEWORK FOR RESPONSIBLE USE OF NETWORKS

Europe cannot afford to let its connectivity infrastructure degrade into a bottleneck, holding back economic growth. A decisive and comprehensive reset of the sectoral policy environment is required to avoid this outcome and to ensure Europe's connectivity infrastructure is fit for the future.

A key component of this is a **Framework for Responsible Use of Networks (RUN)**. This framework draws on well-established principles from dealing with the tragedy of the commons in other sectors, and from Europe's experience during COVID-19, where all actors came together to collectively manage the crisis. As economists have long recognised, over-consumption can be managed if individuals can be motivated to cooperate through monetary or moral incentives or penalties.

This framework should be based on three core principles:

1. **Requiring traffic optimisation to reduce pressure on networks and to minimise traffic waste:** We need a new industry Code of Conduct which sets clear, consistent guidelines to incentivise all actors in the digital ecosystem to design their services more efficiently, and to minimise waste.

2. **Operators must be allowed to dynamically manage traffic on their networks:** We need more flexible network management rules to enable operators to apply fair use policies and deploy technical tools to prevent congestion and deliver a high-quality experience.

3. **Enabling commercial negotiation for traffic conveyance services:** We need a legislative framework, including a dispute resolution mechanism, underpinning the negotiation of commercial terms between network operators and large content providers and their intermediaries for the conveyance of traffic. This would create the right economic incentives to minimise internet traffic inefficiencies, whilst in parallel ensure network operators are fairly compensated for costs incurred in providing traffic conveyance service, including peering, caching and transit.

Europe cannot afford to let its connectivity infrastructure degrade into a bottleneck, holding back economic growth.

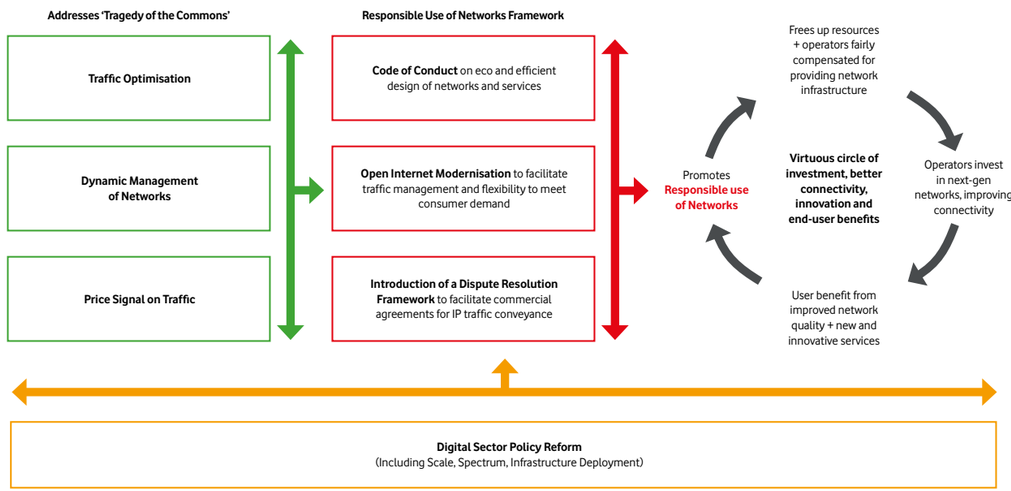
The adoption of this framework would create a virtuous cycle of investment, better connectivity, innovation, and consumer benefits.

The proposed framework is part of Vodafone's call for a new 'Connectivity Union',[1] with the goal of uniting the EU institutions, national governments, industry, regulators and consumers in a shared mission to tackle the shortcomings in Europe's connectivity, and to deliver the economic prosperity our societies need.

The RUN Framework would sit alongside the other critical policy reforms that are necessary to reboot Europe's telecoms infrastructure.

These include longer-term spectrum licences, the strict application of 'same service same rules' across the digital ecosystem, the removal of barriers to the Digital Single Market, and a new approach to assessing mobile mergers.

Europe is at a crossroads in relation to its connectivity infrastructure. To protect our network infrastructure from the path of degradation and depletion, Vodafone is advocating for the path of growth through shared responsibility. This paper sets out how this can be achieved.



01

EUROPE'S DIGITAL POTENTIAL

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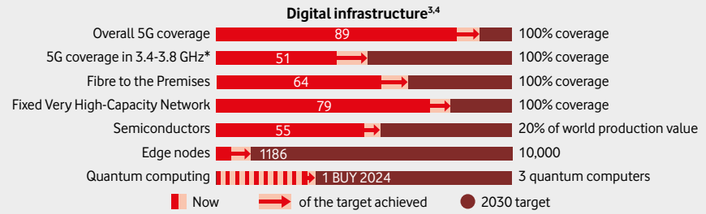
The internet was founded as a niche technology with limited functionality to connect universities, research institutions and government departments. From the early 1980s through to the early 2000s, the internet was made up of relatively few network operators, interconnecting in a linear fashion to exchange small volumes of simple data.

The internet has since expanded in functionality to become a critical part of our everyday lives. In Europe, digital connectivity has become the foundation of modern society and the economy, underpinning public services such as education and healthcare, working life, industry and production, travel, entertainment and socialising. Given the explosion of activities now supported by the internet, the volume and nature of traffic conveyed over connectivity networks has changed dramatically too.

To create a globally competitive digital communications ecosystem, and to ensure these crucial activities can be effectively supported, the EU has consistently set highly ambitious digital infrastructure deployment targets. The recent **Digital Decade goals** established targets to achieve ubiquitous coverage of 5G and high-capacity fixed networks in the last mile.[2]

But progress, particularly in this last mile infrastructure, has stalled. Concerns are growing that many of these targets will not be reached by the goal date of 2030:[3,4]



This slow progress places Europe behind other regions in many critical metrics. Taking mobile networks as an example, the EU lags behind compared to some countries in median mobile downlink speed and 5G midband coverage:[5,6,7,8]

METRIC	EUROPE	NORTH AMERICA	INDIA	CHINA
Median mobile downlink speed (mbps)	**64**[5]	**117**[6]	**96**[7]	**115**[8]
5G Mid-Band Coverage[9]	**45%** (europe exc. Russia)	**90%** (North America)	**95%**	**95%**

The EU[10] is also behind other regions in the deployment of **5G Standalone (5GSA)** – so called 'real 5G', where advanced equipment is used in the network core as well as the last mile.

Map of global 5GSA deployment and trials:[11]

This is important because although the EU is progressing towards overall 5G coverage, it has not been accompanied by the step-change in quality of experience that can be achieved with widespread mid-band coverage and 5G SA deployment.[12] These include enhanced speeds, higher capacity, and the ability to dynamically configure the network through technologies such as slicing.

Policy makers are increasingly alert to this issue. As Mario Draghi bluntly put it in his report on European Competitiveness:[13]

"Europe largely missed out on the digital revolution led by the internet and the productivity gains it brought: in fact, the productivity gap between the EU and the US is largely explained by the tech sector."

02

THE ‘TRAGEDY OF THE COMMONS’ IN THE DIGITAL COMMUNICATIONS SECTOR

THE ‘TRAGEDY OF THE COMMONS’ IN THE DIGITAL COMMUNICATIONS SECTOR

WHAT IS THE TRAGEDY OF THE COMMONS?

At the core of Europe’s connectivity problems lies what economists call the **“tragedy of the commons”**.

The tragedy of the commons rests on the economic concept of ‘common’ resources that provide consuming users with benefits, but over which there is no exclusive claim or regulatory control. The ‘tragedy’ occurs when each individual user of these common and finite resources lacks the incentive to utilise that resource responsibly. This leads to overconsumption and ultimately the exhaustion of the resource to the detriment of society.

Examples include:

- The ‘high seas’, which are not controlled or owned by any individual country, resulting in heavy overfishing and harm to the environment.
- The earth’s atmosphere, where a lack of direct ownership or accountability has led to significant pollution and consequent environmental damage.

The solution to the tragedy of the commons lies in incentivising responsible use of that resource and increasing end-user transparency over the impact of their consumption, thereby encouraging or even obliging individuals and organisations consuming the resource to make more responsible decisions. This protects the shared resource and avoids it becoming weakened, exhausted, or, in the worst case, from complete collapse.

THE TRAGEDY OF THE COMMONS IN ACTION

EU Customs Policy Reform to Tackle the Influx of Cheap, Dangerous and Unsustainable Goods to the EU

The recent call by policymakers in the EU to clamp down on customs exemptions for low cost parcels are an example of where policy has had to intervene when market players do not bear the full societal costs of their actions.

Background: E-commerce goods directly imported by consumers in the EU have surged in recent years, driven by low prices, a lack of import charges, and the rapid growth of Chinese online marketplaces such as Shein and Temu. According to EU surveillance data, 4.6 billion of such low value items were imported in the EU in 2024. This is almost twice the number recorded in 2023 (2.4 billion), and more than triple compared to 2022 (1.4 billion) – equating to almost 12 million items per day.

Consequences: Sellers of these goods do not face incentives to produce and ship their products in an efficient and sustainable way, or to ensure their products comply with EU health and safety laws. This is because they do not face the costs of their actions on consumers, the environment, or customs authorities. This has led to unintended consequences, including:

- Dangerous, counterfeit or non-compliant products entering the EU market, leading to **health and safety risks**.
- Very low prices for these non-compliant goods creating **unfair competition** for legitimate EU businesses.
- A **heavy environmental impact**, with the low cost of these products failing to reflect the **broader environmental costs** linked to their production, shipping and ‘lifecycle’, such as the inability to recycle poor quality products.
- A large number of parcels **overwhelming customs authorities**: such e-commerce imports already account for 97% of customers’ import declarations, leaving them less able to function effectively.

Solutions under consideration: The EU is considering several options in its policy toolbox to address these issues, such as removing the duty exemption for low value parcels (EUR150) for imports, and introducing a handling fee on e-commerce items imported directly to consumers in the EU. This is intended to make retailers, their intermediaries, and consumers account for the costs of sending and consuming such heavy volumes of goods, and thereby mitigate some of the social harms.

WHY DOES THE TRAGEDY OF THE COMMONS IMPACT DIGITAL INFRASTRUCTURE?

Digital infrastructure, and in particular **'last mile' digital infrastructure (access networks),** is a finite resource at any given point in time. Like other 'common' resources, it comes under significant pressure if it is used irresponsibly.

This situation stems from the policy framework developed in Europe since liberalisation. The framework has created unsustainable pressure on last mile digital infrastructure on three different fronts:

1. Content providers, who do not bear the cost of using networks, lack the incentive to use them in a responsible manner
2. Network operators face difficulties in effectively expanding the 'common' of network infrastructure to address this traffic growth
3. Network operators, particularly in the last mile, are unable to effectively manage their existing network infrastructure

We explain each of these components below.

1. CONTENT PROVIDERS, WHO DO NOT BEAR THE COST OF USING NETWORKS, LACK THE INCENTIVE TO USE THEM IN A RESPONSIBLE MANNER

The European framework has, unintentionally, created a situation where many stakeholders treat network infrastructure as an unlimited and free resource, and therefore lack the right incentives to make responsible use of these resources.

NET NEUTRALITY AND THE 'MUST CARRY' OBLIGATION

One of the root causes is the so-called net neutrality rules, underpinned by the Open Internet Regulation.

The basic principle underpinning the Open Internet framework is that networks must carry all traffic in a neutral manner – irrespective of whether that content is efficiently designed or optimised. This is to ensure that all end-users have access to, and can deliver, the content, services and applications of their choosing. This applies not only to consuming end-users but also to content providers, including some of the most powerful digital companies in the world.

The outcome of the well-intentioned but ultimately flawed application of the Open Internet rules is that many content providers' business models have evolved to take advantage of unrestricted and free access to broadband networks, whilst ignoring the impact this has on network operators.

THE IMPACT OF CONVERGENCE AND CONCENTRATION ACROSS THE DIGITAL ECOSYSTEM

When networks, and the mechanisms by which they exchange traffic, were designed, there were a small number of network operators exchanging broadly symmetrical volumes of traffic, from a diverse range of sources. Given the symmetric and mutually beneficial nature of these arrangements, they were typically agreed on a 'settlement free' basis.

However, the make-up of the digital ecosystem has shifted significantly in recent years, as convergence has led to significant levels of concentration across the digital value chain.

At the content end, traffic has become increasingly concentrated in the hands of a very small number of digital service providers. Across both fixed and mobile networks globally, over two-thirds of traffic originates from just eight major players.[14] This concentration has been coupled with increasing imbalance in the distribution of value along the digital communications value chain, with content now representing nearly 60% of overall value.[15]

As a consequence of their position in the content market, and the value extracted from this, these players have been able to leverage their position into other parts of the value chain, including in digital infrastructure.

This has been particularly apparent in 'middle mile' network infrastructure – the series of handover points between the content segment through to the internet service providers in the last mile. For example, in sub-sea cables, ownership of the sub-sea ecosystem is gradually shifting away from a shared resource and towards the largest tech players, with around 20% of new long-distance subsea cable installation being supported by tech giants.[16]

It is a similar picture with content delivery networks (CDNs). Their growing popularity has been driven by the need for more middle mile capacity to handle exploding volumes of traffic, and to deliver this efficiently. A number of big tech providers have therefore built out their own content delivery capabilities, edging out a number of independent players who were previously active in the CDN market.[17] The middle mile is therefore becoming even more concentrated in the hands of the same small number of big tech players. And the volumes of traffic conveyed over CDNs continues to grow: Vodafone estimates that as much as 70% of traffic entering its UK networks is transported via CDN infrastructure.[18]

As a consequence of these trends, the ecosystem has moved from a small number of network operators exchanging symmetrical volumes of traffic, to a small number of content generators leveraging their infrastructure in the middle mile to push highly asymmetric volumes of traffic onto the last mile networks, in order to deliver content to their end-users.

This relationship is evidently an asymmetric business-to-business relationship. Consequently, the mutually beneficial 'settlement free' interconnect arrangements that existed between public network operators for many years are no longer appropriate.

Despite these shifts, network operators have typically been unable to secure reasonable commercial terms for the provision of traffic conveyance, and the existing policy framework does not contain any mechanism to support them, such as a dispute resolution framework.

The consequence is a lack of 'price signal' attached to the significant volumes of data being pushed into network infrastructure, which would incentivise content generators to minimise the impact of their traffic.

This lack of incentives to utilise network infrastructure responsibly has led to the evolution of business models that rely on significant levels of traffic growth.

Providers of digital platforms and services typically rely on boosting engagement (and therefore traffic) through ever-increasing amounts of personalised content, which leads to higher advertising revenues for the service provider. For services that remain based on subscription models, there is also an incentive to drive higher volumes of traffic. Monthly fees are often set according to the quality of video distributed, with higher quality such as UHD streaming typically commanding a higher price.

For these providers, **increased engagement with higher quality and highly personalised content results in higher profits, without the need to internalise the costs of delivering the resulting increased traffic. They therefore have the incentive to grow traffic.**

TRAFFIC GROWTH: THE FACTS

Absent a policy environment to reign in inefficient usage, traffic growth has risen exponentially in recent years, putting significant pressure on connectivity infrastructure, particularly in the last mile.

The most significant leap in traffic volumes was seen during the initial COVID-19 pandemic period, where a shift towards living life online saw annual traffic growth of up to 60% on Vodafone's networks.

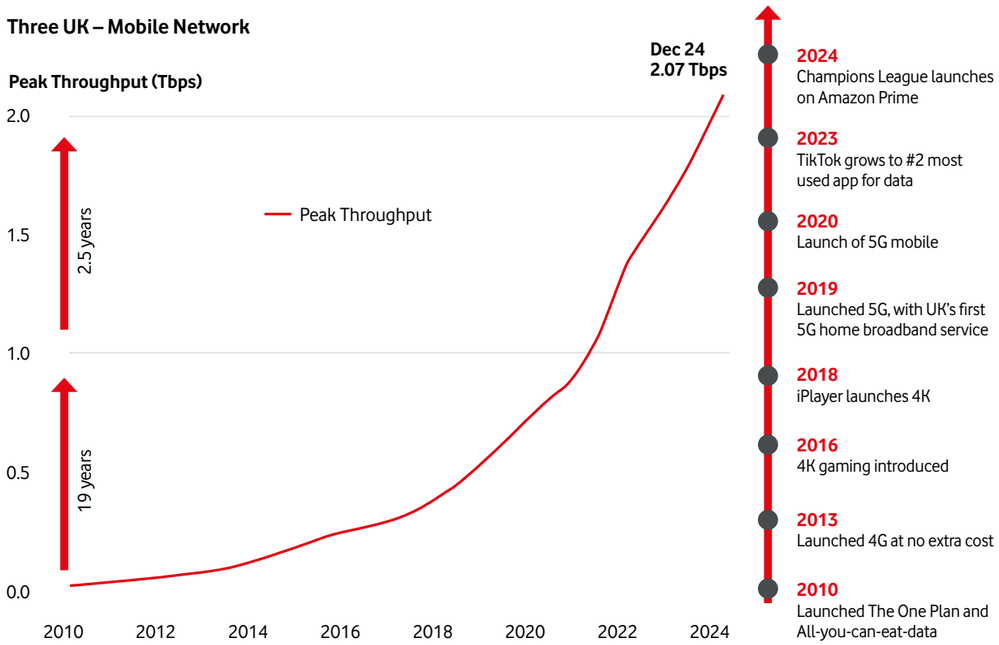
This is not a new trend. Over the last ten years, traffic volumes have grown 25-fold on Vodafone UK's network.[19] And it continues to grow steadily: in the last year alone, Vodafone's German mobile network has grown by 27%.[20]

In parallel, growth in peak traffic (i.e. the point at which the network is busiest) continues to grow at pace. It is peak traffic that influences network investment, as operators must be able to handle these peaks in demand without succumbing to congestion. Across Vodafone's European networks, peak traffic has been growing at around 30% year-on-year, a trend that does not show signs of slowing.

Recent data from other operators shows a similar pattern. It took 19 years for Three's UK mobile network to reach 1TBs peak throughput, then just two years to double it.[21]

This trend is reflected in global mobile network data traffic, which has increased from less than 20 Exabytes per month in 2017 to more than 150 in 2024.[22]

Three UK – Mobile Network



This is not a new trend. Over the last ten years, traffic volumes have grown 25-fold on Vodafone UK's network.[19]

THE UNTAPPED POTENTIAL OF MEASURES TO MITIGATE TRAFFIC GROWTH

Already today, some stakeholders making use of network resources are adopting collaborative and pragmatic steps to address some of the challenges associated with traffic growth. Vodafone has welcomed the opportunity to work with our partners on these initiatives.

Examples:

Video delivery optimisation: It is possible for content generators to optimise their delivery algorithm parameters, such as video resolution, to reduce traffic volumes or improve the efficiency of content delivery, without impacting service quality. This can be done in tandem with network operators, who share network data with the content developer, and can configure their content according to the current status and capabilities of the network. Vodafone recently announced a partnership to apply this approach to Meta's traffic entering the Vodafone network.[23] The partnership has been rolled out across Europe, with an observable reduction in traffic volumes.

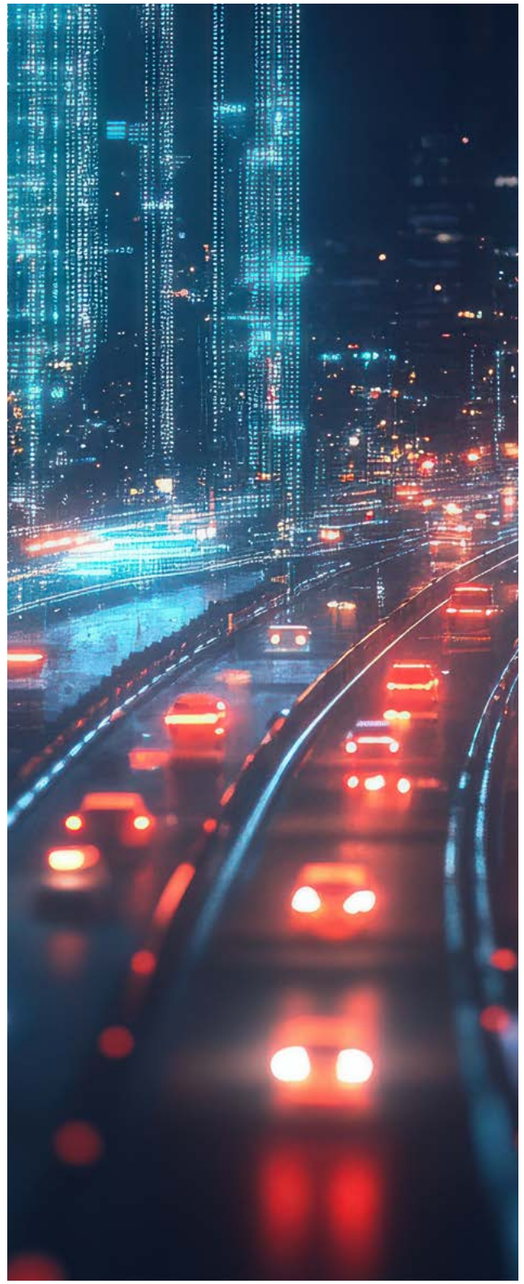
Codecs: Video codecs are a means of 'packaging' video traffic, which often has the effect of reducing the capacity demands of the video traffic. Many major content generators (such as Meta, Google, Amazon and Netflix) already apply compression codecs to their video content. These can be impactful, with modern codecs such as AV1 reducing file sizes by 20 – 30%.

However, various limitations impede the effectiveness of these measures. Some are only available on either fixed or mobile networks. Some are contingent on wider technology upgrades. The growth in the use of different forms of encryption, such as VPNs, also limits operators' visibility of the traffic conveyed over their networks and their ability to manage it efficiently.

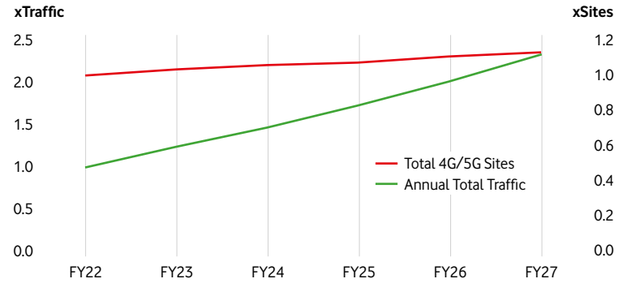
With respect to codecs, a significant limitation is that they must be implemented not just at the content generators' end, but also in the end-user device, yet smartphone support today remains limited. There is also no alignment between hardware, software and content players over the optimum codec to use, as many players have their own proprietary versions which can only be used by the codec owner.

Ultimately, these measures are voluntary only. Stakeholders are free to disregard them, or not deploy them to full effect, meaning they are not as widely adopted as they should be.

The irony is that the targeted application of the Open Internet rules means the only players that are legally permitted to optimise content also have the biggest incentives to generate more of that content.



2. NETWORK OPERATORS FACE DIFFICULTIES IN EFFECTIVELY EXPANDING THE 'COMMON' OF NETWORK INFRASTRUCTURE TO ADDRESS THIS TRAFFIC GROWTH, PARTICULARLY IN LAST MILE ACCESS NETWORKS



The growth in traffic results in a need to continuously increase the capacity of network infrastructure to avoid congestion and quality degradation.

It is the last mile access network, provided almost exclusively by telecommunications service providers, that is the most sensitive to these shifts in traffic patterns. But, expanding it comes with significant cost and practical challenges.

PRACTICAL AND TECHNICAL RESTRICTIONS

Mobile
On the mobile network, there are three primary ways to address the need for new traffic, all of which are constrained by cost, practical or legal barriers.

Build / deploy more towers, antennas, cell sites: One way to add capacity is to densify the network by deploying more sites and installing more equipment. However, this comes at significant cost (both in terms of CapEx and on-going OpEx). Finding suitable locations can also be challenging – the most efficient locations in urban areas are already utilised, and many applications are resisted by planning controls. Operators must also comply with the rules on exposure limits for electromagnetic fields (EMF), which place further restrictions on the distribution of cell sites.

This makes the economics of densification very challenging, and in recent years the growth in cell sites has been outstripped by the annual growth in traffic.[24]

Add more frequencies:
The physical network expansion must also be supported by the allocation of additional spectrum, which is a finite resource and only becomes available periodically and at significant cost. In our European footprint alone, Vodafone has spent around €14 billion on up-front spectrum fees during the last 15 years, excluding any additional annual charges.

5G spectrum bands were identified in the mid-2010s and across Europe have since been auctioned. There is no new spectrum identified for expansion. For Vodafone, this has meant that the total spectrum available in our markets has been effectively stagnant for years, whilst mobile traffic has continued to grow at pace.

Policy decisions over the use of finite spectrum significantly impacts the ability of operators to expand and improve their networks. This issue is particularly relevant in the ongoing debate about the use of 6GHz spectrum. 6GHz is the next and only suitable band for expanding mobile capacity during the next five years, and is at the centre of a debate about whether the upper part of the band of c.700MHz spectrum should be allocated for mobile or to Wi-Fi. If Wi-Fi is permitted to use some or all of the upper part of the band (and having already been allocated 580MHz in the lower part of the band) while mobile traffic continues to grow, the risk of a capacity crunch will come much sooner than would otherwise be expected.

Upgrades to 5G from older technologies: To open up more capacity, many operators are now in the process of upgrading 4G networks to 5G. This modernisation will continue as 2G and 3G are switched off, and more customers move to 5G-enabled devices. However, policy decisions requiring the maintenance of legacy networks are slowing this process down considerably, limiting operator capability to expand capacity through network upgrades.

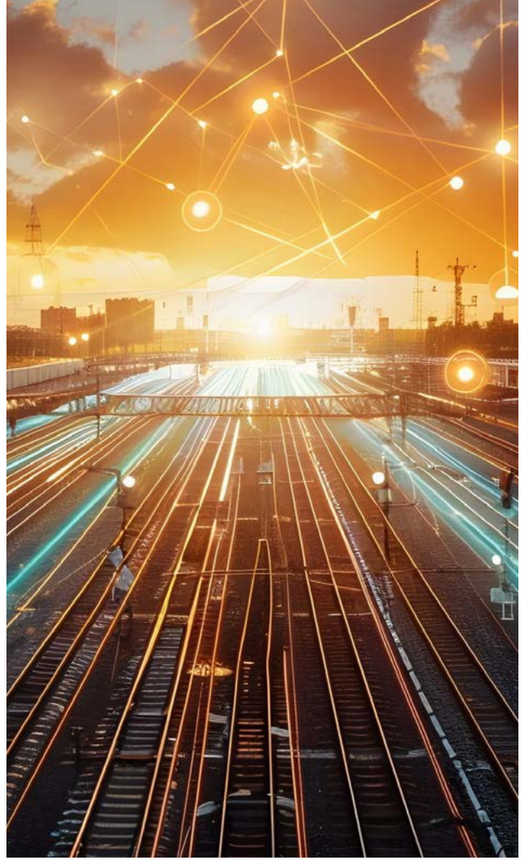
It is also notable that making the necessary upgrades – especially for more advanced "standalone" 5G networks – requires substantially greater levels of long-term capital expenditure than for previous generations of mobile technology.

Fixed

On the fixed network, the primary means of expanding capacity is through upgrading older copper and cable networks to modern very high-capacity networks, such as fibre or hybrid fibre/cable networks.

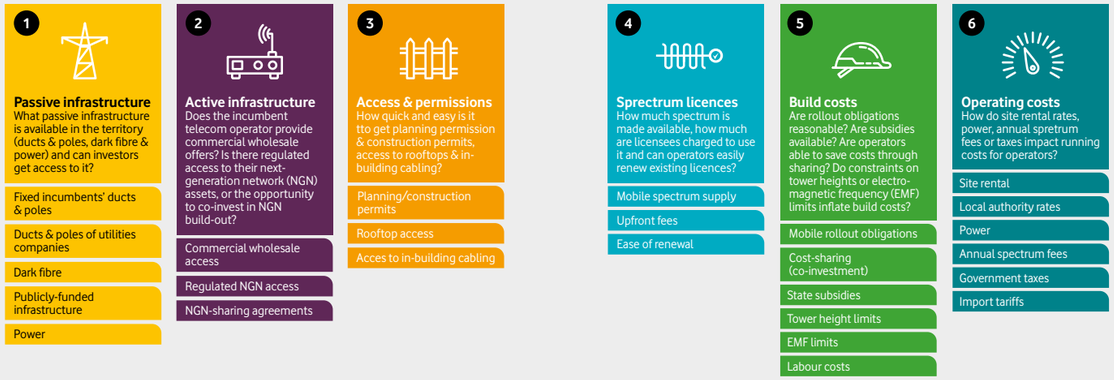
This is a very expensive process, with civil engineering works representing a significant proportion of the costs. A study by WIK-Consult for the Commission estimated that the full cost of achieving Gigabit connectivity for all using Fibre-to-the-Premise would take around € 114 billion in investment.[25]

There are also a range of practical barriers that restrict the continuous expansion of fixed networks, including the need to obtain the right access and permissions.



Digital deployment – key dimensions

A Vodafone study examined the various key policies, including those noted above, that impact the ability to deploy fixed and mobile networks. The results are summarised here:[26]



FRAGMENTED SUPPLY AND LACK OF SCALE

The financial health of the sector calls into question the ability of network operators to continue making these costly and difficult investments into capacity expansion.

Whilst there has been significant growth in the consumption of digital services, the benefit of this has not been evenly spread, with the vast majority of the value being accrued by players in the cloud and content markets, instead of those providing the underlying connectivity (in particular in the last mile).

Competition policy

This is in large part due to conscious policy choices which prioritised market entry – often on subsidised terms – in order to keep prices relatively low, rather than focusing on long-term investment. This has hindered the growth potential of the telecoms sector by driving returns down, sometimes below the cost of capital. The resulting lack of scale in the sector has also curtailed operators' ability to profitably invest in upgrading network infrastructure, in particular 5G, which requires greater scale than previous generations of mobile technology. As a result, such investments – even though they would deliver both higher quality and lower prices for consumers and businesses in the longer term – are not being made.

Retail pricing practices

The extent of retail competition has also had a dampening impact on innovation in connectivity services, with operators left to compete on price alone. Connectivity is increasingly seen by consumers in Europe as a simple commodity and as a 'basic need'.[27] Consequently, consumers continually expect more capacity and quality from their operators for the same or lower prices. This has led operators to offer more for less.

The overall outcome of this continued competitive pressure in last mile connectivity services is that Average Revenue Per User (ARPUs) in the sector have continued to fall over the last decade. Compared to other regions, European operators' ARPUs are 65% and 61% less than in the US for mobile and fixed broadband services respectively.[28]

These trends combined mean that operators are increasingly unable to make sustainable returns which are required to invest in their networks.

The communications sector has consequently become an outlier in terms of overall inflation in the last three years, showing a price deflationary trend in contrast to the rest of the economy.

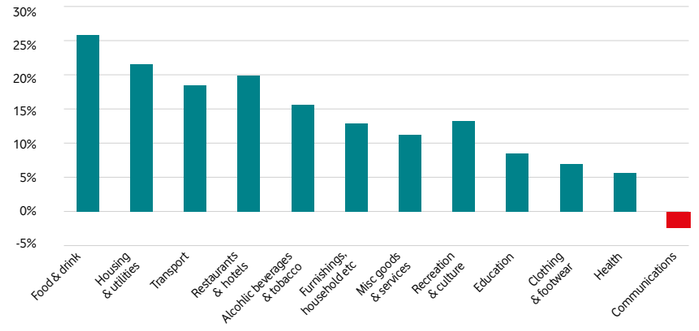
Impact of Unlimited Contracts in Mobile

Operators introduced these into the market to meet consumer expectations of a simple, worry-free tariff, without risk of data exhaustion, that mirrored the end-user experience in fixed broadband.[30]

These have proven popular – around 20% of Vodafone's mobile customer base in Europe are on unlimited mobile tariffs.[31] Similarly, 'fixed wireless access', where fixed broadband is provided through mobile connectivity, is increasingly popular.[32]

At the point of introduction, consumption patterns over these services were reasonably predictable. However, the advent of unlimited tariffs, and the lack of incentives on content providers to avoid excessive consumption of network capacity, has led to service providers taking advantage of these unlimited tariffs in ways outside of mobile service providers' control.[33] The consequence is customers are engaging in increasingly high bandwidth activity, putting increasing demands on the mobile network.

Euro area inflation by sector – Nov 21 to Oct 24[29]



Despite this overall growth pattern on the content side of the market, most end-users on 'unlimited' or FWA tariffs continue to consume growing but reasonable levels of data. But their introduction has had unforeseen consequences, with a small minority of users making excessive use of the service. Almost 50% of the traffic on Vodafone's EU mobile networks in 2024 was associated with just 6.5% of the total mobile customer base. Such usage can result in network congestion and slower speeds for all other users of the network.

Despite this, there are very limited means for operators to reign in excessive consumption. The existing policy framework – in particular, Open Internet rules – prevent more robust protections against this behaviour, discussed in more detail below.[34]

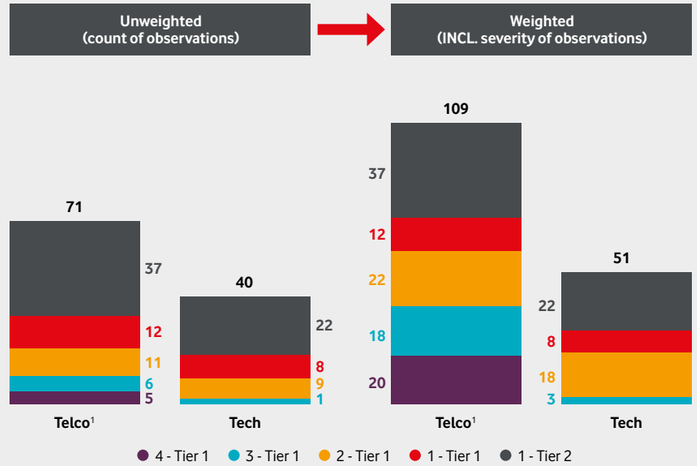
Significant regulatory cost burdens

Despite the privatisation of telecoms operators from the 1980s onwards, digital communications policy still places the responsibility, and therefore much of the cost, of enabling certain societal and consumer welfare outcomes onto telecommunications operators. This is facilitated through heavy ex-ante regulation, underpinned by a 'General Authorisation' regime, which allows national regulatory authorities (NRAs) to impose a range of regulatory requirements on network operators. For example:

- **Security obligations**: Prescriptive obligations on how to manage security and resilience risks on the networks, for example, through localisation requirements (e.g. data and location of network support nodes) and rules in relation to trusted suppliers. These each add costs and constrain efficiencies.
- **Legacy maintenance**: Obligations to maintain legacy technology to ensure public good outcomes, such as the maintenance of legacy 2G networks to support emergency calls, even when the valuable spectrum resources could be used elsewhere more efficiently and effectively.
- **Universal service**: Member States are required to ensure the availability and affordability of an adequate level of broadband and voice connectivity at a fixed location for all EU citizens. They are able to require telecommunications operators to deliver this and, to the extent it is not funded by the state, for the operators themselves to fund it.

THE DISPARITY IN REGULATORY BURDEN BETWEEN TELCO AND TECH:

There is a significant disparity in the level of regulatory obligations that sit on 'technology' versus 'telecommunications' providers (even where similar or competing services are being provided). Analysys Mason completed a weighted assessment of EU regulatory obligations sitting on each part of the ecosystem, concluding that the burden on telecommunications operators is more than twice that of 'big tech' players:[35]



The lighter-touch regulatory framework, together with the 'winner-takes-all' nature of digital services, has helped underpin the increasing concentration in many parts of the digital communications value chain as detailed above, compared to the scale achievable in the telecoms sector.

Constraints on new business models

The regulatory framework limits the ability of telecommunications operators to create new sources of revenue, which exacerbates the weak financial position of the sector. For example, the prescriptive application of the Open Internet rules limits network operators' capability to develop dynamic solutions based on 5G network slicing and the quality-of-service solutions this could support. Additionally, as mentioned above, with the Open Internet rules imposing a de facto must-carry obligation on network operators, the lack of a dispute resolution mechanism to support the introduction of commercial arrangements for IP-interconnect hinders operators' ability to obtain fair compensation for the service they provide to content generators.

The European policy environment and the excessive burden it places on telecommunications network operators has negatively impacted the financial health of the sector. In less than a decade, the market capitalisation of the EU telecom sector has fallen by 40%.

Institutional investors have many options of where to deploy their capital, and they are acutely aware of the low and stagnant return on capital expenditure (ROCE) for the sector over the last decade.[36] They do not believe that further capex investments will generate returns, and are therefore unwilling to invest in such projects, investing instead in other sectors. Indeed, significant capex announcements by network operators typically have the effect of reducing instead of boosting market capitalisation.[37]

In combination, this limits the capital available to operators and constrains their ability to both expand network capacity to meet the demands of traffic and transform and modernise their networks. In fact, capex expenditure in telecoms is now falling, having declined by 2% in 2023.[38]

3. NETWORK OPERATORS, PARTICULARLY IN THE LAST MILE, ARE UNABLE TO EFFECTIVELY MANAGE THEIR NETWORK INFRASTRUCTURE

An alternative to constantly expanding network capacity would be for network operators to better manage their existing network resources. But, Europe's policy environment restricts network operators' ability to do this effectively.

For example, the highly prescriptive interpretation of the Open Internet rules only allows for traffic management in exceptional circumstances. This has also reduced flexibility to offer consumers tailored tariffs that would more effectively address their needs in relation to different types of online services.

The adoption of such approaches to network management and pricing would create incentives on users to avoid wasteful consumption of network resource, helping address the impact of traffic growth.

Examples

Network Management: There are many network management techniques that could help mitigate the impact of traffic growth. However, whilst the Open Internet framework permits what it calls "reasonable" traffic management measures, what is considered reasonable is heavily restricted. Even measures that have no discernible impact on end-users, such as limiting ultra-HD transmission to smartphones, are generally prohibited.

Fair Usage Policies: Many mobile operators have sought to introduce Fair Usage Policies (FUPs), stipulating that a personal mobile tariff should be for personal use. Such policies should restrict, for example, an end-user tethering their personal mobile contract to provide connectivity to multiple fixed devices (which can drive very high consumption levels). Yet, the concept of device neutrality within the Open Internet rules prevents operators from effectively applying such FUPs.

Addressing end-user demand: Operators have sought to introduce flexible and innovative tariffs that brought together elements of unlimited with elements of metered tariffs. A clear example of this was Vodafone Pass, which offered so-called 'zero-rated' access to certain categories of application, where the end-user was willing to pay a supplement for this. The remaining traffic would remain subject to the standard data limits of the tariff. These were very popular propositions in Europe and had been deemed compliant under the Open Internet rules for many years.

However, a very prescriptive application of the rules by Europe's highest courts resulted in almost all such propositions being deemed non-compliant with the Open Internet rules, despite the fact these involved no technical differentiation in the way the traffic was delivered.

The result has been a push towards a binary offering of either limited or unlimited tariffs, inhibiting the ability of operators to manage their services and segment traffic based on customer preferences and willingness to pay.

Although the net neutrality rules stem from a sensible desire to avoid ISPs from exercising unjustified control over internet content, in practice, their restrictive application undermines the use of entirely pragmatic traffic mitigation and management measures.

As a result, network operators are pressed into making continuous investments into upgrading capacity on their networks, even where this could be otherwise managed through more efficient design and distribution of traffic.

At the same time, other providers in the digital ecosystem who are not caught by the Open Internet rules are able to design their services in a way that both impacts the way traffic is delivered, and prevents network operators from managing their networks effectively.

Growth of 'privacy enhancing' services:
Some operating service providers are offering 'privacy enhancing' services, e.g. Apple Private Relay. When activated, these solutions can fully block operators' visibility of traffic, thereby limiting their ability to manage the traffic efficiently. At the same time, alterations to IP packets at the transport layer can impact the quality of service experienced by the end-user (e.g. by increasing latency by re-routing the traffic through a path dictated by the internet relay service).

This imbalanced application of the Open Internet rules therefore further limits the ability of network operators to take practical steps to mitigate the impact of traffic growth.

03

EUROPE IS AT RISK OF REACHING ITS ‘TRAGEDY OF THE COMMONS’ TIPPING POINT

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LEARNING FROM THE COVID-19 EXPERIENCE

Europe has faced a tragedy of the commons outcome in the digital communications sector before. As the onset of the global COVID-19 pandemic drove more and more services and spaces online, immediate action was required to avoid network overload and the risk of failure.

Operators were required to make immediate and unplanned investments in network capacity and to re-architect their networks to handle the sudden influx of traffic. Policymakers entered into urgent discussions with global technology companies to reach agreement on reducing the impact of their services on connectivity infrastructure, e.g. by limiting some streaming services to Standard Definition.[39] By acting together, a 'crisis' in connectivity was avoided.

However, Europe has since slipped back into complacency. Absent an immediate and apparent 'crisis', little has been done to formalise measures that would help avoid a tragedy of the commons in connectivity infrastructure.

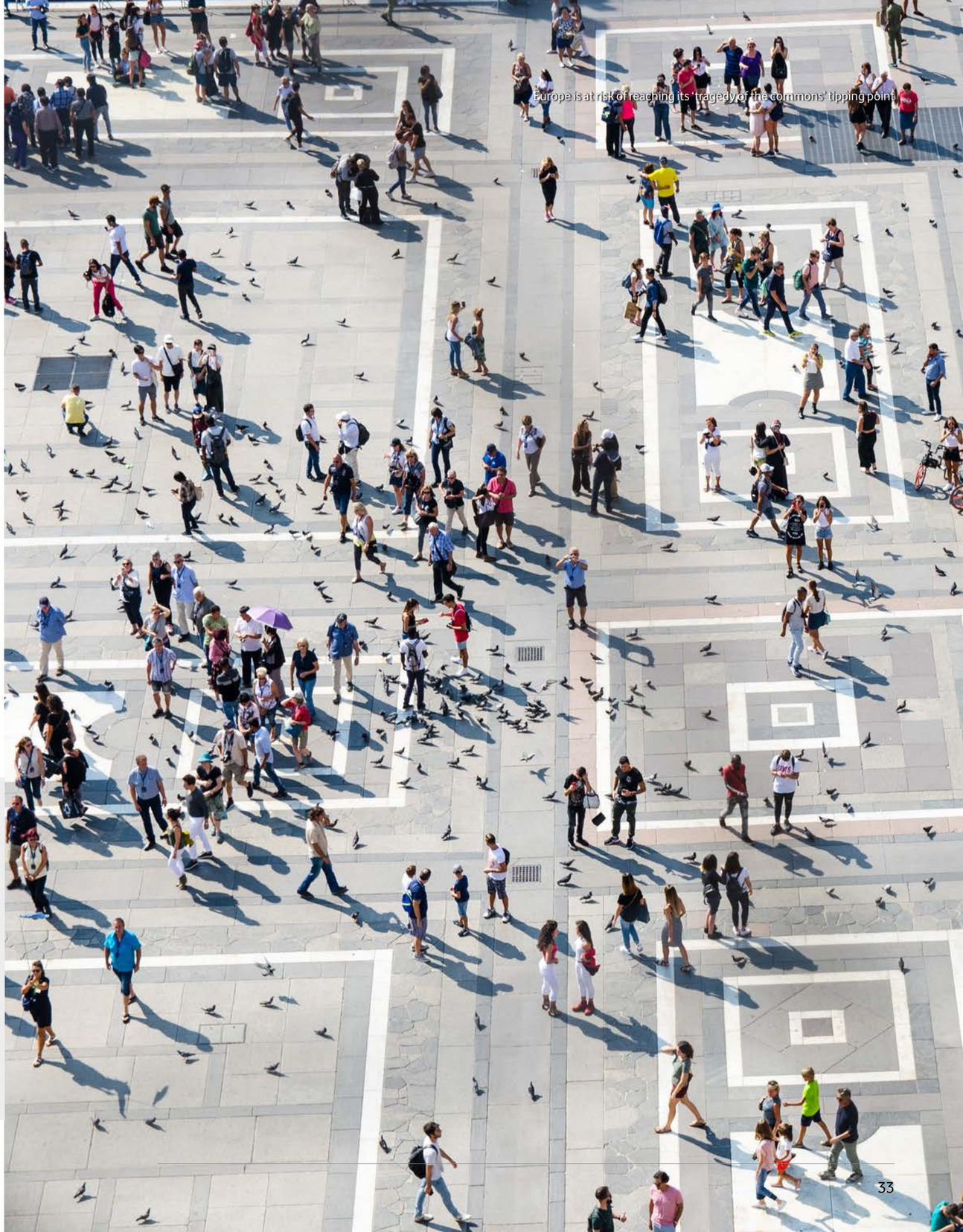
We are now at that tipping point again. The challenges of traffic growth and network demand are only going to intensify.

KEY TRENDS DRIVING TRAFFIC GROWTH

Already, we are seeing new digital trends placing further demands on networks. Whilst annual growth has slowed since the pandemic-peak, it is still increasing at a steady rate. A recent study for the GSMA predicts an annual growth rate of approximately 25% a year on mobile and 20% per year on fixed in Europe until 2030.[40] This translates into heavy growth in absolute volumes of traffic, given the high baseline networks are starting from.

This trend is set to accelerate in the coming years. Since the dawn of the internet, there has been an increasing trend towards the 'digitalisation' or 'softwarisation' of what was previously done via 'hardware' or other physical means. What was analogue is now digital, for example:

CDs	Music streaming services
DVDs	Video on Demand services
Games Consoles & Discs	Cloud gaming
Satellite & Terrestrial Television	Digital streaming
SMS & voice calls	OTT communication platforms
Card & cash payment	Digital wallets
Paperbacks & hardbacks	Audio and eBooks
Newspapers & magazines	Online media and apps
Physical or telephone tickets and reservations	Apps and online
Physical home hardware	Smart devices
High street & grocery shopping	eCommerce



Europe is at risk of reaching its 'tragedy of the commons' tipping point

Here, we focus on a few of these key trends.

Broadcasting of sports and other live events

A particularly impactful example of this in recent years is the sharp rise in the number of sports and other major live events that are streamed digitally, replacing traditional broadcast delivery of this content. Alongside 'traditional' broadcasters such as the BBC, other digital providers have entered the streaming markets, such as DAZN or Amazon. They have become significant players in live-streamed video content, particularly sporting events.[41]

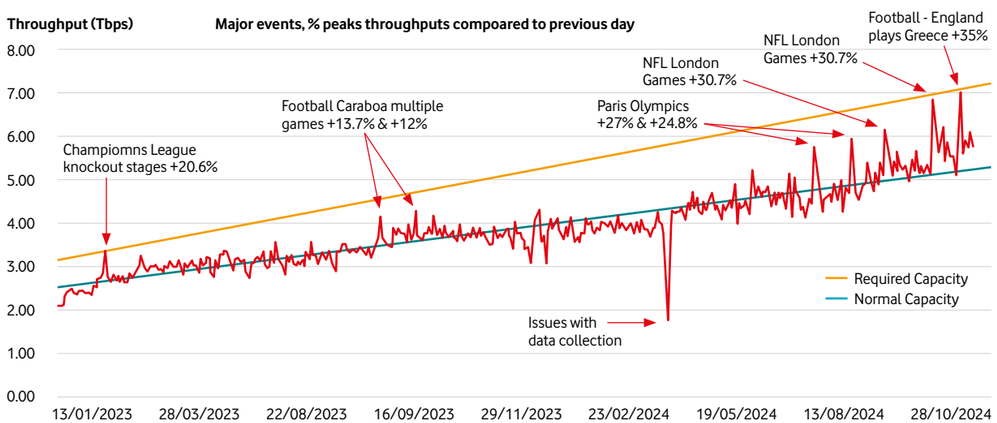
This is partly driven by an arbitrage where digital providers can deliver digital content over the last mile to end-users free of charge. By contrast, traditional broadcasters on terrestrial and satellite networks must pay for last mile content delivery, either by investing in their own distribution network or paying third-parties who run the transmission infrastructure.

This shift is driving the increasingly erratic traffic peaks operators see on their networks. Analysis of Vodafone's UK network shows an increasing number of peaks, primarily driven by sports events being streamed online, with peak traffic growth increasing faster than total traffic growth. (see graph below)

Design decisions for new digital services

As the business models of most major online content providers are driven by increased engagement with their services, this has led to application design decisions that trigger an uplift in traffic volumes.

For social media applications, there has been a trend towards user-generated video content replacing less traffic-intensive photo sharing,[42] boosting overall data consumption.[43] Furthermore, to keep end-users engaged and encourage them to spend more time on the app, many social media apps now feature infinite scroll and autoplay. This content is also often 'pre-fetched' on the network, meaning the traffic is carried on network even if it does not ultimately get viewed.[44]



Europe is at risk of reaching its 'tragedy of the commons' tipping point

These shifts drive not only data intensity, but also the amount of time end-users spend on applications such as social media. A recent study by AD Little estimated that between now and 2030, the average end user will increase their time on social media from around one to two hours per day to around three to four[45] driving up consumption.

With respect to Video on Demand apps (such as Netflix) and user-generated video services (such as YouTube), design and business model decisions also have a significant impact on the volumes of traffic generated.

For example, Netflix has introduced different price and quality subscription options, which all impact traffic models, including:

- Higher cost, higher quality subscriptions: The shift to 'ultra-high definition' services can have a significant network impact, with UHD bit rates more than nine times greater than SD.[46]
- Free or lower cost ad-supported subscriptions:[47] These still result in increased capacity demands, with additional advertising traffic being pushed onto the network. With ad-based video platforms, such as YouTube, a significant percentage of the overall traffic volumes is made up from content other than the video requested by the end-user. In a recent active test run by Vodafone on our network, we identified that over a third of a sample YouTube video was made up from a combination of advertisements or other unsolicited content, such as pre-fetched traffic.

SIDE EFFECT – THE GROWTH OF ONLINE HARMS

There is also growing concern that the design decisions of content developers are having potentially harmful consequences, and are driving what are commonly referred to as 'online harms'. This is another area where content developers have not been required to internalise the full effects of their activities, resulting in business decisions that create a cost (online harm) towards end-users.

For example, many online platforms employ highly addictive app design to drive users towards relentless engagement, contributing to a variety of societal harms including addiction, social isolation and radicalisation. This is not a fringe problem. A 2019 study by the European Parliament Research Service indicated that digital addiction affects millions of EU consumers.[48] A more recent BEUC study showed that 83% of consumers report spending more time on social media than they intended.[49] This issue is likely to compound as advancements in AI spur increasingly personalised and targeted content, thus driving further engagement.[50]

These risks are compounded by the type of data then being consumed. Opaque algorithms have been found to push the consumption of content that promotes highly harmful material, such as content related to self-harm, suicide, 'fake news', eating disorders, misogyny, racism and terrorism. Decisions by large platform providers, such as X and Meta, to remove independent 'fact checking' from their services risk exacerbating this problem.[51]

Another particularly disturbing example is the growth of illegal child sexual abuse material (CSAM) online. More than 300 million children annually are affected by child sexual exploitation and abuse online – equivalent to a case being reported every second.[52]

Despite these alarming statistics, the existing legal framework, including 'must carry' obligations stemming from the Open Internet rules, negate any potentially countervailing power on the part of the ISPs to tackle this issue. For example, operators are limited in their ability to take a more proactive role in the blocking of CSAM, even where this has been identified by recognised charities such as the Internet Watch Foundation.

The EU is now taking action to tackle this and create the right incentives to prevent online harms, for example through the introduction of the Digital Services Act, and on-going consideration of a dedicated regulation to tackle CSAM, alongside new proposals to tackle addictive design through a Digital Fairness Act. These must now be implemented then enforced effectively.

Europe is at risk of reaching its 'tragedy of the commons' tipping point

Cloud hosting for digital services
Three factors have been a catalyst for the development of cloud services.

1. The volume of content that customers want on-demand and dynamic access to increases year-on-year. This is leading to, for example, more photos, videos and other files, at higher resolution, being added into digital storage. The sheer volume of content being stored means that the capacity on device hardware is quickly exhausted.

2. An increasing number of 'operations' are being managed outside of physical or on-premises hardware, given the significantly larger scale of cloud infrastructure compared to private hosting solutions.

3. There is an increasing practice of accessing content from multiple devices, e.g. OneDrive files on smartphones, tablets and laptops.

This is where cloud service providers (CSPs) have stepped in. CSPs offer a place to remotely store and access content, and to support the hosting and processing of these services in a variety of models to suit the needs of the user. The growing appetite for cloud has catapulted the value of the global market to $480 billion in 2022, and it is expected to hit $2.3 trillion by 2032.[53] Most of this is concentrated in the 'big three' of Amazon Web Services, Microsoft and Google.[54]

Now, most iPhone and Android users consume some level of iCloud or Google Cloud storage respectively;[55] and many more businesses are moving to host their data and applications in the cloud.

This increased use of the cloud has driven significant recent growth in upload (or 'uplink') traffic. The growth of smart and connected devices (like home virtual and voice assistants, surveillance cameras and wearables) is also fuelling this trend for more traffic onto the upstream network.

These 'upload' processes occur constantly, and can clash with peak download periods, exacerbating congestion and strains on the network. For now, this is more noticeable on the fixed network, as most cloud uplink activities happen when end-users are connected to home Wi-Fi. However, with the growth in popularity of unlimited tariffs and the use of FWA, the trend is also impacting mobile networks: over the past five years, mobile uplink traffic has grown by around 20% annually on Vodafone's mobile network. New mobile-based activities, such as connected wearables and generative AI, are also more dependent on the uplink, driving this trend.

Whilst this growth is, for now, still slightly lower than growth in downlink traffic, it is still having a significant impact on network deployment. This is because it is not possible to simply 'transfer' some capacity from the downlink to the uplink, which in any case would only reduce capacity on the already strained downlink component of the network. It requires significant incremental capacity investment into expanding capacity in the uplink, and at a faster rate than had been anticipated.

DARK DATA

One consequence of the increasing reliance on cloud storage is the growth of so-called 'dark data', being processed and hosted on the cloud and connectivity networks. Dark data is data that is gathered and stored, and then never accessed again – like the full photo library of an end-user's device, or the billions of unused data points collected by connected devices each day. It is estimated that between 2022 and 2027, the volumes of dark data will quadruple.[56] The need to carry and host this dark data should be considered an inefficient use of valuable network and energy resources.

Whilst last mile network operators must make significant investments to address this new demand, it is comparably easy to expand capacity on cloud infrastructure. It is highly centralised, and whilst capacity at individual data centres will, of course, differ, hyperscaler data centres can now host hundreds of exabytes (equivalent to roughly 1 billion GB of data).[57] Therefore, the impact of adding an additional terabyte of capacity, typically through deploying additional servers, racks and power, is small relative to the cost at the last mile of distributing this to end-users.

The cloud market has therefore been able to react flexibly to growth in demands, with near daily announcements of new cloud capacity being built globally.[58] This, in turn, is enabling increased end-user consumption of cloud capacity, further driving up traffic across connectivity infrastructure.

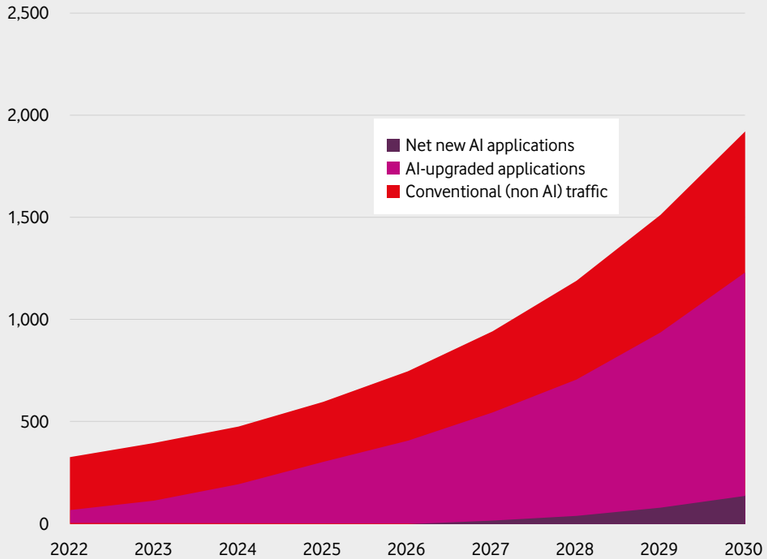
Artificial Intelligence (AI)

The mass proliferation of AI technologies in digital content, applications and services is in its nascent stages. However, it is expected that by 2030, over two-thirds of traffic will involve AI technology in some shape or form.[59]

Data from Omidia shows that most of the new traffic growth globally will come from either new AI applications, or AI upgraded applications. It is also expected that AI-driven traffic is likely to be unpredictable in nature, further driving possible 'peak' traffic spikes, and requiring high-quality, low-latency networks to function effectively. This trend will increase as AI becomes integrated beyond chat and voice, but also into latency critical applications like video, AR and VR.

Impact of AI on network traffic: volume and shape

Projected global network traffic* growth, 2022-30



*Exabytes transferred per month

Source: Omdia 2023

It is also anticipated that the use of AI to further personalise and target content at end-users will increase user engagement by up to 30%, which will have a knock-on impact on network traffic.[60]

The trends are not happening independently of each other. For example, Meta has just announced a $100 billion investment into smart glasses technology, bringing together digital services, enhanced AI capabilities and cloud computing support. This multiplicative effect means this innovation, and others like it, will only deliver their full potential if supported by best-in-class connectivity.

But this ever-increasing consumption of network infrastructure, combined with the limitations network operators face in tackling this through expanding network infrastructure or managing their network resource more effectively, is leading to a tipping point. As a result, a point will be reached where networks, as the essential conduits of internet traffic, are no longer able to meet these developing demands.

THE PARALLEL RISK TO EUROPE'S ENVIRONMENT

The unabated growth in the volumes of traffic being consumed over digital networks is having significant consequences for our environment. Considerably more work is needed to truly understand the impact this data explosion is having on greenhouse gas emissions and the consumption of other environmental resources, such as water. In this regard, we welcome the work being undertaken by the Commission to understand the complex interconnection between ICT services and environmental harm across the digital ecosystem.[61]

However, there is already significant data available demonstrating a clear linkage between the growth of data and impact on our planet. The figures are stark. Looking specifically at data centres, where resource consumption is driven by additional hosting and processing of data, the International Energy Agency estimates that data centres account for around 1-1.3% of global electricity demand. This is expected to rise to 3-4% by the end of the decade.[62] The energy footprint of the cloud 'giants' (Amazon, Microsoft, Google) more than doubled between 2017 and 2021.[63]

Whilst many cloud providers have indicated they are meeting this increasing demand through renewable energy sources, independent calculation methods indicate that claims of energy efficiency by cloud providers[64] may be significantly overstated, with one report indicating that data centre greenhouse gas emissions may be over 600% of what is stated publicly.[65]

Beyond energy consumption, there is also an impact on other scarce resources such as water. Many data centres rely on water to cool their infrastructure and recent studies suggest that by 2021, water consumption from data centres had already risen to more than 840 million litres annually.[66] This can add further demand for ever-more scarce sources of freshwater, which are already under strain from rapid changes in our climate.

Even where these data centres are making use of self-supplied or renewable energy sources, the latter in particular remains a scarce resource, that could be more effectively deployed to other sectors and uses, to bring down global emissions.

With respect to other parts of the network ecosystem, this increase in internet traffic has not, or at least not yet, driven a significant increase in energy demand, due primarily to significant and sustained improvements in energy efficiency by network operators. For example, each unit of traffic carried by Vodafone's network requires around 65% less energy than it did in 2020. These improvements in energy efficiency have been driven by the modernisation of legacy network equipment. Newer generations of technology, such as 4G and 5G, are significantly more energy efficient than older generations, such as 3G.

Network operators like Vodafone have also introduced digital solutions that reduce energy consumption on low-load conditions, optimise energy use based on traffic flows, and improve data centre energy efficiency.

However, the forecasted rate of data increases may outpace the rate of energy efficiency improvements that can be delivered by network equipment manufacturers in the coming years. This is exacerbated by the limited capability of network operators to make the necessary capital investments to further improve energy efficiency and reduce emissions.

Europe is at risk of reaching its 'tragedy of the commons' tipping point

04

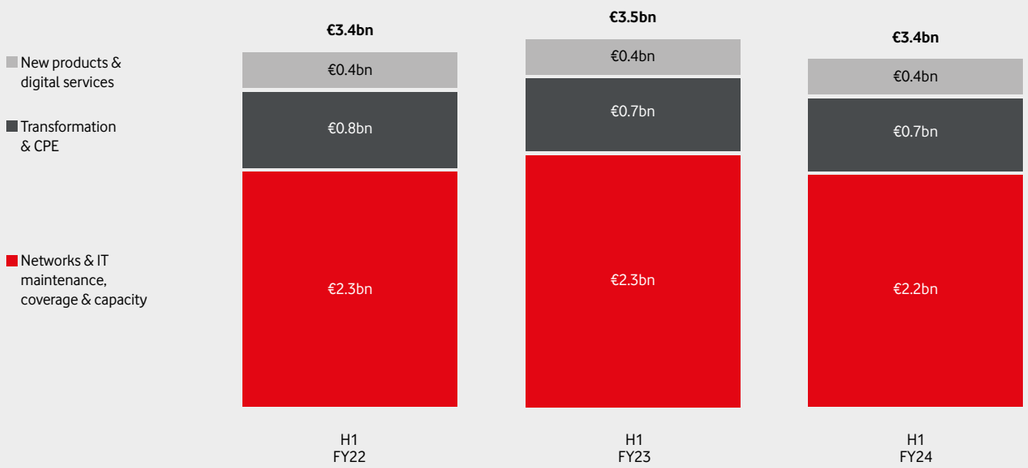
THE OPPORTUNITY LOSS FOR EUROPE

THE OPPORTUNITY LOSS FOR EUROPE

As a consequence of the tragedy of the commons, telecommunications operators face the dilemma of being obliged to invest in their networks to avoid becoming overwhelmed by additional internet traffic in the short-term, whilst also seeking to invest in longer-term transformational capabilities. They must therefore make difficult decisions on how to allocate the limited available capex budget.

This trade-off is a constant challenge and, whilst operators do engage in both maintenance and transformational activity, the primary focus is to ensure a full and effective service to existing customers. This has resulted in investment decisions being primarily driven by **maintaining existing networks**, and specifically on expanding capacity to handle traffic growth. This leaves only a small portion for true transformation – such as 5GSA and network slicing, or network cloudification and orchestration / automation and edge expansion – and other potentially revenue-creating investment.

This can be seen in Vodafone's own capex allocation, where over two-thirds is spent on network, IT maintenance and expanding capacity and coverage, with only a small portion remaining for transformation and new product and services.



Footnote 67

EU RISKS MISSING ITS DIGITAL DECADE TARGETS

This focus on purely 'maintaining' existing networks, and doing this with a limited budget, means that Europe is already behind other regions when it comes to the deployment of high-quality connectivity infrastructure. As a consequence, the EU is not on course to meet its Digital Decade infrastructure targets.

This has led to the situation Europe finds itself in now: falling behind on its own digital infrastructure targets and lagging behind its global peers in high-quality connectivity.

The size of the opportunity loss cannot be underestimated. As recognised by Draghi, "digitalisation in the EU plays a key role in all industrial and service sectors in terms of both cost competitiveness (efficiency and productivity gains), and increasingly of innovation and the quality of products and services".

As a consequence, "the EU's competitiveness will increasingly depend on the digitalisation of all sectors and on building strengths in advanced technologies, which will drive investment, job and wealth creation."[68]

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EUROPEAN OPERATORS ARE AT PARTICULAR RISK

It could be assumed that telecommunications operators in other regions would be impacted by the relentless traffic growth and increasing concentration in the digital communications ecosystem as in Europe.

However, this has not proven to be the case. This is primarily due to the different regulatory and policy decisions in other regions. A case-in-point is the relative scale of operators in the EU versus other regions – a direct consequence of the differing policy decisions in these regions.

As highlighted in Draghi's report on European Competitiveness, the EU has a total of 34 mobile network operators (MNOs) and 351 virtual operators (MVNOs), compared with three MNOs in the US (plus 70 MVNOs) and four MNOs in China (plus 16 MVNOs).[69] The difference in scale has a number of knock-on consequences. For example:

- The ability to spread fixed costs over more customers.
- A greater bargaining position with content generators, allowing them to reach more favourable agreements with respect to traffic deployment over internet infrastructure.

This is also complemented by the more harmonised and, in many cases, modernised regulatory frameworks in these markets. For example, the US, Canada, Japan, China and South Korea have either removed prescriptive Open Internet rules, or applied a more principles-based approach. This has allowed for more effective management of traffic and the development of innovative and revenue generating services.

In some of these markets, such as South Korea, there is also a clear framework to support commercial settlement between network operators where there is a clear imbalance in traffic.

As a consequence of these differences, the market capitalisation of telcos in these regions sits in a different league to that of European telecommunications operators. Only one European telco (Deutsche Telekom) appears in the top 20 telcos by market capitalisation globally, and the vast majority of that value relates to T-Mobile USA.[70]

This puts operators in other regions in a considerably better financial position, with the opportunity to invest profitably. In the EU, telecoms capex per capita sits considerably behind other regions at €109 compared to, for example, the USA's €240 or Japan's €271.[71]

Therefore, although impacted by the same global internet traffic patterns, operators in other regions are better equipped to manage this than in the EU.

EUROPEAN COMPETITIVENESS IS AT STAKE

By falling behind in advanced connectivity, the EU faces the parallel risk of falling further behind in all other economic sectors.

For example:

Industry 4.0[72]

'Industry' accounts for more than 20% of the EU economy and employs around 35 million people. Yet, it is under threat from geopolitical shifts and a more turbulent export market alongside increased costs for raw materials, human resources and energy.

Significant improvements in efficiency and innovation are needed to counter this. Having access to high-quality connectivity will enable manufacturers to improve efficiency and increase output. By connecting all 'things' within a production line, improvements can be gained in many areas.

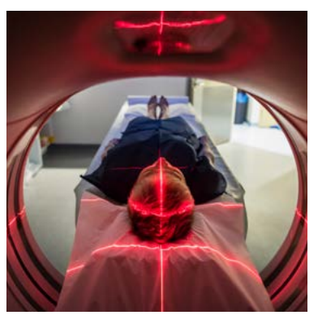
Such improvements are already visible in markets with higher rates of high-quality connectivity. In Foshan, China, thousands of manufacturing businesses are using 5G connectivity to improve their operations. As a result of 5G-enabled digital transformation, SMEs have reported labour productivity increases of 40-60%, manufacturing costs lowering by 25-35%, and equipment energy consumption reducing by 15-20%.

Healthcare[73]

The COVID-19 pandemic demonstrated how connectivity could support the delivery of healthcare, with better efficiencies for practitioners and better outcomes for patients.

This will rely, however, on both hospitals and other primary and secondary care settings getting effective access to best-in-class connectivity.

This enables the use of emerging solutions, such as network slicing, to enable highly sensitive procedures such as remote surgery to take place safely. This is not a pipe dream – in China, there are already examples of 5G connectivity being used to enable surgeons to conduct fully remote lung surgery.[74]



Artificial Intelligence

The increased adoption and integration of AI capabilities will help drive efficiencies and productivity across a broad range of sectors. Recent estimates indicate that widespread adoption of AI innovations can be estimated to increase European GDP by as much as 7% over a 10-year period[75] However, to reach its full potential, the development, deployment and consumption of AI tools must be supported by high-quality network infrastructure. Given Europe's laggard position compared to these metrics, it is perhaps unsurprising that it also falls behind in the development of AI tools. 73% of large AI models are being developed in the US and another 15% in China, while no EU country has yet managed to host its own general purpose AI system.[76] The US has close to 14,000 organisations active in AI, spanning companies, universities and research institutes, while China has 10,000. The EU again lags at just under 6,000.[77]

Quantum Computing

The development of quantum computing technologies presents opportunities for the connectivity sector. The successful integration of quantum capabilities could dramatically enhance a wide range of applications and activities. For example, the ability of quantum to detect even the most miniscule changes in data patterns would improve fraud detection capabilities considerably.

But to understand where and how such technologies could be integrated into digital communications activities will require significant investment into research and development, trials and deployment. Developments in this space are therefore slow. Consequently, the communications sector is falling behind sectors including the pharmaceutical and automotive industries, which are already practically applying quantum capabilities.[78]

The deployment and adoption of high-quality connectivity, and a need to spend on the transformation of network infrastructure, is crucial to Europe reaching its full economic potential and competing effectively with our international counterparts. This 'lag' in productivity is clearly demonstrated by the poor performance productivity index for the EU, where in the last 20 years productivity has grown twice as fast in the US as in the Eurozone.[79]

It is essential that European citizens and businesses can benefit from the incredible technological developments that rely on these capabilities. But deployment of this next generation of connectivity infrastructure will take investment, and a lot of it. The current policy framework is not creating the right conditions for investment to address the gaps faced by Europe in deploying new network capabilities.

Without incentives for all parties to make responsible use of network resources, limited investment resources will continue to be funnelled into network maintenance rather than the much needed transformation of European network assets.

Robust, urgent action is therefore needed to address the already significant investment challenges faced by the digital communications sector.

05

A FRAMEWORK FOR RESPONSIBLE USE OF NETWORKS

A FRAMEWORK FOR RESPONSIBLE USE OF NETWORKS

The totality of the EU digital communications policy environment, and the resulting behaviour of the stakeholders within the digital communications ecosystem, has resulted in a tragedy of the commons in the sector. Action will be needed across all identified areas to fully address this and ensure a competitive digital communications sector.

A FULL RESET OF DIGITAL SECTOR POLICY IS NEEDED

Full scale sectoral policy reform is required to address the tragedy of the commons in the digital sector. In particular:

The policy framework should be used to **strengthen, not weaken, the investment capacity of the sector**. Existing policies place significant regulatory and financial cost on operators, either through extracting value (e.g. spectrum auctions), creating costs (e.g. security or sustainability obligations) or limiting the profitable development or deployment of digital infrastructure and related services (e.g. the highly restrictive approach to mergers and the use of spectrum allocation to subsidise market entry).

It should also **support the effective expansion of network infrastructure**. There continues to be practical and legal constraints on the ability of network operators to expand capacity to meet traffic demands in the EU, for example, decisions related to allocating new spectrum bands, EMF rules going beyond international guidelines, slow/restrictive permitting, limited access to public infrastructure, etc. And, whilst the recent Gigabit Infrastructure Act has sought to facilitate infrastructure deployment and permitting processes, it will not be fully applicable until May 2026 and (i) fell short of putting forward a fully-fledged tacit approval process for permits; (ii) still gives several grounds for owners of physical infrastructure to refuse access.

A reset policy framework should **create a regulatory level playing field, where the same services are governed by the same rules**. To date, policy decisions that have failed to create regulatory equivalence between telecommunications and technology service providers, even where they are providing complementary and in some cases competing services (such as the EECC framework or the Open Internet rules).

It should also look to **protect the environment and tackle the growing problem of online harms**. Europe must ensure it creates the right incentives to minimise the impact of digital services on the environment, and also to reduce risk of online harm (with a suite of digital platform regulations being introduced to address this, such as the DSA, and the upcoming CSAM rules and DFA).

This broad set of challenges will require far-reaching reforms, going beyond adjustments to the existing sectoral framework. A full reset of digital communications policy is needed to help address some of the root causes of Europe's tragedy of the commons in the sector. This could be through the development of a holistic Digital Networks or Digital Communications Act, covering all relevant service and network providers in a manner that ensures an equivalent level of regulatory protections across the digital ecosystem.

A FRAMEWORK FOR A RESPONSIBLE USE OF NETWORKS

This full suite of policy measures needed to truly tackle the tragedy of the commons in the digital communications context goes beyond the scope of this paper. Vodafone is pleased to see that many of these issues have been acknowledged, and solutions proposed, through the Commission's White Paper on Digital Infrastructure, alongside the influential policy reports of Mario Draghi and Enrico Letta. Vodafone looks forward to continuing our engagement with policymakers to address these issues.

A necessary part of this broad policy reset is a **Framework for Responsible Use of Networks (RUN)**. This framework should be in line with well-established principles for dealing with the tragedy of the commons. As explained by the Harvard Business School, overconsumption can be managed if "individuals can be motivated to cooperate through monetary or moral incentives or penalties".[80]

The framework shall include the following key measures, to incentivise cooperation and responsible use:

Action 1: Requiring traffic optimisation to reduce pressure on networks and minimise traffic waste

As outlined above, there are many technologies and techniques that can be deployed to effectively reduce the impact of traffic. However, for a number of reasons, they are not adopted as widely as they could and should be. Policymakers should therefore consider what further incentives should be introduced.

Vodafone welcomes the work the Commission has commenced on this topic, including existing Codes of Conduct for Data Centres and Broadband equipment, and eco-design requirements for servers. The Joint Research Centre (JRC) report and upcoming work on a new Code of Conduct for the sustainability of telecommunications networks is also welcome, although its focus on harmonising approaches to environmental impact indicators/ measurements may limit its impact.

Given the convergence across the digital ecosystem and the multitude of stakeholders at play, the Commission should consider a single Code of Conduct for the Digital Ecosystem. This would be a more effective way of driving forward change, and would focus not only on environmental impacts, but also on broader ecosystem impacts (such as efficient use of network resources). A joined-up code of conduct would also function as an input into the EU Taxonomy, where digital is currently not recognised.

Activities that are already taking place at a national level can provide a blueprint. For example, in France, ARCEP, ARCOM and ADEME have published a policy framework for the eco-design of digital services. It is targeted at all the digital players in the ecosystem, posing a series of questions that allow providers to self-assess whether their services are designed in ways that minimise environmental harm.

The measures encourage 'background' technical measures, but would also raise awareness amongst consumers, giving them more choice over their consumption. They include more visible and easier-to-use mechanisms to turn on data-saving modes in their devices or applications, or, for example, options to turn off auto-play / infinite scroll. Recent studies indicate that making such mechanisms more transparent would lead to end-user adoption – nearly half of Europeans said they would be open to accepting lower video quality in exchange for higher sustainability.[81]

Whilst voluntary, it offers the opportunity for providers to publish a certificate of conformity against their services after self-assessment. The framework has been in place since May 2024, and the authorities are now running an impact assessment process.

Binding traffic optimisation targets: If voluntary Code of Conducts do not engender action and tangible results, policymakers may need to consider more robust measures. They could include clear legal obligations to optimise and minimise traffic to improve energy efficiency and reduce pressures on Europe's connectivity infrastructure.

Action 2: Operators must be allowed to dynamically manage traffic on their networks

As set out in Chapter 2, operators have sought to introduce practical measures to prevent abuse of network resources and better manage internet traffic on connectivity infrastructure.

Examples

Fair use policies: Contractual measures directed at the small group of end-users that make excessive use of network resource to ensure a better quality of experience for all. This may include, for example, conditions which stipulate that a mobile tariff should only be used for personal use. Where applied effectively, this would limit end-users' ability to, for example, tether their mobile device to multiple fixed devices (which can lead to very high consumption levels).

Technical traffic management: Networks are also technically able to apply measures to better manage the traffic flow on their networks, thereby reducing the impact of overall increasing volumes of traffic. For example, techniques such as L4S[82] allow operators to queue up data packets according to their technical need, reducing the risk of a negative congestion impact.

However, there are limitations as to how far network operators can go in these measures. These primarily stem from highly prescriptive applications of the Open Internet rules, which create very strict conditions on the use of traffic management and the imposition of fair usage policies.

There is a need for policymakers to provide more clarity to operators as to how they can manage their networks effectively. This could be achieved in the short-term by issuing guidance setting out clearly that measures taken to drive network efficiencies and protect against abusive consumption should be permitted.

This more permissive and flexible interpretation and application of the current rules should also open up opportunities for network operators to develop innovative services based on network differentiation capabilities. These could be monetised to support investment in upgrading network infrastructure, driving a virtuous cycle of value-creation for consumers, operators and content providers.

Action 3: Enabling commercial negotiation for traffic conveyance services

As highlighted in the preceding chapters, the digital ecosystem and the way in which traffic flows through it has changed dramatically in recent years. It has moved from an ecosystem where a small number of network operators exchanged broadly symmetrical volumes of traffic to the increasing privatisation of the 'middle mile', with a small number of content generators and their intermediaries pushing highly asymmetric volumes of traffic onto mobile and fixed networks.

Consequently, the mutually beneficial arrangements that existed between network operators and the settlement-free peering arrangements underpinning these are, in many cases, no longer

appropriate. Rather, the relationship between network operators and the large content generators and their intermediaries has shifted to an asymmetric business-to-business relationship.

Despite, or because of this, nearly all network operators in Europe have been unable to secure reasonable commercial terms for the provision of these services. The policy framework and the impact this has had on the market position of these players means that they are in a weak bargaining position, from which it has proven near-impossible to negotiate a reasonable commercial settlement for services provided.

Vodafone therefore welcomed the Commission's recognition that ISPs and CAPs (and their intermediaries) should be able to reach both technical and commercial terms for IP Interconnect services, such as bilateral peering.[83] Similar conclusions were reached by Mario Draghi in his report on European Competitiveness, where he recommended that the Commission "encourage the definition of commercial contractual agreements for terminating data traffic".[84]

Because of this steer, Vodafone has been considered in updating our approach to IP traffic conveyance services to introduce reasonable charges.

However, progress to date has been slow, indicating a need for a legislative framework underpinning these negotiations and IP-IC relationships. Vodafone advocates for the introduction of a dispute resolution mechanism, to be used in the event of a breakdown in commercial negotiation for IP traffic conveyance services.

In the absence of such a mechanism, the options open to ISPs are severely restricted. This is primarily because they must carry all content, irrespective of whether agreement can be reached: there is no option to drop the CAP's traffic in the event they refuse to pay, and nor would any operator want this outcome.

None of the options left on the table are particularly desirable:

- Operators can choose to end the direct interconnect relationship with the partner and require them to send their traffic via an indirect route. This will likely result in a reduction in quality from an end-user perspective, which is not in any party's interest. It may also result in additional costs to both parties if they are required to reconfigure the network to manage traffic from another less optimal location.
- Alternatively, the ISP could seek redress through the courts, as seen in the long running legal dispute between Meta and Deutsche Telekom on the question of interconnect fees. However, this is a lengthy and costly approach. It would only be easily accessible to the extent there is a contract in place to dispute, which is not the case in most existing interconnect arrangements. Absent this, operators would need to prove tacit agreements, which is not always easy.Therefore, ISPs have limited leverage if a partner simply refuses to pay.

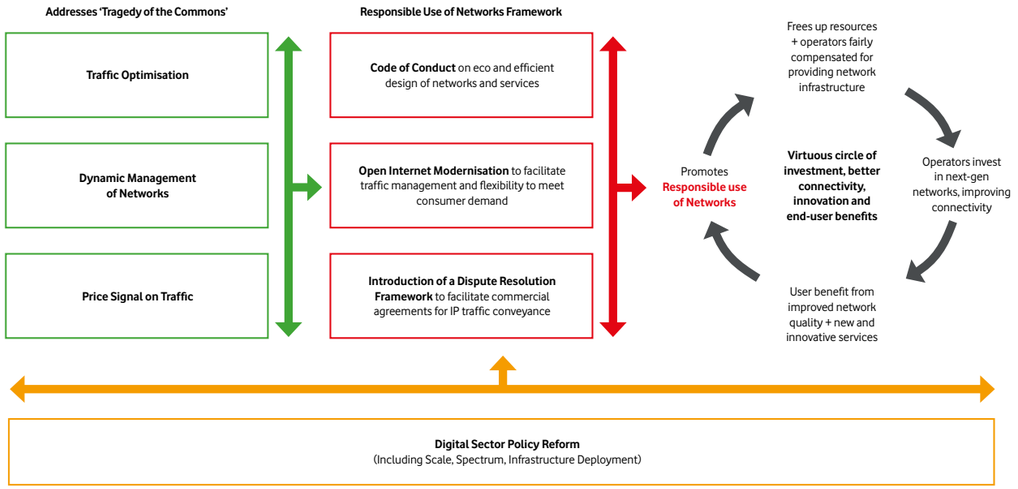
It is therefore concerning that the Commission has indicated it will wait for evidence of disputes before intervening with policy measures. In this regard, Vodafone agrees with Draghi that "the safeguard of mandatory final arbitration offers made by national compe¬tition authorities should be foreseen, in case of failed negotiations within a reasonable period."[85]

There are different options available to the Commission to achieve this. However, one approach could be to expand relevant provisions of the Code, Article 15 (which enshrines the obligation to negotiate for interconnection) and Article 26 to relevant network operators in the middle mile. Whilst careful assessment will be needed to understand how this can be done effectively, this could be wrapped up as part of the Commission's upcoming review of the Code during 2025.

The introduction of such a dispute resolution framework, and the consequent introduction of fair commercial terms into these technical arrangements, would have the dual effect of (1) incentivising traffic minimisation on the part of content generators and their intermediaries; and (2) improving the financial position of network operators, enabling further investment, thereby helping to tackle two of the root causes of the tragedy of the commons.

This Framework for Responsible Use of Networks builds on the experience of COVID-19, where all actors played a role in managing the crisis situation. This now has to be formalised and adapted for the situation Europe finds itself in.

The measures proposed bring together policymakers, service providers, network operators and end-users, to work together to address this complex challenge, and to help address the misaligned incentives that currently exist between driving traffic growth, and ensuring a responsible use of network infrastructure. This will help to prevent the degradation and exhaustion of valuable network resource, and instead promote its transformation to be fit for Europe's future as a digital leader.



By addressing the lack of incentives on all actors to utilise network resources responsibly, this framework will help address one of the root causes of Europe's tragedy of the commons, and will help to reverse the current vicious circle into a **virtuous one**, where more limited traffic growth opens up opportunities for operators to re-focus investments into transformational (and revenue-generating) activity, which in turn should help them continue to – steadily – expand network resources and invest in new transformational capabilities that will support the next generation of digital services.

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32. According to data from Ericsson, in Western Europe, the number of providers offering FWA speed-based offerings (i.e. offers with speed parameters similar to cable or fibre) has increased to over 50%, with Europe alone accounting for 73% of all 5G FWA launches between 2023 – 2024. Source: EMR – early movers pursue performance-based business models
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34. This is, in particular, due to the highly prescriptive application of the Open Internet rules.
35. The weighted chart includes a multiplier to account in a simple way for the level of intrusiveness of the regulations in each case.
36. Whilst Vodafone's ROCE has increased marginally to 7.5% this year, primarily due to right-sizing our footprint, it has remained otherwise stagnant, at around 4 – 4.5% for the preceding 5 years. Furthermore, these ROCE figures include Vodafone's non-EU markets that have higher ROCE (e.g. Egypt and SA): a strict EU figure would be lower.
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