Report for the Internet Society

How the Internet continues to sustain growth and innovation

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Michael Kende

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Contents

Analysys Mason Limited
818 Connecticut Avenue NW
Suite 300
Washington DC 20006
USA
Tel: (202) 331 3080
Fax (202) 331 3083
washingtondc@analysysmason.com
www.analysysmason.com

Registered in England: Analysys Mason Limited
Bush House, North West Wing, Aldwych
London WC2B 4PJ, UK
Reg. No. 5177472

1 Introduction

The ability of the Internet to keep pace with increasing demand and changing usage is a recurring concern in the history of the Internet. Today, such concerns are raised with respect to two overlapping trends: first, the accelerating growth in access worldwide, notably in developing countries; and second, the rapid growth in Internet usage by existing and new users, driven by demand for video content and new services such as machine-to-machine applications. Specifically, some stakeholders argue that current business models are unable to supply the infrastructure needed to meet this demand, which could lead to a reduction in service quality or even a collapse of the Internet.

In this paper we show that, in the face of constant growth and changes, fears about the sustainability of the Internet are almost as old as the commercial Internet itself, while market forces continue to meet the challenges presented by new demands on the Internet. In particular, we show how these challenges have been continually met in developed countries, based on a combination of new technology, investment, and changing business models, and how these same forces are already addressing new demands in developing countries today.

2 Sustainable development is a continual concern

Over the history of the commercial Internet, there have been numerous warnings that growth was unsustainable, based first on the growth of World Wide Web traffic, then on the growth of video, and today based on the growth of mobile broadband access in developing countries. Two particularly notable examples of this are summarised below.

Catastrophic collapse

As early as 1995, soon after the introduction of the first commercial web browsers, Bob Metcalfe (the co-inventor of Ethernet and founder of 3Com) predicted in a column in *InfoWorld* that the Internet would suffer a catastrophic collapse in 1996, and that if this did not happen he would 'eat his words.'[1]

The exaflood

Starting in 2007, a series of industry experts predicted that the Internet could not keep pace with the explosion of traffic, referred to as the 'exaflood', primarily resulting from then new video sites such as YouTube. The term 'exaflood' was invented by Bret Swanson, formerly with the think tank Discovery Institute, who first used the term in a 2007 *Wall Street Journal* editorial.[2]

As we know today, these predicted collapses did not come to pass. Most dramatically, in front of a conference in 1997, Bob Metcalfe admitted that his 1995 prediction had not been realised, and kept his promise by literally eating his words (prepared by placing his paper column in a blender with water). There is no record of the exaflood proponents making a similarly dramatic admission; however, today we can see that the Internet is capable of not just carrying short home-made videos, but also of streaming high-definition movies and even live broadcasts. For instance, YouTube streamed live video of the 2012 Olympics to the United States and 64 countries in Asia and Africa, with a total of 231 million streams viewed, and a peak of more than 500,000 simultaneous live streams.[3] In both cases, the predicted collapses were clearly avoided through a combination of new technology, investment, and innovation, as described below.

The latest warnings that Internet growth is unsustainable appear to stem primarily from the rapidly growing global demands for mobile broadband access and usage. In the remainder of this paper we will show that the same forces that met the earlier challenges discussed above are already responding to the challenges imposed by these emerging demands, particularly in developing countries.

1 See http://www.ibiblio.org/pjones/ils310/msg00259.html

2 See http://www.techdirt.com/blog/?tag=exaflood

3 See http://youtube-global.blogspot.ch/2012/08/how-olympics-played-out-on-youtube.html

3 The basis for Internet sustainability

The history of the Internet is filled with examples of new technologies and applications that are quickly adopted by users, further adapted by providers, and lead to a repeated cycle of growth and innovation. For instance, July 2012 marked the 20th anniversary of the first known photograph uploaded to the World Wide Web by its creator, Sir Tim Berners-Lee.[4] 18 years later, on 17 July 2010, the first photo was uploaded to a then new photo-sharing site, Instagram, and, now, just two years later, 1 billion pictures have been uploaded by 50 million users.[5] Similar rapid evolutions have taken place with websites, music, and video, to name just a few examples.

At the time the web was being invented, Internet access was through dial-up connections, the backbone of the network was a T1 connection, and most users were in the United States. It is in this context that new websites quickly created significant new demand for Internet access, leading to fears of collapse. Likewise, as web content became increasingly multimedia, evolving from text to video, and as usage of the Internet increased, further stress was put on the Internet.

Rather than leading to a collapse, these new demands were met through a number of overlapping responses, including advances in technology, investment, and innovation. In this section we focus on how developed countries responded to the past challenges cited above, while in the next section we look at how these responses are unfolding in developing countries in the face of current challenges.

In general, in the face of new demands, networks can either increase their capacity or find ways to reduce the capacity that is required. Typically, both approaches are taken, based on the following overlapping responses.

- **Technology**. First, new core and access technologies are developed that both increase the capacity of existing network deployments and make new investments more efficient.[6]

- **Investments**. Investments are made to upgrade existing networks with the new technology, and in parts of the network where upgrades are not possible or insufficient to meet demand, further investments are made to increase the capacity and extend the network.

- **Innovation**. Finally, new technologies and business models are developed to distribute content to multiple locations, so that it is closer to end users and costs less to deliver.

We examine each of these in turn.

4 The image, a promotional picture of a band that played at CERN, where Sir Berners-Lee worked when he invented the World Wide Web, was uploaded on 18 July 1992. See http://www.bbc.co.uk/news/technology-18928858

5 See http://blog.instagram.com/post/27359237977/2-years-later-the-first-instagram-photo

6 Access networks – both mobile and fixed – are used to transfer content to and from the Internet, while core networks carry the traffic between access networks and around the world.

3.1 Technology

Vendors continually develop new network technology that enables existing Internet infrastructure to be upgraded to higher bandwidth capacity, and typically also become the basis for new investments. These advances take place at both the core and access level, on both fixed and mobile networks.

- *Core network*. Submarine and terrestrial fibre networks are critical to the growth of the Internet, and also represent a significant deployment cost. Advances in wavelength-division multiplexing (WDM) enable multiple streams of data to share the same optical fibre. This increases the capacity of a strand so that it can accommodate new traffic without the need to lay new fibre. For instance, in the early 1990s, each fibre carried one light stream, with less than 10Gbit/s of throughput – today, depending on the system, one fibre can carry up to 160 wavelengths, each with at least 10Gbit/s of throughput, thereby increasing the capacity of the strand by many orders of magnitude.

- *Access network*. Access to new applications, using devices such as connected TV sets, tablets and smartphones, is not possible without high-bandwidth access. On the fixed side, there has been a significant shift from dial-up access capped at 56kbit/s to broadband access with significantly greater bandwidth. Over copper access lines in the public switched telephone network (PSTN), successive versions of asynchronous digital subscriber line (ADSL) technology boosted access speeds up to 24Mbit/s, while over cable networks, the DOCSIS standard, first introduced in 1997, has seen successive progressions in capacity to well over 100Mbit/s. Meanwhile, a similar evolution has been taking place in mobile access networks, culminating in the fourth-generation long-term evolution (LTE) standard that is currently being deployed in many countries.

While such technologies have led to significant increases in capacity, new investment is also needed at all network levels. In the core network, new terrestrial and submarine cable deployments have been required to further increase capacity, while in many countries the access and backhaul networks have received significant investments in fibre access to deploy higher-capacity versions of DSL (e.g. VDSL) and DOCSIS. Likewise, on the mobile side, operators are investing in capacity by installing more towers and replacing microwave backhaul links with fibre networks.

3.2 Investment

Investment in new infrastructure (such as submarine cables and backbone networks), along with upgrades to increase the capacity of existing infrastructure using the above technologies, has always arisen to meet the demands of new users and applications in the past. Here we show how investment in developed countries has consistently met past challenges of increased demand; in Section 4.1 below we show how a similar response is now taking place in developing countries.

In Figure 3.1, which shows telecommunications investment in OECD countries by region, two recent spikes in investment can be seen: the first beginning around 1995 and peaking during the

dotcom bubble in 2000, and the second starting soon after, and peaking around the start of the current economic crisis.

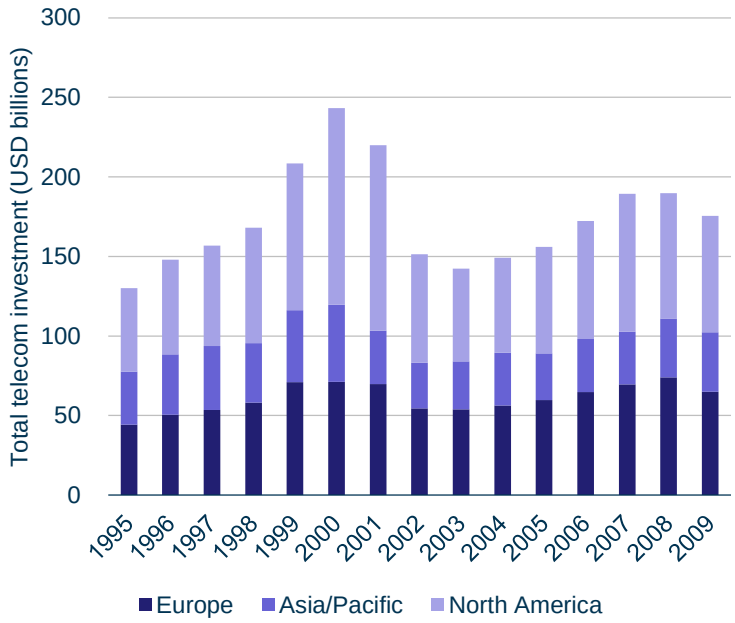


Figure 3.1: Total telecommunications investment [Source: OECD Communications Outlook 2011]

The OECD notes that the first trend involved investment in core long-distance networks, while the more recent investment was in access, specifically "new wireless networks (3G and the first 4G), upgraded copper networks (e.g. DSL), cable television networks and new fibre optic access (FTTH)."[7] It is noteworthy that both investment cycles coincided broadly with the two warnings of unsustainability of the network described above – the first commencing in 1995 corresponding to the increase in web traffic, and the second in 2007 corresponding to the increase in video traffic – and clearly helped to prevent those predictions of collapse from being realised.

3.3 Changes in traffic flows

Much of the content with the greatest bandwidth requirements, such as streaming video, is essentially static content that can originate in one place, but be stored in multiple locations in order to reduce the cost of delivering the content to end users. According to Cisco, as of 2011 up to 98% of consumer Internet traffic[8] consisted of such data, notably video, web pages, and file sharing, as shown in Figure 3.2. Delivering this traffic from the source to each destination would take significant capacity and create congestion that would affect all users.

7 Based on data from OECD (2011), *OECD Communications Outlook 2011,* OECD Publishing http://dx.doi.org/10.1787/comms_outlook-2011-en

8 Note: Cisco defines Internet traffic as "any IP traffic that crosses the Internet and is not confined to a single service provider's network". This figure is restricted to consumer traffic only, which includes IP traffic generated by households, university populations, and Internet cafés, but excludes Internet traffic generated by businesses and governments. See http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360_ns827_Networking_Solutions_White_Paper.html

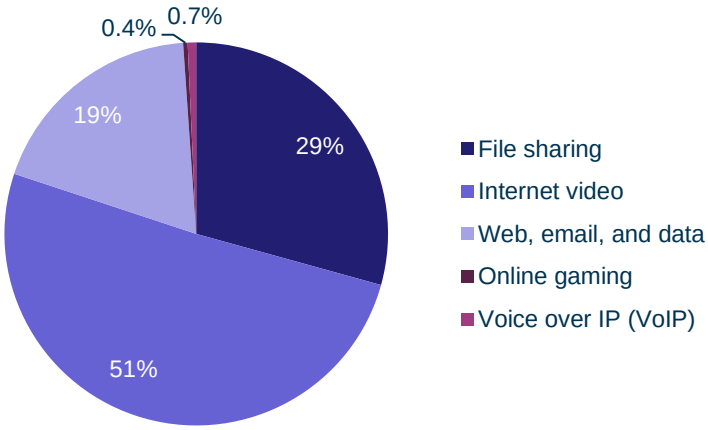


Figure 3.2: Split of consumer Internet traffic (fixed and mobile) by type of traffic, 2011 [Source: Cisco Visual Networking Index: Forecast and Methodology, 2011–2016]

For instance, it would take up significant resources throughout the network if a user who made a popular video only stored that video locally on his/her own computer, and sent it from there to thousands or even millions of viewers. While the investments in capacity described previously can help to alleviate any congestion, new technology and business models help to deliver and store content closer to users, and thereby efficiently reduce congestion in the core network. Using these technologies, the user is only required to upload the video once, and then it can be distributed to multiple caches and servers around the world, allowing it to be downloaded closer to the viewer.

Below we discuss three related changes that have served to alter traffic flows with the aim of increasing the efficiency of traffic delivery, in particular through more direct interconnection (e.g. through Internet Exchange Points) and through more efficient storage and delivery of content to end users (e.g. caching in content delivery networks and cloud services).

Internet Exchange Points

Internet Exchange Points (IXPs) are locations where a variety of providers (including ISPs, content providers, and enterprises) can locate servers and caches in order to exchange traffic with one another. In the context of this paper, the significance of these IXPs is that they act as centres of connectivity where, among other things, content can be stored on servers and easily delivered to ISPs at low cost and with low latency. Figure 3.3 shows the growth rate in the number of IXPs by region, illustrating that over the past ten years, the annual rate of growth in all regions exceeded 10%, with the fastest growth in the emerging regions of Latin America and Africa.

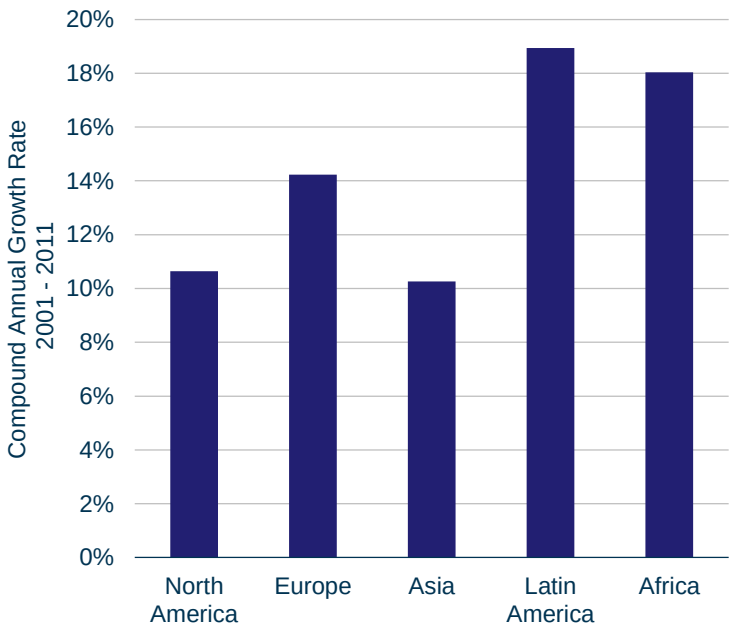


Figure 3.3: Compound annual growth rate in IXPs, by region, 2001-2011 [Source: Packet Clearing House (www.pch.net), Analysys Mason estimates]

As more caches arise across countries and regions, they allow traffic exchange to be localised, and reduce the need to rely on longer-distance backhaul, including notably expensive transcontinental submarine cable capacity. Content delivery networks (CDNs) and cloud services leverage IXPs to help manage the flow of content, as described next.

Content delivery networks

CDN providers manage a network of servers and caches on behalf of content providers. CDNs function to reduce the cost and increase the quality of service associated with content delivery by storing it closer to users, often in IXPs. The figure below illustrates Cisco's forecasts for growth in the CDN business, showing that video delivery is a significant share of that business.

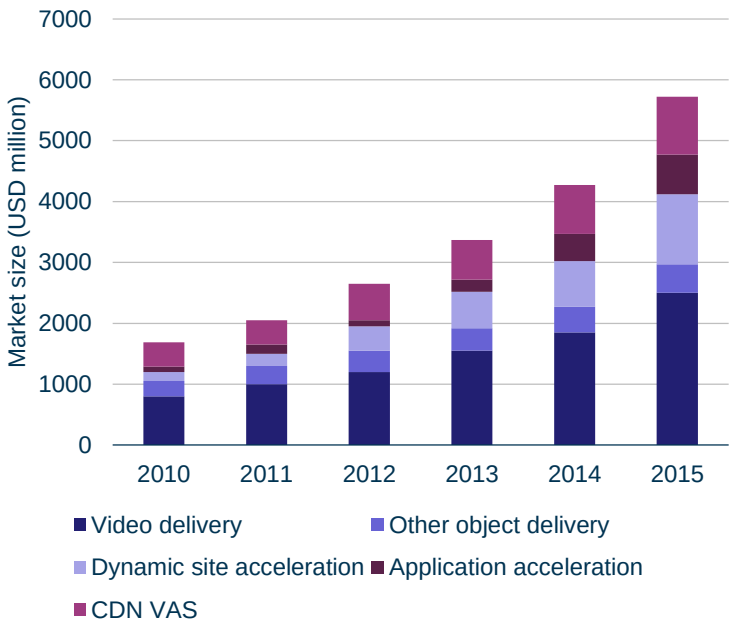


Figure 3.4: Global CDN market forecast [Source: Cisco, Next Generation Content Delivery Services (October 2011)]

Cloud services

Cloud services facilitate the storage and delivery of content. While CDNs are very convenient for managing 'one-to-many' content, such as video offered by providers such as BBC iPlayer, cloud services are notable for providing a front-end that is convenient for user-generated content, which is typically 'many to many' in nature, such as Youku, the largest Chinese video aggregator. In other words, consumer cloud services enable users to conveniently upload their content once and distribute the content to allow easy access for themselves and others around the world. This is significantly more efficient than sending the content across the Internet from source to destination each time a user requests a video.

The following chart shows the rapid rate of growth forecast for cloud services.

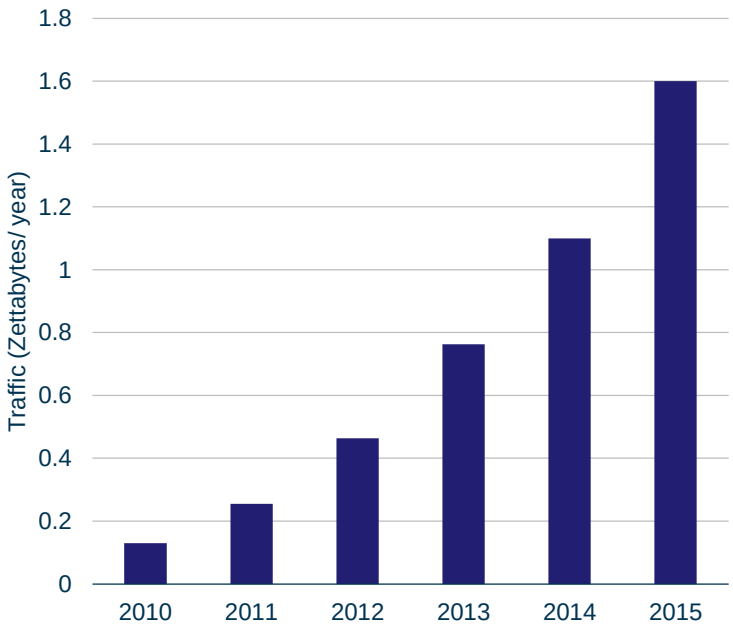
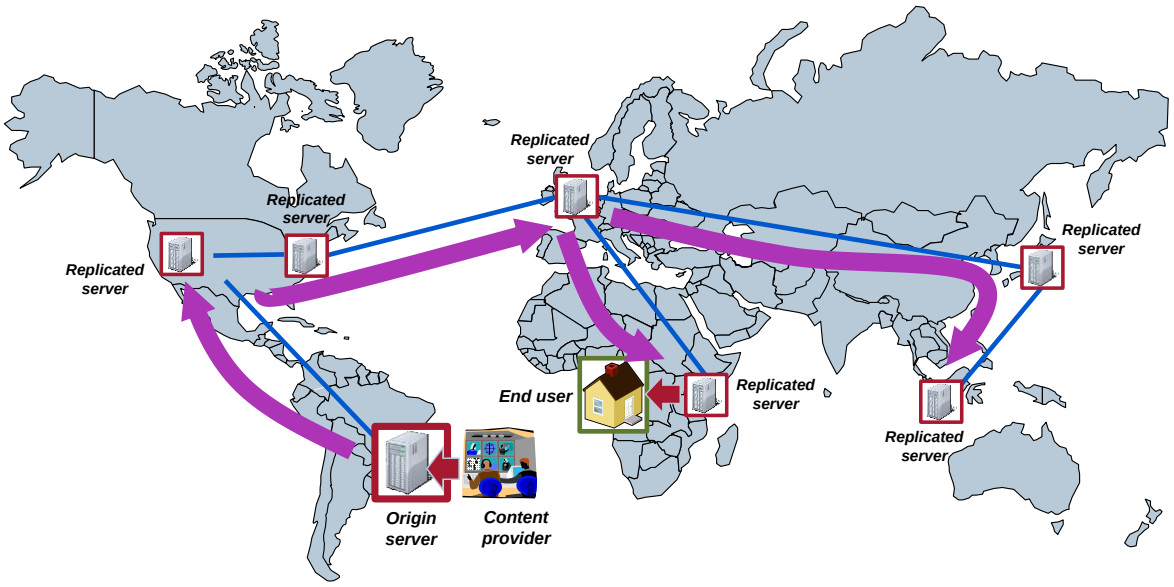


Figure 3.5: Forecast of growth in global cloud traffic [Source: Cisco Global Cloud Index: Forecast and Methodology, 2010–2015]

Conclusion

Figure 3.6 summarizes how content can be distributed worldwide in order to improve the performance of the Internet while reducing the amount of capacity needed. In this example, a user can upload a video once onto a cloud-based service in Brazil, which may then use a CDN to distribute the video to caches around the world, often located in IXPs. When users around the world request this content it is delivered from their nearest cache, which speeds the delivery and lowers the cost.

Figure 3.6: Distribution of video content via a CDN (illustrative) [Source: Analysys Mason, 2012]



In conclusion, these trends have reduced the demands on both international and national infrastructure, by enabling providers to move content to caches in IXPs and data centres located closer to end users. Along with the infrastructure investment described above, this has significantly improved the sustainability of the Internet in the face of increasing demand and new applications. As discussed in the next section, all indicators show that this process is repeating itself in the face of new pressures on the Internet, particularly the challenges of meeting mobile broadband demand in developing countries.

4 Internet sustainability in emerging markets

Many of the recent doubts that have been expressed about the sustainability of the Internet suggest that the issue is global. In fact, however, developed and developing regions are at substantially different stages – with telecoms markets in developing countries growing faster and receiving correspondingly higher levels of investment than the more saturated developed countries.

The following two figures show trends in fixed and mobile telephony penetration levels for developed and developing countries, according to the classification used by the ITU.[9] Fixed penetration has been falling worldwide, with a compound annual growth rate (CAGR) of –0.8% from 2006 to 2011 in both developed and developing countries. In contrast, the evolution of mobile subscriptions over the same period demonstrates not only the significant growth of the mobile market in developing countries (CAGR of 18%) compared to developed countries (CAGR of 5%), but also the vast size of the market for mobile subscriptions in developing countries worldwide.

Figure 4.1: Fixed telephone lines [Source: ITU, 2012]

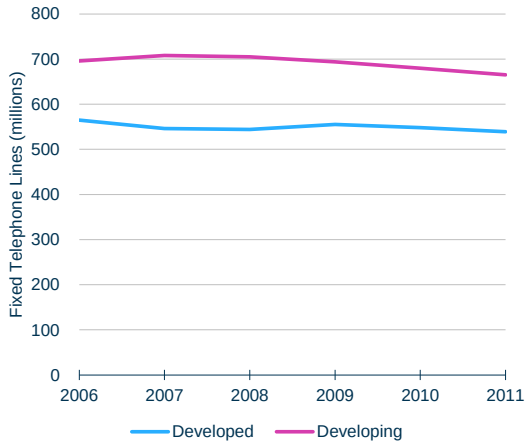
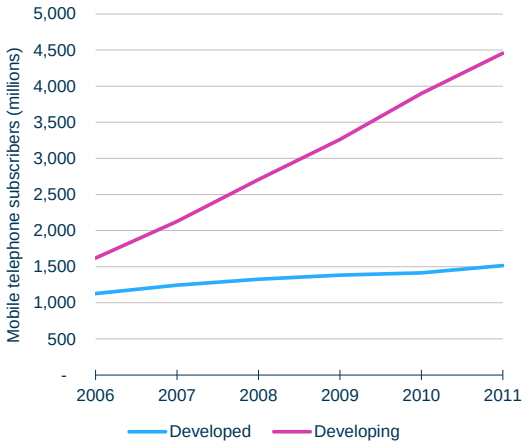


Figure 4.2: Mobile telephone subscriptions [Source: ITU, 2012]



With respect to broadband, developed countries still have a greater number of subscriptions than developing countries, for both mobile and fixed broadband, as shown in Figure 4.3 and Figure 4.4. However, the growth rate in developing countries significantly outpaces that of developed countries. For fixed broadband, the CAGR in subscriptions between 2006 and 2011 was 9% for developed countries versus 20% growth in developing countries. Between 2007[10] and 2011 mobile broadband subscriptions grew at a CAGR of 23% in developed countries, outpacing fixed broadband growth in those countries, but mobile broadband grew at a much higher rate of 61% in developing countries.

9 The developed/developing country classifications are based on the UN M49. See http://www.itu.int/ITU-D/ict/definitions/regions/index.html

10 Unlike the other measures used here, the ITU only began to provide numbers for mobile broadband in 2007.

Figure 4.3: Fixed broadband subscriptions [Source: ITU, 2012]

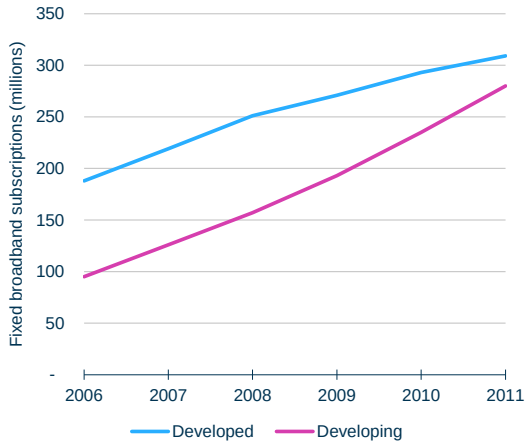
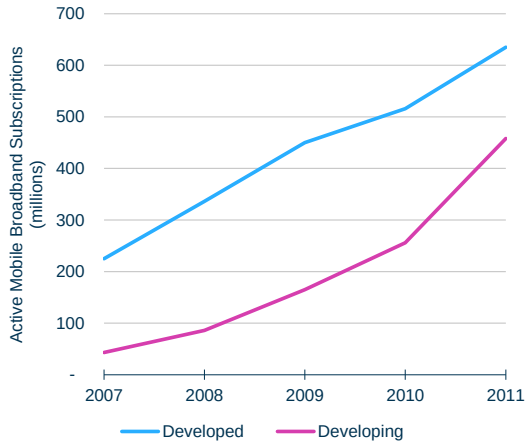


Figure 4.4: Mobile broadband subscriptions [Source: ITU, 2012]



These differences in the maturity and size of markets in developing countries are reflected in the global accounts of three multinational operators based in Europe – Vodafone, Orange, and Telefónica, and perhaps best epitomised in France Télécom's recent decision to sell its Swiss mobile network operator, Orange Switzerland. According to the New York Times, "France Télécom […] is shedding assets in Europe, where phone companies are vying for a shrinking pool of new customers amid tightening regulation, to embrace faster-growing markets in Africa and the Middle East."[11]

Indeed, in the first quarter of 2012, Orange experienced overall revenue growth of 6.8% in Africa and the Middle East, spearheaded by 57% growth in Uganda, compared to a –1.7% revenue reduction in France.[12] Likewise, Vodafone experienced 3.7% revenue growth in Africa, the Middle East, and the Asia–Pacific region in the year ended 31 March 2012, compared to a –0.6% decrease in Europe.[13] Finally, Telefónica had 8.3% revenue growth in Latin America in the first quarter of 2012, compared with a –6.6% decline in Europe.[14] Telefónica noted that "[t]his performance shows the benefits of our high diversification, our key strength against a backdrop of challenging economies and adverse regulation in Europe."[14]

As noted by Telefónica, operators in Europe are subject to significant regulatory oversight. Current regulations on the fixed broadband side include efforts to foster competition via local loop unbundling requirements, along with requirements to invest in next-generation networks as part of the Digital Agenda for Europe. On the mobile side, mobile termination rates are on a downward path, while wholesale and retail price caps limit European roaming charges.

11 "France Télécom in Deal to Sell Swiss Mobile-Phone Unit," December 24, 2011, *The New York Times.* See http://www.nytimes.com/2011/12/25/business/france-telecom-to-sell-orange-switzerland-to-apax-partners.html

12 See http://www.orange.com/en/finance/investors-and-analysts/all-the-consolidated-results

13 See http://www.vodafone.com/content/dam/vodafone/investors/financial_results_feeds/preliminary_results_31march2012/dl_prelim2012.pdf

14 See http://www.telefonica.com/en/shareholders_investors/pdf/rdos12t1-eng.pdf

These regulations recently led the so-called 'E5' telecom group (comprising top executives at Deutsche Telekom, France Télécom, Telecom Italia, Telefónica and Vodafone) to warn that "regulation hampers the ability for the industry to react to new challenges and will simply squeeze their ability to invest. There is a conflict given the desire by the European regulator to want both the latest next-generation technologies but also services delivered at an affordable price."[15] Vittorio Colao, Vodafone's CEO, explained during the 2012 Mobile World Congress that "Vodafone would not cut investment overall, but the decision would be where to invest, and the company would 'definitely' invest more [in Europe] should regulation be relaxed." After the speech he noted that "I have never cut investment but I might put it in different geographic areas."[16]

The evidence below shows that multinational operators are already choosing to direct their investments to developing regions, which are also benefitting from significant investments from domestic and regional players. The resulting investments should ensure that growth is sustainable without any global regulatory intervention. Of course, emerging markets will face challenges similar to, or more acute than, those experienced in developed countries when deploying network infrastructure nationwide, as a result of low income levels and/or high deployment costs in certain regions. However, there is no evidence that such shortfalls in meeting demand cannot be addressed with best-practice policy and regulatory solutions that focus on increased investment and access.

4.1 Investment

Investment is taking place across developing regions, at every infrastructure level needed to provide broadband Internet access to end users and enterprises.

- **Submarine cable capacity to connect coastal countries to one another and other continents**. Without the competitive provision of submarine cable capacity, ISPs are forced to rely on satellite capacity (which is expensive and introduces latency), or expensive access to monopoly fibre.
- **Terrestrial fibre to serve two purposes**. First, terrestrial fibre is used to connect ISP points of presence to the submarine cable landing station and to one another, and second, it enables ISPs in landlocked countries to access submarine cable capacity in adjacent countries.
- **Traffic exchange solutions**. IXPs are being developed, where ISPs can exchange traffic with one another and access content caches and even submarine cable capacity at low cost and latency.
- **Last-mile access**. This includes notably mobile infrastructure, which must be built out to cover populations and/or be upgraded to offer broadband Internet access.

In recent years there has been a significant amount of investment in all of these layers of infrastructure, and more is currently underway and proposed for the future.

Submarine cable capacity to Africa has grown significantly in recent years. As shown in Figure 4.5 below, for Sub-Saharan Africa the amount of capacity coming online between the end of 2011 and

15 See http://www.ft.com/intl/cms/s/0/28ebab8a-6df1-11e1-b98d-00144feab49a.html#axzz24m9DfORg

16 See http://readymadeinvest.com/vodafone-chief-hits-at-regulators/

2013 (24,640 gigabytes) is almost double the amount that was active prior to 2011 (13,340 gigabits). This growth in capacity results from a significant amount of investment by African and international operators, development organisations, and governments: indeed, recent and upcoming submarine cables connecting Africa represent aggregate investment of at least USD3.8 billion.[17]

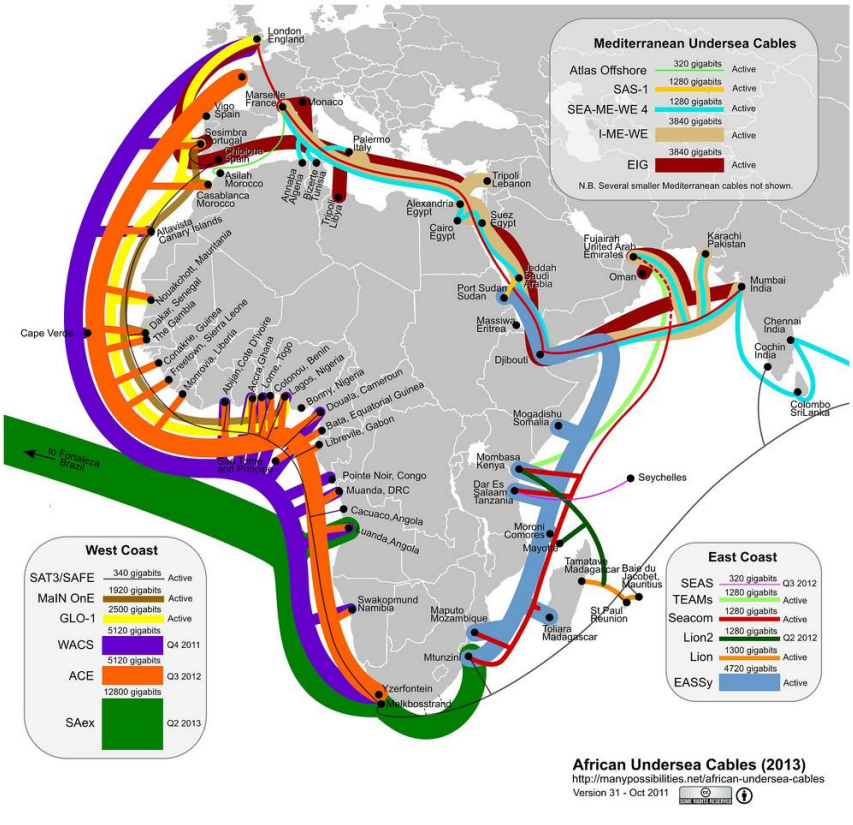


Figure 4.5: African submarine cables [Source: Steve Song, http://manypossibilities.net/african-undersea-cables, October 2011]

The result of this increase in capacity, in conjunction with other changes described below that have increased demand, is that the amount of international Internet bandwidth connecting African countries increased by 85% per annum between 2001 and 2011.[18]

In Latin America, the growth of international Internet bandwidth has been almost as dramatic, increasing by 78% per year from 2001 to 2011.[18] This increase was also made possible with substantial investments to increase submarine cable capacity. In recent years, Telefónica upgraded the SAm-1 cable from 320Gbit/s to 3.6Tbit/s, Columbus Networks upgraded ARCOS from 240Gbit/s to 720Gbit/s, GlobeNet was upgraded from 160Gbit/s to 1.12Tbit/s, and the Colombia–Florida Subsea Fiber (CFX-1) was installed, reaching 580Gbit/s lit capacity in 2011.[18]

Similar increases in terrestrial fibre are also taking place. For instance, according to *Africa Bandwidth Maps*, the amount of cross-border Internet bandwidth in sub-Saharan Africa grew by 213% per year from 2005 to 2011, based on over USD10 billion in investments. Cross-border

17 Reported costs are: SEACOM (USD650 million), EASSy (USD265 million), TEAMs (USD130 million), WACS (USD600 million), Main One (USD240 million), GLO-1 (USD800 million), ACE (USD700 million), and SAex (USD500 million). See http://manypossibilities.net/african-undersea-cables/

18 TeleGeography, *Global Bandwidth Report 2012* (Regional Analysis).

projects include the Central Africa Backbone (part of a World Bank/African Development Bank programme connecting Cameroon, Chad, and the Central African Republic), and the Liquid Telecom backbone (connecting Botswana, Namibia, Zambia, and other countries with one another and with submarine cables in South Africa and Mozambique).

Further, as shown in Figure 3.3 overleaf, the number of IXPs established or emerging in developed regions is growing quickly, and will help to bring Internet traffic exchange to the national or regional level. One of the fastest growing IXPs in the past few years is the Kenya Internet Exchange Point (KIXP) in Nairobi, which recently opened a second exchange in Mombasa near a submarine cable landing station. Meanwhile, other IXPs are growing in Nigeria, alongside the larger IXPs in South Africa.[19] According to Packet Clearing House, Latin America recorded the highest percentage growth in the number of IXPs over the past few years, and Brazil hosts the highest density of IXPs outside the United States, with 19 active IXPs today.[20] Also, a recent study recommended the development of an IXP in Paraguay, after establishing that the cost of international connectivity represented 40% of the final price of a 2Mbit/s Internet connection and noting that an IXP would encourage more local hosting of content.[21] Figure 4.6 shows the geographic distribution of IXPs in Latin America today.

Finally, telecoms operators in Latin America and Africa are investing heavily to provide and improve mobile broadband access in their home markets; examples are provided below.

- América Móvil announced plans to invest between USD8.5 billion and USD9 billion in Latin America in 2012.[22] In Argentina alone, América Móvil plans to invest USD249 million in the second half of 2012 to build new mobile cell sites and extend its fibre-optic network, in addition to a previously announced USD1 billion investment programme for 2011–2012.[23]
- In Peru, Telmex and América Móvil committed a total of USD880 million of investment in infrastructure (over three years),[24] while Movistar will invest PEN1.2 billion (around USD460 million) in broadband during 2012.[25]
- In Africa, Econet Wireless invested more than USD270 million in 2011 (versus USD160 million in 2010).[26]
- In Nigeria, MTN plans to invest USD1.4 billion in 2012, including an upgrade of the wireless network. This investment represents 45% of the MTN Group's total capital expenditure for 2012.[27]

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19 For more information on the benefits of IXPs in emerging markets, see the Internet Society study "Assessment of the impact of Internet Exchange Points – empirical study of Kenya and Nigeria," Analysys Mason, April 2012 (available at http://www.internetsociety.org/ixpimpact)

20 See http://www.pch.net

21 See http://www.eclac.org/cgi-bin/getProd.asp?xml=/socinfo/noticias/noticias/3/45943/P45943.xml&xsl=/socinfo/tpl-i/p1f.xsl&base=/socinfo/tpl-i/top-bottom.xsl

22 See http://www.ibtimes.com/articles/296941/20120211/america-movil-plans-heavy-investments-2012.htm

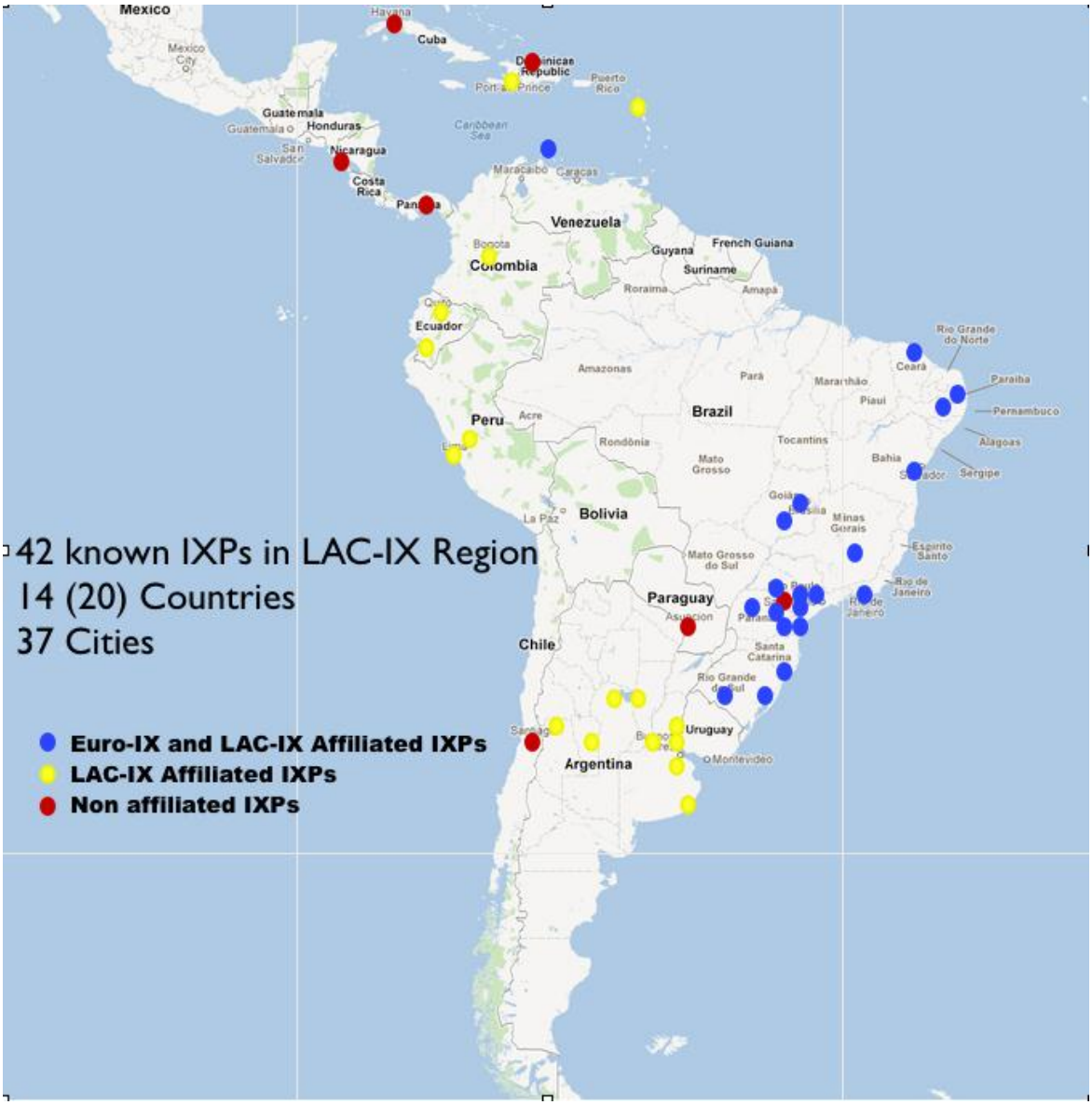
23 See http://online.wsj.com/article/BT-CO-20120628-716167.html

24 See http://origin-www.bloomberg.com/news/2010-04-16/america-movil-telmex-to-spend-880-million-to-expand-in-peru-andina-says.html

25 See http://storify.com/latamtelecom/movistar-to-invest-pen-1-2-bln-in-peru-fiber-netwo

26 Source: Econet Wireless Annual Report 2011.

Figure 4.6: Distribution of IXPs in Latin America [Source: Bijal Sanghani, Euro-IX, 2012]



As noted above, multinationals from Europe are also shifting their investments towards the same countries:

- Orange invested EUR800 million in 2011 as part of its 'Orange for Development' plan to increase ICT benefits in 21 countries in Africa and the Middle East, where it has 80 million subscribers[28]
- Telefónica invested EUR906 million of capital expenditure in Latin America in the first quarter of 2012, a 28.8% year-on-year increase, compared with a capital expenditure increase of only 2.9% in Europe[29]
- Vodafone, via its Vodacom subsidiary, has invested more than USD1 billion recently to upgrade its African networks, most notably in South Africa.

27 See http://www.punchng.com/business/business-economy/mtn-to-invest-n224bn-in-network-expansion/

28 See http://cajnewsagency.com/index.php/investing/839-orange-investments-immense-for-africa

29 See http://www.telefonica.com/en/shareholders_investors/pdf/rdos12t1-eng.pdf

These investments show that development is reaching countries in Latin America and Africa, as companies pursue the revenue opportunities available in these growing markets.

4.2 Innovation

Finally, developing regions are beginning to experience changes in traffic flows similar to those that previously affected other countries, largely associated with the rise in the number of IXPs and growth in their traffic volumes. This growth of IXPs is also beginning to support other trends, such as CDNs and content providers building their networks out to Africa and Latin America and placing caches or servers in or near the IXPs and data centres. Below we highlight examples to show the innovative ways in which content providers are already investing in ways to deliver traffic to developing countries. These examples demonstrate that there is a connection between the value that content providers receive from delivering their content to end users in developing markets, and the investment they are willing to commit to make this process more efficient.

Below, we summarise actions that a number of content providers or vendors have taken to increase local or regional traffic in developing regions.

- *Google Global Cache*: Google has begun to build out its network into Africa with cache servers and points of presence, to allow YouTube and other content to be made available locally through IXPs. According to *Balancing Act*, "the presence of Google cache servers has been a major motivation for ISPs and other content providers to exchange content locally."[30] The result is savings on international connectivity, lower latency, and increased Internet usage.

- *Facebook Zero*: Facebook offers a low-bandwidth text version of its mobile site (0.facebook.com), and has negotiated with a number of mobile operators in developing countries to allow consumers to access that page with no data charges. This allows users to access all main features of Facebook, other than viewing photos (which incurs a data charge), but is faster because it is text-only, and saves users money. When announced, Facebook had deals with 50 mobile operators in 45 countries.[31]

- *Huawei IDEOS*: Huawei has developed a smartphone based on the Android operating system that sells for approximately USD80 in Kenya – as little as 10% of the cost of unsubsidised high-end phones. The Android operating system is open source, and enables vendors to provide smartphones and tablets at a significant discount to those based on proprietary operating systems. The IDEOS has already sold 200 000 units in Kenya, giving users access to new applications and services that further stimulate demand.

Clearly, content providers can, and do, play a significant role in lowering the cost of access for users in developing regions based on commercial considerations. In addition, the significant investments described above in all parts of the network show that the Internet is responding to current and future growth challenges through the same combination of innovation and investment with which it has met previous challenges.

30 "Google cache servers drive interconnection in Africa," *Balancing Act*, Issue no. 568, August 2011.

31 "Fast and Free Facebook Mobile Access with 0.facebook.com," Facebook blog by Sid Murlidhar, 18 May 2010.

5 Conclusion

A number of commenters have argued that the current growth of the Internet is not sustainable. In particular, some stakeholders question the sustainability of the Internet due to a combination of accelerating growth in subscribers worldwide and the rapid growth in Internet usage by existing and new users, led by demand for high-bandwidth content such as video.

We show here that, in the face of constant growth and changes, fears about the sustainability of the Internet are almost as old as the commercial Internet itself, and that market forces continue to meet the challenges presented by new demands. In particular, we show that each successive wave of demand for new Internet services has unleashed investment, innovation, and new business models that have met that demand while avoiding any collapse predicted by commentators. Further, all indicators show that this process is repeating itself in the face of new pressures on the Internet, particularly the challenges of meeting mobile broadband demand in developing countries.

This paper illustrates the significant amount of investment and innovation that is helping to promote Internet access and usage in developing regions. Nonetheless, it is true that there are still roadblocks to the expansion of mobile Internet access, given the amount of territory to be covered and the income levels among potential users. As has already taken place in developed countries, these challenges require policy and regulatory responses such as market liberalisation and/or targeted creative policy and regulatory access programmes. However, there is no indication that the Internet and its growth are unsustainable in developing regions, or that any outside global intervention is required.

Appendix A: About us

A.1 About the Internet Society

The Internet Society is a leading advocate for a free and open Internet, promoting the open development, evolution and use of the Internet for the benefit of all people throughout the world. We are the trusted independent source for Internet information and thought leadership from around the world. The Internet Society has worked for more than 20 years to ensure the Internet continues to grow and evolve as a platform for innovation, economic development, and social progress.

The Internet Society educates, informs, and communicates with technology, business and government stakeholders, as well as the general public, to promote an open Internet for everyone. We advocate for the ongoing development of the Internet as an open platform that empowers people to share ideas and connect in new and innovative ways, and which serves the economic, social, and educational needs of individuals throughout the world. To achieve this mission, the Internet Society:

- facilitates open development of standards, protocols, administration, and the technical infrastructure of the Internet
- supports education in developing countries specifically, and wherever the need exists
- promotes professional development and builds community to foster participation and leadership in areas important to the evolution of the Internet
- provides reliable information about the Internet
- provides forums for discussion of issues that affect Internet evolution, development and use in technical, commercial, societal, and other contexts
- fosters an environment for international cooperation, community, and a culture that enables self-governance to work
- serves as a focal point for cooperative efforts to promote the Internet as a positive tool to benefit all people throughout the world
- provides management and coordination for on-strategy initiatives and outreach efforts in humanitarian, educational, societal, and other contexts.

The Internet Society is at the centre of the largest global network of people and organisations focused on ensuring the Internet continues to evolve as a platform for innovation, collaboration and economic development. By tackling issues at the intersection of technology, policy and education, we work collaboratively to preserve and protect the multi-stakeholder model of development and management that has been key to the Internet's success. With more than 130 organisational members and over 55,000 individual members in over 90 Chapters, the Internet Society represents a worldwide network of corporations, non-profit organisations, entrepreneurs, and individuals who are interested in working to identify and address the challenges and opportunities that exist online.

Among its many initiatives, the Internet Society has embarked on a multi-year programme to assist emerging economies in developing robust, cost-effective, and efficient Internet interconnection and traffic exchange environments. Our work includes a range of activities, such as:

- assisting universities, government network operators, and ISPs to gain the world-class knowledge and skills needed to build reliable, cost-effective, and interconnected networks
- facilitating the development of new Internet Exchange Points (IXPs), and helping stakeholders to maximise the use of IXPs already in place
- assisting policy-makers and regulators in developing approaches to expanding the Internet achieving a beneficial interconnection and traffic exchange landscape
- building human and technical capacity through targeted training and outreach activities

- facilitating multi-stakeholder collaborations on these issues, including the African Peering and Interconnection Forum (AfPIF), and supporting the Latin American and Caribbean IXP association (Lac-IX).

For more information about the Internet Society, including our work to improve the Internet interconnection and traffic exchange environment in emerging economies, please visit our website at http://www.internetsociety.org

A.2 About Analysys Mason

The only constant is change. What worked yesterday won't necessarily work today. That's why we look beyond the obvious, seeing things from a client's perspective so that a truly effective solution is delivered every time. A key part of this is our international perspective. Business never sleeps, and with offices spanning six time zones, neither does Analysys Mason.

Telecoms, media and technology are our world; we live and breathe TMT. This total immersion in our subject underpins and informs everything we do, from the strength and reliability of our market analysis, to improving business performance for clients in over 100 countries around the globe

We're experts in telecoms, media and technology (TMT). This know-how underpins everything we do and helps our clients change their businesses for the better.

At the heart of our approach is a simple, but enormously powerful idea: applied intelligence. By harnessing our collective brainpower we can solve real-world problems and deliver tangible benefits for our customers. As a Japanese proverb says, 'all of us are smarter than any of us'.

We're passionate about what we do, with the focus and determination to take on and solve the toughest problems to help our clients. We'll rise to the challenge and enjoy it. In fact when it comes to problem solving, there's a real sense of 'the tougher the better'. It's this unique combination of our applied intelligence, effective problem solving and the ability to look closer and see further that makes Analysys Mason special.

A.2.1 Consulting from Analysys Mason

For more than 25 years, our consultants have been bringing the benefits of applied intelligence to enable clients around the world to make the most of their opportunities

Unlike some consultancies, our focus is exclusively on TMT. We advise clients on regulatory matters, support multi-billion dollar investments, advise on network performance and recommend commercial partnering options and new business strategies. Such projects result in a depth of knowledge and a range of expertise that sets us apart.

We look beyond the obvious to understand a situation from a client's perspective. Most importantly, we never forget that the point of consultancy is to provide appropriate and practical solutions. We help clients solve their most pressing problems, enabling them to go further, faster and achieve their commercial objectives.

We blend our range of skills each day, every day, to solve our clients' most complex challenges

For more information about our consulting services, please visit www.analysysmason.com/consulting.

A.2.2 Research from Analysys Mason

Our subscription research programmes address key industry dynamics in order to help clients interpret the changing market

The programmes focus on five areas:

- consumer services
- enterprise services
- network technologies
- telecom software
- market data.

We analyse, track, and forecast the different services accessed by consumers and enterprises, as well as the software, infrastructure, and technology that underpin the delivery of those services. Subscribing to our research programmes gives you regular and timely intelligence. It also provides direct access to our team of analysts – that is, the opportunity to engage one to one with our subject experts for insight, opinion, and practical advice relating to your most-critical business decisions.

Take advantage of this service and you'll be in good company. Many of the world's leading network operators, vendors, regulators, and investors subscribe to our programmes and rely on our insight on a daily basis to inform their decision making.

Our custom research service offers in-depth, tailored analysis that addresses specific issues to meet your exact requirements

Our experienced custom research team can undertake market sizing and analysis, and competitor and partner profiling, supported by all the analysis and insight you require. In addition, we can carry out expert interviews and quantitative surveys to obtain fresh and genuine insights, and we deliver reliable benchmark data together with first-class interpretation and advice on getting the best from such information.

Clients call on us for our authoritative market forecasts, which are based on our comprehensive knowledge of the TMT industries, and draw on a large base of data that we have collected over many years and refresh through continuous research. Our subject experts also produce tailored white papers which are highly valuable for sales and marketing campaigns, and deliver presentations and facilitate workshops that keep your teams up to date with the latest emerging trends and technologies.

For more information about our subscription research programmes and custom research services, please visit www.analysysmason.com/research.

A.3 About the Author

Michael Kende is a Partner and co-head of the global Regulation and Policy group at Analysys Mason. Prior to joining Analysys Mason, Michael was the Director of Internet Policy Analysis at the Federal Communications Commission, where he was responsible for managing a wide range of policy analyses and regulatory decisions on Internet policy. Michael led the review of several mergers involving Internet backbones and wrote an FCC working paper entitled *The Digital Handshake: Connecting Internet Backbones*. At Analysys Mason, Michael has worked with operators and regulators in six continents, providing advice on a variety of Internet issues. In particular, he has consulted on Internet issues for companies or governments in Australia, Brazil, Ireland, Singapore, Saudi Arabia, Sri Lanka, and the United States, and for the European Commission.