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Report

Internet global growth: lessons for the future

September 2012

Michael Kende

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Contents

This report was made possible by support from Amazon, AT&T, Cisco Systems, Comcast, Google, Intel, Juniper Networks, Microsoft, National Cable & Telecommunications Association (NCTA), News Corporation, Oracle, Telefónica, Time Warner Cable, Verisign, and Verizon.

The analysis and conclusions presented in this report are those of the stated author and Analysys Mason Limited, and have been arrived at independently of any client-specific work.

Analysys Mason Limited
Bush House, North West Wing
Aldwych
WC2B 4PJ London
United Kingdom
Tel: +44 845 600 5244
Fax: +44 845 528 0760
london@analysysmason.com
www.analysysmason.com

1 Executive summary

The International Telecommunication Union (ITU) will hold a treaty conference, the World Conference on International Telecommunications (WCIT), in December 2012, which will revise a 1988 treaty, the International Telecommunication Regulations (ITR). The ITR treaty established how operators compensate each other for terminating international voice calls through the payment of settlements. This paper demonstrates that adapting the ITR treaty to the Internet is not only unnecessary, but could harm the growth of the Internet in developing countries.

The Internet is governed under a multi-stakeholder model with no global regulation, but well accepted and efficient 'rules of the road' allowing business arrangements to be based on commercial considerations. There is significant evidence that this model works – including in developing country regions such as Africa, Asia and Latin America – and does not need a fundamental regulatory overhaul. The striking progress of the Internet, based on its inherent flexibility and perpetual adaptations, makes the possibility of revisions to the ITR treaty concerning for the following reasons:

- **The Internet and the international voice network are fundamentally different:** The two networks differ substantially in terms of technology, architecture and market structure. Any attempt to impose settlements, which are increasingly difficult to apply even to voice, to the Internet are likely to hinder its development and evolution.

- **Imposing ITU accounting rules on the Internet will harm developing countries:** Any attempt to impose settlements would lead some providers to take actions to lower their settlement fees, while others would take actions to increase their settlement earnings, which could impact the availability of content and corresponding investments in developing nations.

In particular, the Internet is far more susceptible to impacts from the imposition of settlements than the voice system, due to an intrinsic difference in traffic flows. While voice traffic between two countries must originate with a caller in one country and terminate with a caller in the other country, many Internet services do not have to originate from a fixed location, as up to 98% of Internet traffic consists of portable data traffic such as file sharing (peer-to-peer), video or web pages. Such content can be stored in servers located in multiple locations around the world, and from there traffic can be delivered to users faster and at lower cost. This has led to dramatic ongoing shifts in usage patterns and global Internet traffic flows – For example, the vast majority of international Internet bandwidth from Africa has shifted from the US to Europe, and now, increasingly it is being stored in servers in Africa where it can be accessed domestically or regionally. Such movements would be disrupted by imposing settlements on the flow of such content.

Significant investment will be required to maintain the growth of Internet access in line with current projections that show the number of global Internet users increasing from 2.2 billion today to 3.5 billion in 2020. Instead of imposing international economic regulation, policies should focus directly on developing a robust Internet ecosystem.

- **Promoting network infrastructure:** Focus on increasing investments throughout the network, from mobile broadband access through to national and cross-border connectivity and IXPs, by removing roadblocks to lower the cost of investment, including allocating spectrum for mobile broadband and limiting licensing requirements and fees, in order to promote competitive entry and growth.

- **Telecom liberalization:** As demonstrated in numerous studies, establishing policies to increase competition at all levels of the Internet value chain is a prerequisite for developing information societies and attracting sustainable investment flows. According to a World Bank report, increased competition under independent regulators lowers costs and raises private investment by 50 percent.

- **Policies to increase demand:** Finally, actions can be taken to increase demand for services, such as promoting entry and development of content that is critical to demand. Further, reducing taxes on equipment such as smartphones will promote ownership and increase demand for services.

Shifting costs for international transit is unpractical, and may serve to reduce investment. Even in the best case, however, settlements are not directly targeted towards promoting investment in national infrastructure and traffic hubs, nor stimulating demand for Internet services, and thus there is no assurance these purported goals will be realized.

2 Overview

The International Telecommunications Union will hold a treaty conference, the World Conference on International Telecommunications (WCIT), in December, 2012. This conference will consider revisions to the International Telecommunications Regulations (ITR) treaty, last revised in 1988, which led to the development of the current accounting rate regime that establishes how international operators compensate each other for terminating voice calls. We understand that some countries are seeking to impose this regime on Internet traffic, with the apparent purpose of providing additional revenues to increase the build-out of infrastructure in various types of markets. This paper demonstrates that such adaptions are not only unnecessary, but could harm the development of the Internet in developing countries.

The Internet is working

First and foremost, adapting the ITR treaty to the Internet is a solution in search of a problem. The architecture of the Internet is flexible and continually changes, governed under a multi-stakeholder model with no global regulation, but well accepted and efficient 'rules of the road', which allow business arrangements to be based on commercial considerations. In particular, when challenged with increased demand and changes in usage, the Internet can and does continually evolve and adapt. Indeed, there is a significant amount of evidence that the Internet model is working as it is in all regions, including developing countries, and does not need a fundamental regulatory overhaul.

The Internet is in the process of adapting to a series of profound changes that began in the past decade: content has evolved from relatively static text and web pages to high-bandwidth multimedia content; usage has rapidly globalized from an initial base in developed countries; and access is increasingly mobile, rather than fixed. In response, the architecture of the Internet has addressed the challenges from the new traffic, first in developed countries and more recently in developing countries, in the following ways:

Internet Exchange Points (IXPs)

The global spread of IXPs represents a significant evolution in the global architecture of the Internet. IXPs provide locations for Internet players, including ISPs and content providers, to interconnect with one another. After becoming established in developed countries, IXPs are increasingly being deployed in developing countries, allowing domestic and regional traffic to be exchanged closer to the end users, thereby lowering the cost and latency of traffic exchange. The number of IXPs in Latin America, for example, grew by 52% between 2007 and 2011.[1]

[1] Source: Packet Clearing House (www.pch.net).

Portability of content

While video content has high bandwidth and can be expensive to deliver, much of it can be stored in servers and streamed to end users. Indeed, it is estimated that up to 98% of Internet traffic consists of data traffic that can be stored in servers, such as file sharing (peer-to-peer), video or web pages.[2] As these servers are placed in or near IXPs, the result is that content is closer to end users and costs less to deliver.

Traffic migration

The effect of moving content to local or regional IXPs in response to increasing demand has been profound, resulting in a shift away from the historical reliance on the US for international connectivity. In Europe and Asia, traffic patterns have already shifted such that the majority of traffic originates within the region. A similarly profound migration has taken place with African traffic; while 70% went to the US in 1999, by 2011 less than 5% went to the US, having been replaced by bandwidth to Europe.[3] Only Latin America still has a significant reliance on the US for bandwidth, with about 85% of its international Internet bandwidth still being connected to the US.

In the past few years, market forces have responded to increased demand and the lack of supply in all under-served regions of the world. For instance, according to TeleGeography, the amount of international Internet bandwidth serving African countries has increased from 1.21 Gbit/s in 2001 to 570.92 Gbit/s by 2011, as a result of a number of new and competing submarine cables that began service in 2010. Further investments have taken place in under-served countries to provide: cross-border terrestrial networks to connect landlocked countries to submarine cables; domestic backbone networks; regional IXPs where traffic can be exchanged and content can be accessed; and mobile broadband networks to deliver Internet access to end users. These investments demonstrate that the same market forces that have increased broadband access and accommodated increases in content in developed countries are now at work in developing countries.

Given how the Internet has grown into a platform encompassing many aspects of business, government, and civic life – in addition to its intrinsically borderless nature – many Internet governance issues are increasingly addressed in multi-national, multi-stakeholder forums. In spite of the increased focus on governance, one constant factor throughout the evolution of the Internet has been that the expansion of underlying infrastructure and the interconnection between networks have been governed by market forces rather than government regulation. Commercial flexibility is the foundation of all of the recent changes in the architecture of the Internet, and will continue to be crucial for the development of new business models necessary to support infrastructure investment and to ensure that all ecosystem participants can meet the evolving demands of consumers.

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2 Source: Cisco Visual Networking Index: Forecast and Methodology, 2010–2015 (June 1, 2011). See Section 4.2.2 below.

3 Source: Telegeography Global Internet Bandwidth. See Section 4.2.3.

The enduring reliance on commercially negotiated interconnection arrangements has led to the growth of Internet traffic through Europe and Asia, and more recently developing countries, as increased connectivity is followed by IXPs facilitating the local exchange and delivery of content. In particular, we have not identified any roadblocks at the international level that would delay or prevent this progress from continuing to increase the global number of Internet users from 2.2 billion today to the projected number of 3.5 billion in 2020.[4]

The Internet and the international voice network have fundamental differences

There are significant differences between circuit-switched voice telecommunications and packet-switched Internet traffic, which make applying any form of the ITU accounting regime to the Internet much more problematic than it already is to apply to telephony. The main differences between voice and Internet traffic are summarized in the table below.

Figure 2.1: Differences between voice and Internet traffic [Source: Analysys Mason, 2012]

Characteristic	Telephony	Internet
Traffic origination	An international call must originate with a caller in one country and terminate with a caller in another country (regardless of routing)	Approx. 98% of Internet traffic (video, file transfers, etc.) can be stored in multiple locations, and thus can move and originate from servers in multiple alternative countries
Routing	Telephone calls are routed over a dedicated circuit between end points, which enables a call to be measured and billed	IP routes packets independently, based on the destination, and thus the ability to measure traffic depends on where it is measured
Payment regimes	Traditionally a calling party pays (CPP) regime, with the originating network paying settlements to the terminating network and any transit fees to intermediate networks	End users typically pay a flat fee based on bandwidth and possibly usage; ISPs may pay transit fees based on capacity, or use settlement-free peering
Value	It is easy to determine who initiated a call, and well accepted that the caller pays for the call, and the calling network pays settlements to the terminating network	It is harder to determine who initiated a transmission, and even where it is possible, it is not always clear whether the sender or the receiver should pay for the transmission
Billing	Billing is per minute, based on (a) the origination and termination points of the call (including whether the call went to a mobile); and (b) the time and day that the call was made	Billing is typically based on capacity rather than traffic quantity; billing is not based on where the traffic originated or terminated, nor on the time or day of the transmission

[4] Source: ITU.

In addition to these intrinsic differences between telephony and the Internet, the international voice system has changed significantly since the advent of the current accounting rate regime, which was developed as a result of the ITR treaty that was adopted at the 1988 World Administrative Telegraph and Telephone Conference. The purpose of the ITR treaty was to facilitate global interconnection and interoperability of international telecom networks by establishing regulations for the international exchange of telecom traffic, in particular the international accounting rate regime to govern compensation between networks for the termination of international calls.

The international telecom landscape was very different in 1988 when the ITR treaty was adopted: there was a limited and known set of international operators, almost exclusively owned by the very governments negotiating the ITRs; only three international operators had been privatized; and only six countries had liberalized their international telecom marketplaces. In that environment, the treaty could easily encompass the whole of international telecommunications, and ensure that the operators offering international services could interconnect around the globe, and would get a fair share of revenues for the resulting services.

However, many operators have now been privatized, and competition has been introduced around the world, making it difficult to apply the accounting rate regime to voice. Further, the differences with the voice system described above make it yet more difficult – both conceptually and technically – to impose any form of settlements on international Internet traffic. Any such regime has the potential to harm the successful Internet model that continues to expand and adapt through the operation of market forces.

Imposing ITU accounting rules on the Internet will harm developing countries

Imposing a settlement regime on the Internet is likely to be complicated and costly to do, given the inherent architecture of the Internet and the dynamic industry structure. Based on experience in both national and international telephony, any attempt to impose settlements would lead some providers to take actions to lower their settlement fees, while others would take actions to increase their settlement earnings. Such actions could impact the availability of content in developing countries, and even affect investment in infrastructure serving those countries.

In particular, the Internet is far more susceptible to impacts from the imposition of the accounting rate system than the voice system, due to an intrinsic difference in traffic flows. While it is possible to change the route, and protocol, of voice calls to reduce or avoid settlements, it is not possible to change the basic principle that voice traffic between two countries must originate with a caller in one country and terminate with a caller in the other country. In contrast, many Internet services do not have to originate from a fixed location, as up to 98% of Internet traffic consists of portable data traffic such as file sharing (peer-to-peer), video or web pages.

Thus the introduction of an accounting rate regime for Internet traffic would surely impact the routing of traffic, depending on the economic incentives that would be created by the new regime. Potential impacts include the following:

- Operators may be induced to maintain their customers' web sites abroad, to generate incoming settlements.
- At the same time, foreign operators, in order to compensate for the settlements, would likely raise the price of hosting web sites serving countries with high settlement rates, which may lead web sites to develop less content targeted at a particular country in order to limit their costs, if the conditions are not favorable to deploy a local server to avoid the settlements.
- In addition, it is likely that infrastructure investment decisions would be impacted, as providers would be reluctant to invest in providing infrastructure to a particular country to which it is expensive to deliver traffic.
- A final significant concern may be the possibility that huge volumes of Internet traffic could be artificially generated in order to arbitrage a rate-regulated model, to generate inbound payments, alter traffic balances, or otherwise unfairly leverage any accounting rate regime that might be applied to the Internet.

Recommendations for expanding the growth of the Internet in developing countries

Instead of imposing this international settlement structure – which is increasingly difficult to maintain even for voice – on the Internet, policies could focus directly on developing a robust Internet ecosystem. This requires, as a prerequisite, widespread Internet access, which in turn requires investment in network infrastructure, from international connectivity through Internet access. Actions could include the following:

Promoting network infrastructure	Focus on increasing investments throughout the network, from mobile broadband access through national and cross-border connectivity and IXPs, by removing roadblocks to lower the cost of investment, including allocating spectrum for mobile broadband or limiting licensing requirements and fees, in order to promote competitive entry and growth.
Telecom liberalization	As demonstrated in numerous studies, establishing policies to increase competition at all levels of the Internet value chain is a prerequisite for developing information societies and attracting sustainable investment flows.

Removal of barriers to foreign investment and ownership	General public policy that creates incentives for foreign investment also helps to increase investment in telecommunications, which serves to provide for sharing of technology and know-how, and delivers the advantages of economic scope and scale from an alliance with foreign operators.
Policies to increase demand	Finally, a number of actions can be taken to increase demand for services, such as promoting entry and development of content that is critical to demand, including both domestic and foreign private content as well as government applications. Further, reducing taxes on equipment such as smartphones will promote ownership and increase demand for services.

These actions would address growing issues that the application of the settlement regime to the Internet would not address. In particular, Internet services and applications will continue to increase in bandwidth and/or become more sensitive to latency, and this must be addressed by increasing national connectivity and providing more local and regional hubs to store traffic. Shifting costs for international transit is unpractical, and may serve to reduce investment. Even in the best case, however, the settlements are not directly targeted towards promoting investment in national infrastructure and hubs, nor stimulating demand for Internet services, and thus there is no assurance these outcomes will take place.

3 Introduction

The International Telecommunications Union will hold a treaty conference, the World Conference on International Telecommunications (WCIT) in December, 2012. The Conference will consider revisions to the International Telecommunications Regulations (ITRs), last revised in 1988, which led to the development of the current accounting rate regime that establishes how international operators compensate each other for terminating voice calls. We understand that some countries have initiated discussions to assess the viability of adapting the existing accounting rate regime for international voice to Internet traffic, with the hope that this regime will lead to increased infrastructure deployment in these countries.

A number of approaches have been proposed within the context of the upcoming WCIT as part of the proposal to apply settlements, such as limiting the number of international gateways to facilitate metering traffic. These proposals would fundamentally result in re-engineering the architecture of the Internet and/or the existing, and evolving, charging structure. This paper demonstrates that such an adaption is not only unnecessary, but would likely harm the evolution of the Internet in developing countries. Our argument falls into three parts, as follows.

First and foremost, adapting the ITR treaty to the Internet is a solution in search of a problem. We argue in Section 4 that although the Internet always will be an imperfect work in progress, it continues to be the most successful and vibrant communications network for economic growth, and the communication of information. In particular, it has faced similar challenges in the past, and has responded through organic changes in architecture and business arrangements based on commercial considerations, rather than regulatory dictates. In summary, the Internet can and does continually evolve and adapt, but it does not need a fundamental regulatory overhaul.

This is not to say that there are not challenges facing the growth of the Internet today. In particular, the Internet is adapting to a series of profound changes that began in the past decade:

- Usage has changed significantly as the Internet has evolved beyond text and static graphics to encompass a rich array of content and applications including voice and video, which require a significant amount of increased bandwidth and efforts to reduce latency.
- The Internet has also globalized significantly over the same time period, increasing the number of users and usage, while also increasing the scope of investment required to meet the demands of users in developing countries.
- Access has moved beyond desktop computers to encompass a wide array of devices, including mobile phones and tablets, and is increasingly extending to the "Internet of things" which connects objects to the Internet for a variety of purposes such as creating a smart grid, thereby requiring significant new access networks and technologies.

As a result of these three trends, and in spite of the corresponding challenges, the Internet is increasingly central to the lives of citizens, enterprises, and governments for an increasing array of activities beyond communications, including commerce, education, health care, and social inclusion. Throughout this multi-dimensional growth, the underlying architecture of the Internet has adapted itself to delivering new applications to new devices in the most efficient manner across the world. In particular, significant investments have been and continue to be made to deliver new high-speed access and applications to developing countries. These trends are likely to continue and further expand the global reach of the Internet and, as we show, would be negatively impacted by the imposition of any accounting rate regime to the Internet. Current projections are that the number of global Internet users will increase from 2.2 billion today to 3.5 billion in 2020.[5]

In Section 5 we show that the forces driving the growth and adaption of the Internet underscore significant differences from traditional telecommunications, particularly with respect to the telecom system in place when the ITR treaty was last updated, in 1988. These differences encompass the origination and routing of traffic, as well as corresponding payment and billing regimes. Any attempt to replace current Internet interconnection arrangements that have facilitated the growth of the global Internet with a traditional accounting rate regime, or any similar metered traffic payment mechanism, would be significantly difficult to design and implement.

We then note in Section 6 that it is increasingly difficult to apply the existing accounting rate regime even to traditional international voice calls, as competitive operators in liberalized markets increasingly use new business models and technologies to avoid the existing system. The architecture of the Internet would intrinsically allow even greater opportunities to avoid the accounting rate regime than international voice, meaning that few, if any, of the benefits of any new regulations would materialize, while the new accounting rate regime would be unproductive, or even counter-productive, in terms of benefiting the intended recipients of the settlements. In particular, such a system could lead to inefficient movement of content to decrease settlements; could increase the cost of delivering content to countries with high settlements; and/or retard investment in those countries.

Finally, in Section 7, we provide recommendations for how governments in developing countries could directly develop a robust Internet ecosystem in these countries without imposing any form of accounting rates on the Internet. This requires, as a prerequisite, widespread Internet access, which in turn requires investment in network infrastructure, from international connectivity through Internet access. Specific actions include removing roadblocks such as high license fees in order to increase supply, and removing taxes on devices to promote demand. More general steps include full liberalization of the sector, at the same time removing barriers to foreign investment and ownership. These actions are all directly aimed at increasing investment and usage, unlike the imposition of settlements which, along with the flaws pointed out above, are not even directly linked to increasing investment and usage.

[5] Source: ITU

4 The Internet is working

In this section we show that there is a significant amount of evidence that the Internet model is working as it is. Notably, we show how demand for Internet services has evolved over the years; how supply has successfully adapted to the new demands; and how this was achieved in an unregulated environment. In particular, we demonstrate how the same market forces that have made the Internet near-ubiquitous in developed countries are now delivering increasing benefits to developing economies.

However, long-term sustainability of the Internet model requires recognition of the challenges associated with exponential traffic growth and increasing globalization, which requires higher bandwidth to deliver content to a broader geography. Infrastructure providers have successfully addressed similar challenges in the past as the Internet grew and began to globalize, and will be able to do so in the future if they have commercial flexibility to implement new business models that ensure the necessary revenues to fund their investments in connectivity. Such commercial flexibility, in the absence of global regulation of infrastructure and services, has been successful to-date and will remain the best approach to addressing the challenges and opportunities in the future.

4.1 The evolution of the Internet

The Internet has evolved in three important ways over the past decade: content has evolved from relatively static text and web pages to multimedia high-bandwidth content that requires low latency; usage has rapidly globalized; and access has moved beyond desktop computers using fixed connections to a variety of new devices using mobile broadband. Importantly, the speed of this evolution in technology and its adoption is unparalleled in human history.

4.1.1 Service evolution

Services have evolved on the Internet in two directions that are important to the growth of global traffic flows. First, an increasing number of high-bandwidth applications, notably video, are becoming available, resulting in a significant and growing amount of bandwidth demand. Second, there are increasingly latency-sensitive applications, such as VoIP.

The figure below shows how the Internet has evolved from predominantly web, email, and file sharing in 2008 to a predominance of video today, a situation which is expected to continue into the future.

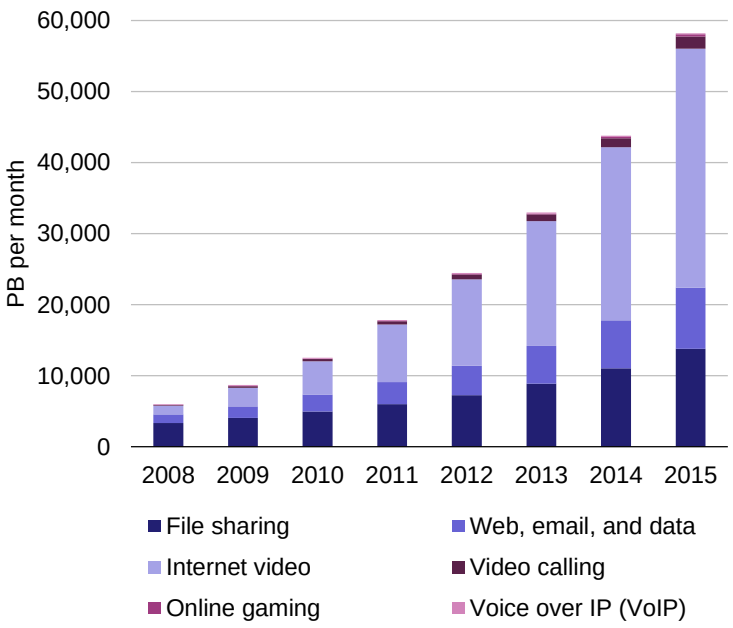


Figure 4.1: Worldwide Internet traffic generated by different consumer services [Source: Cisco Visual Networking Index]

Further, the nature of usage is rapidly evolving, particularly with respect to communications. Early applications such as email were asynchronous ones in which interaction was sequential. As the sender was not expecting an immediate response to an email, for instance – and indeed did not even know if the recipient was online – the timing of delivery was not essential. This situation was well adapted to the dial-up Internet access that prevailed as these applications gained popularity. In particular, dial-up was low bandwidth, not always on, and often charged per-minute, and was thus appropriate to communications such as email that did not require immediate response and simultaneous usage.

In the past decade, there has been an explosion in the use of VoIP applications, and although these only contribute a small portion of overall Internet traffic, they do constitute simultaneous communications that are highly dependent on having low latency and for that reason take advantage of the benefits of broadband access. More recently, video chats have come to the fore, as an increasing number of users do not just have broadband access – fixed and increasingly mobile – but also possess devices equipped with video cameras. These chats are not just latency-sensitive like voice calls, but also add the challenge of carrying the increased bandwidth from the video.

As described below, a significant amount of investment is taking place to increase the amount of bandwidth available and accommodate the increased amount of video – requiring high bandwidth – as well as VoIP – requiring low latency. In addition, changes in the architecture, notably the development of Internet Exchange Points (IXPs) that localize traffic exchange and access to content, are further improving the performance of the Internet and fueling the increased usage of such applications. These investments are taking place without imposing accounting rates, while the applications are accommodated without the need for guaranteed quality of service (QoS).

4.1.2 Globalization of the Internet

At the same time that services are evolving, the Internet is globalizing at a quickening pace. The following graph shows how Internet access has moved from being centered on the developed world in 2000, to becoming more and more focused on developing countries by 2011, more in line with the split of world population.

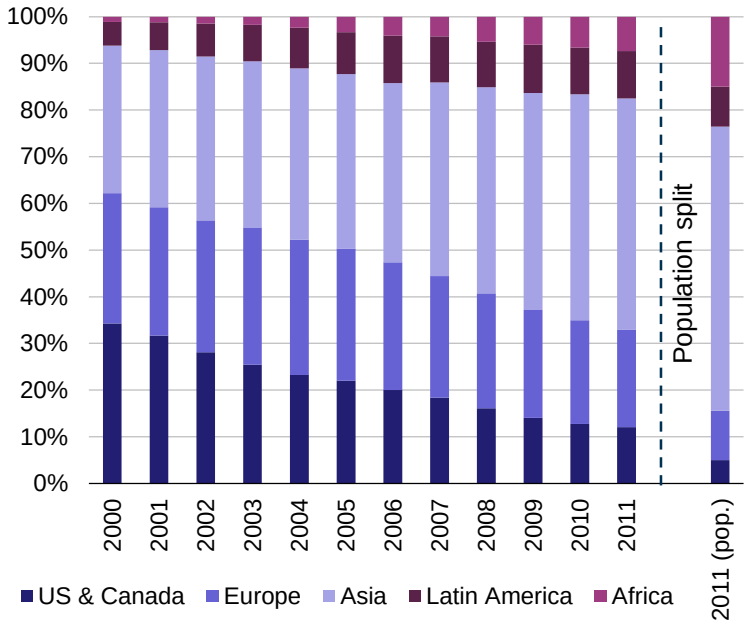


Figure 4.2: Geographic distribution of Internet users [Source: ITU, Analysys Mason]

The annual growth rate in the number of Internet users in Africa over the past decade has been 33%, almost double the rate in Asia and Latin America (each with a growth rate of 17%), and well ahead of the growth rates in Europe (10%) and the US and Canada (4%). While there is still some way to go, particularly to increase the amount of broadband (both fixed and mobile) available in developing countries, significant changes have occurred, and these changes have been driven by, and have driven, significant changes in the global architecture of the Internet (discussed further in Section 4.3 below).

4.1.3 Mobile access

The third way in which the Internet has evolved is the change in the nature of Internet access: this has evolved from being reliant on fixed access, typically through a desktop terminal, to mobile access through a smartphone or tablet. To demonstrate the differences in fixed versus mobile access, the following figures shows the level of fixed and mobile broadband subscriptions and annual growth by region. It can be seen that mobile broadband is growing fast, with an annual growth rate faster than the fixed annual growth rate in each region. In all regions, particularly developing markets, mobile

broadband already exceeds fixed broadband in terms of the number of subscribers. [6] The availability of mobile broadband over fixed connections is a significant driver of the globalization of Internet access in developing countries, and in turn mobile access will change the nature and usage of Internet access.

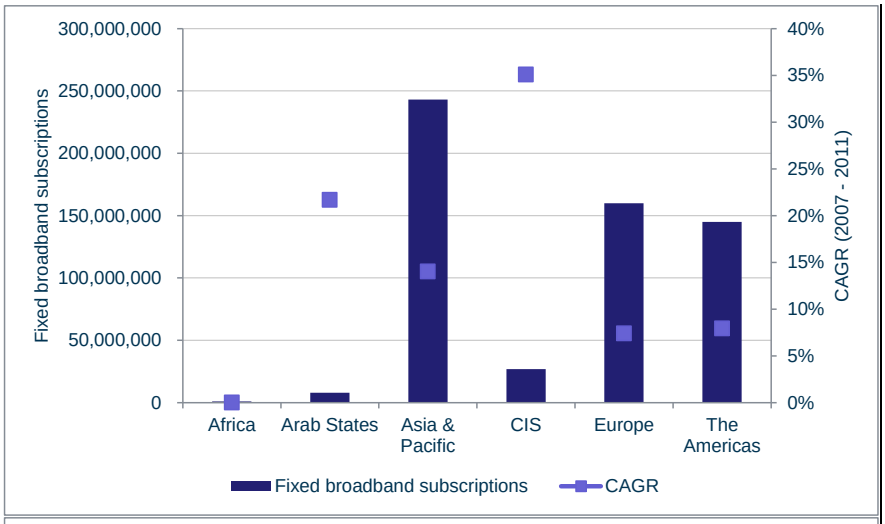


Figure 4.3: Fixed broadband subscriptions and growth by region, 2011 [Source: ITU, Analysys Mason, 2012]

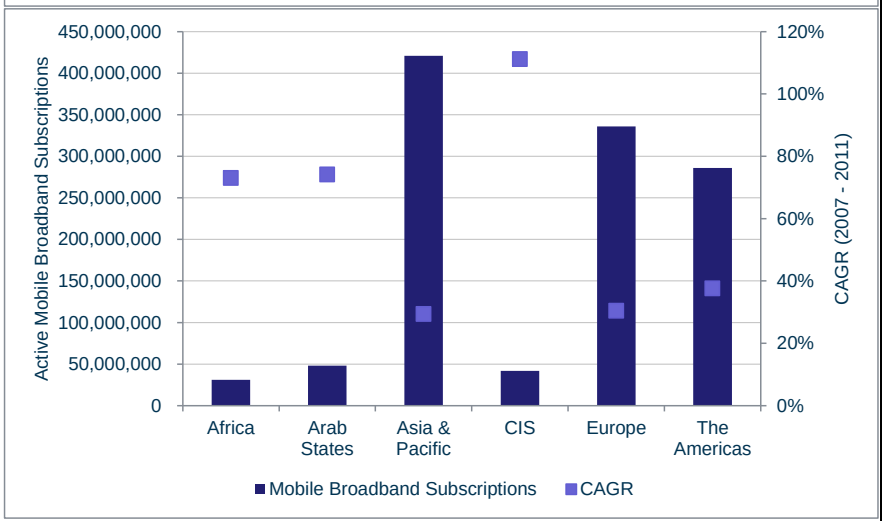


Figure 4.4: Mobile broadband subscriptions and growth by region, 2011 [Source: ITU, Analysys Mason, 2012]

4.2 Adaptation of the architecture

All three of the changes just discussed (service evolution, globalization and mobile access) have had a significant impact on the architecture of how traffic is delivered, both within developed countries and also increasingly globally. Below we describe how the architecture of the Internet has adapted in significant ways in order to address the challenges, first in developed countries and more recently in developing countries.

6 It is true that fixed broadband subscriptions tend to be taken per household and shared by all household members, while mobile broadband subscriptions tend to be personal and thus there could be multiple subscriptions per household. Nonetheless these numbers clearly demonstrate that the trend, particularly in developing regions such as Africa, favors mobile access in lieu of fixed access.

4.2.1 Internet Exchange Points (IXPs)

The nature of the exchange of Internet traffic has been changing for the past decade. Historically, most traffic transited through US-based network access points (NAPs) in which backbones interconnected their networks and exchanged traffic. As all ISPs had to connect to the US for international transit, they also used these links to exchange domestic and regional traffic, a process referred to as *tromboning*. Tromboning involves the carriage of traffic on unnecessarily long and technically sub-optimal routes, and this increases transit costs and diminishes network performance. For this reason, various Internet players began to set up and use IXPs in their own countries or regions to exchange traffic.[7] This process is largely completed in developed regions, and fully underway in developing ones, where local or regional traffic exchange can significantly lower the usage and cost of international links, while also improving network performance. As described below, efforts to impose settlements on international Internet traffic may slow or impede this trend to use local or regional IXPs, reducing their benefits accordingly.

Following the initial successes of several IXPs in Europe, the expansion of IXPs has accelerated and globalized. We may distinguish three phases, which each had a different geographical focus. In the first phase, exchange of international Internet traffic was concentrated in the US (US-centric). In the second phase, traffic exchange migrated to developed countries in Europe and Asia that form the core of the OECD (OECD-centric). The third phase of evolution, taking place now, focuses on the rest of the world (ROW-centric), and is moving towards a global Internet in which regional IXPs will always be used for local traffic. These trends are illustrated in the figure below, which shows the changing distribution of IXPs between the various regions.

[7] IXPs are designed for Internet players (including ISPs and content providers as well as backbones) as locations at which to peer and/or to sell or purchase transit over direct cross-connections. This enables the delivery of connectivity closer to the end users, while also accommodating the increasing volume of content.

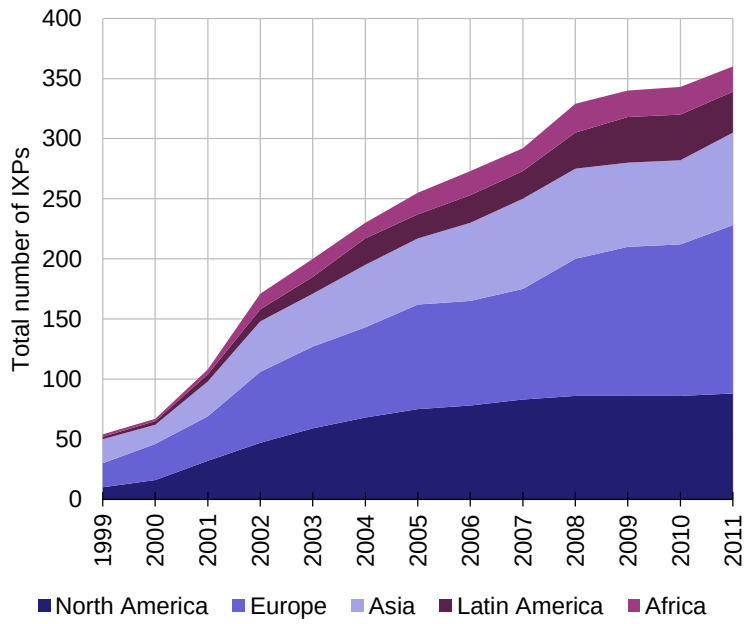


Figure 4.5: Number of IXPs in the world, by region [Source: Packet Clearing House (www.pch.net), Analysys Mason estimates]

There are two main reasons for the fast development of regional IXPs in the past 15 years:

- First, *economic factors*: peering at a national IXP allows for the efficient exchange of local traffic (see Section 4.4), and reduction in tromboning translates into a reduction in payments to upstream transit providers in other countries. As the price of regional connectivity fell dramatically following liberalization in OECD countries in particular, intra-regional traffic exchange became even more affordable. Reducing reliance on international connectivity has a particularly significant impact on the cost of providing service, particularly for high-bandwidth applications such as video streaming.

- The second factor relates to *network performance*: by exchanging traffic at a nearby IXP, ISPs have been able to reduce the traffic route distances and thus decrease the latency experienced by end users, compared to a situation where traffic has to pass through multiple backbones. This facilitates the usage of latency-sensitive applications such as VoIP – and it also addresses the increasing portability of content, as described below.

4.2.2 Portability of content

According to Cisco, as of 2011 up to 98% of consumer Internet traffic[8] consists of relatively static data, such as file sharing (peer-to-peer), video, or web pages, as shown in Figure 4.6 below. Video in

[8] Note: Internet traffic encompasses 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.

particular often consists of movies, television shows, and other clips that may have begun as live broadcasts, but then are stored in files that can be streamed to end users. The advent of caching servers, mirroring servers and distributed architectures means that this static content can be stored in places different from where it was developed, reducing the cost of delivering high-bandwidth applications such as video. Such servers are increasingly available in the local and regional IXPs described in the previous subsection, bringing significant benefits to developing countries by lowering the cost of accessing such content, and reducing the latency experienced by users. The arrival of such content could be slowed or reversed through the imposition of settlements, with a corresponding reduction in the benefits.

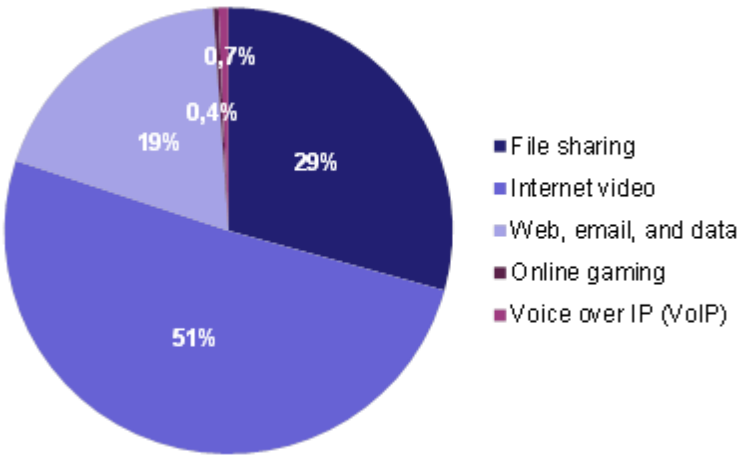


Figure 4.6: Split of consumer Internet traffic (fixed and mobile) by type of traffic in 2011 [Source: Cisco Visual Networking Index: Forecast and Methodology, 2011–2016]

As described in the next subsection, the 'portability' of such content means that traffic patterns can – and do – shift as providers move their content to IXPs closer to end users. Finally, while it is true that roughly 2% of traffic comes from services such as email and voice and video calling, that take place between users at fixed end points and cannot be stored in servers, the introduction of IXPs helps to localize traffic exchange, thereby reducing latency and enabling high-quality voice or video calls between domestic and regional users.

4.2.3 Traffic migration

The result of moving content in response to increasing demand, along with the increasing number of IXPs available to host and distribute that content, has been profound. These trends are illustrated by the increase in the proportion of intra-regional traffic over time in Europe, and later in Asia. The following charts provide evidence of this evolution: they show the percentage of international Internet bandwidth provisioned from each of the major world regions to each region. The first chart (Figure 4.7) shows that the bulk of European bandwidth is used to connect European countries to each other; the proportion going to the US and Canada has fallen from 30% in 1999 to roughly half as much

by 2011, displaced to some degree by bandwidth to Asia. It should be noted that by 1999 most traffic tromboning through the US had already been eradicated, thanks to the introduction of major European IXPs in the mid-1990s – for example, the London Internet Exchange (LINX, founded 1994) and the Amsterdam Internet Exchange (AMS-IX, founded 1997).

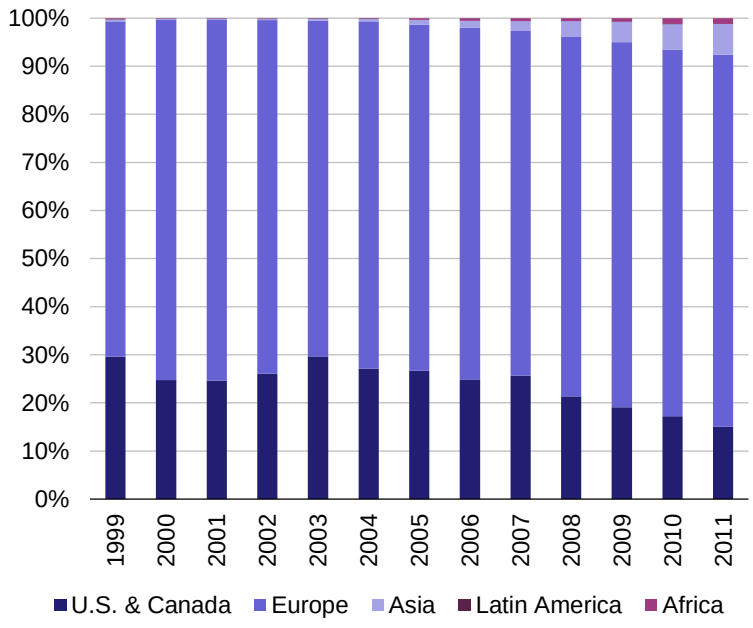


Figure 4.7: International Internet bandwidth from European countries, by region [Source: Telegeography, 2012]

The second chart (Figure 4.8 below) shows Internet bandwidth from Asian countries; in 1999 this was still heavily skewed towards the US, but has been displaced by bandwidth between Asian countries, along with more bandwidth to Europe as well. As a result, bandwidth to the US has fallen from over 90% of total international connectivity in 1999 to just over 40% in 2011.

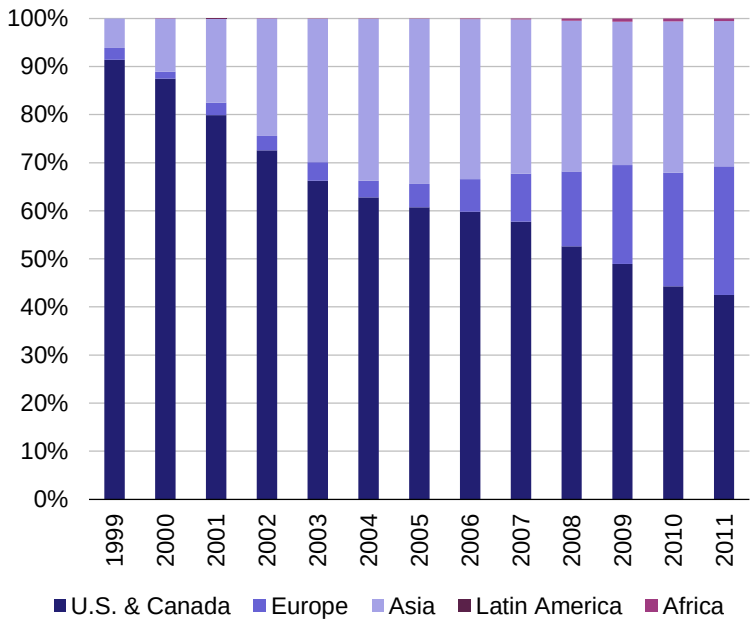


Figure 4.8: International Internet bandwidth from Asian countries, by region [Source: Telegeography, 2012]

4.3 Impact on developing countries

The market response to the increased Internet usage in developing countries in Africa and Latin America has, if anything, been more profound than in Europe and Asia.

4.3.1 Traffic migration

While a significant amount of African connectivity was US-centric in the early days of the Internet, as a result of the flexibility of the Internet architecture much of Africa's international traffic has shifted to Europe. This demonstrates concretely that much Internet traffic, unlike voice traffic, does not have to originate in a fixed location – for instance, a YouTube video can be uploaded in California, moved to a server in London, and then stored in a cache in Nairobi in order to be accessed locally (or in the region) via the Kenya IXP (KIXP).

As an illustration of how traffic flows can change, Figure 4.9 below shows international Internet bandwidth within Africa and between Africa and other regions. While in 1999, 70% of bandwidth from Africa went to the US, by 2011 this had fallen to just a few percent, and nearly 90% went to Europe. This does not mean that over time Africans began to rely almost exclusively on European content, but rather that much of the content originally from the US began to be stored on servers in Europe as providers began to build out their networks. This shows how traffic can shift in response to changes in bandwidth costs and local conditions, as Europe liberalized its telecom networks and IXPs developed to host the content, and demonstrates how in future similar shifts could localize traffic in Africa to further reduce latency and costs.

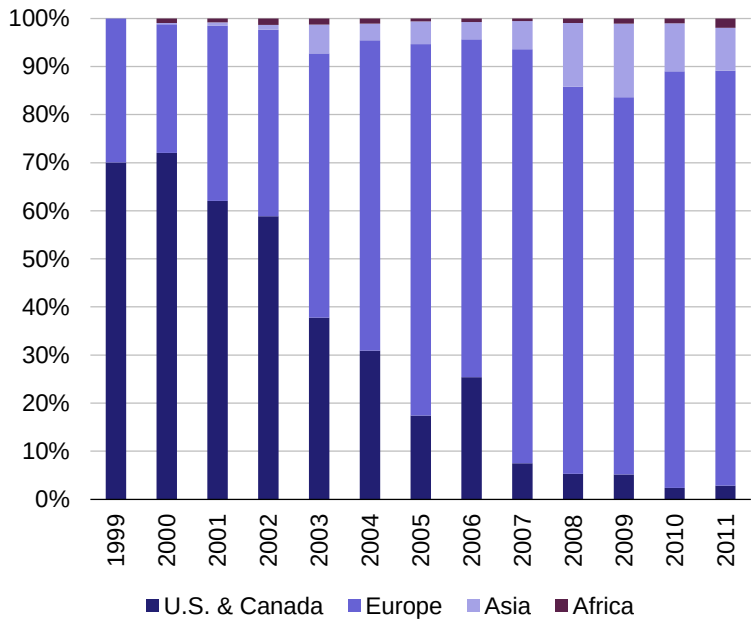


Figure 4.9: International Internet bandwidth from African countries, by region [Source: Telegeography, 2012]

Although traffic has now shifted from the US and Canada to Europe, there is still relatively little regional traffic within Africa. According to TeleGeography, a total of 570.92 Gbit/s of international Internet bandwidth serves African countries – a number that is itself relatively low[9] – and only 10.98 Gbit/s of that capacity connects African countries to each other. While it is true that IXPs are emerging to facilitate local exchange of traffic in Africa, the cost of cross-border connectivity between many African countries is still quite high, and this is hindering the emergence of regional IXPs to help exchange traffic and distribute content.

The bandwidth from Latin America presents the same broad picture, with some minor differences (see Figure 4.10 below). Between 1999 and 2011, the percentage of bandwidth going to the US fell from just under 90% to 85%, replaced by more intra-regional traffic as the bandwidth going to other regions is minimal. The main similarities between Africa and Latin America are that over 80% of their Internet bandwidth is connected to another region (Europe and the US respectively). At the same time, little bandwidth goes between countries within the region – 15% in the case of Latin America, and just 2% in Africa. This highlights the relative lack of liberalization of regional connectivity, which in turn results in tromboning via major IXPs in Europe or the US, along with an apparent reluctance of content providers and other stakeholders to invest in regional hubs. However, there has been and continues to be significant investment in connectivity that is likely to lead to further traffic migration.

[9] The total 570.92 Gbit/s of international Internet bandwidth connecting African countries is much lower than the 16,646 Gbit/s for North America, and the 40,694 Gbit/s for Europe (all figures are for 2011). This is despite the fact that Africa has a higher population than both of the other continents.

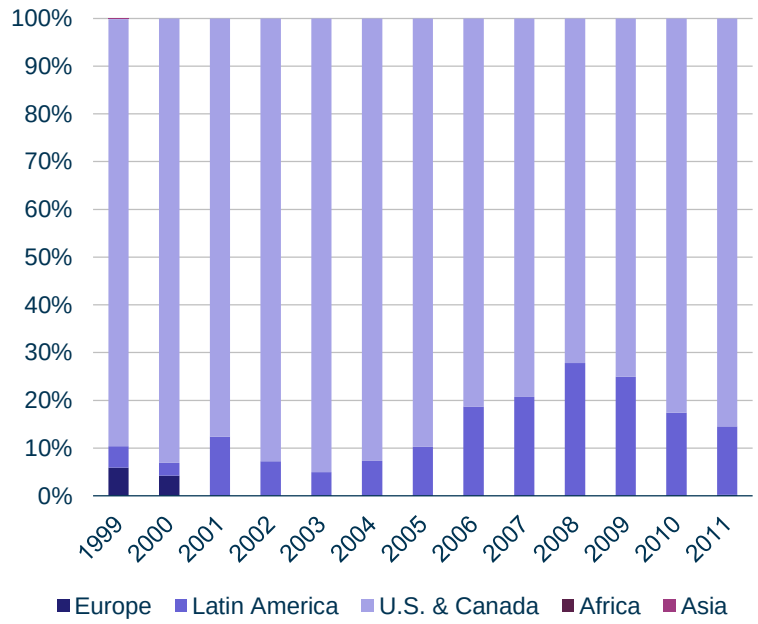


Figure 4.10: International Internet bandwidth from Latin American countries, by region [Source: Telegeography, 2012]

4.3.2 International connectivity

There has been a significant upsurge in the deployment of international submarine capacity to under-served countries in sub-Saharan Africa, Latin America, and the Asia-Pacific region, giving rise to benefits in the cost and quality of connectivity. For instance, until recently, the options for international connectivity in sub-Saharan Africa were satellite, at a price up to USD2000 per Mbit/s, or monopoly submarine cables, at prices near or even above satellite prices. For an ISP that has to depend on satellite, international connectivity is a significant part of the cost of Internet access (see Figure 4.11 below), and there is little incentive to upgrade domestic networks, given the overall cost of service and the resulting low revenues.

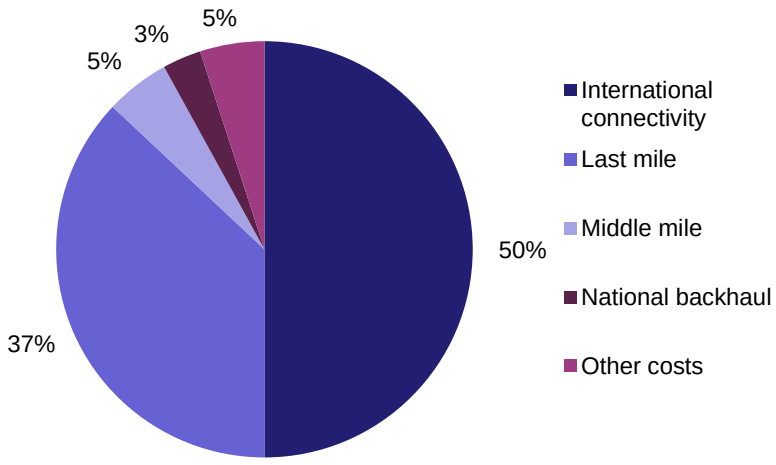


Figure 4.11: Costs of providing mobile broadband in Africa, using satellite for international connectivity [Source: Analysys Mason, 2011]

In the past few years, in all under-served regions, market forces have responded to the increasing Internet demand and lack of supply. For instance, according to TeleGeography, the amount of international Internet bandwidth serving African countries has increased from 1.21 Gbit/s in 2001 to 570.92 Gbit/s by 2011. The greatest growth rate occurred between 2009 and 2010 as a result of a number of new and competing submarine cables that began service in 2010, including the East African Submarine Cable System (EASSy), the East African Marine System (TEAMS) and the SEACOM cables. By the end of 2012, almost 25Tbit/s of submarine cable capacity will link Sub-Saharan African countries to each other and the rest of the world. [10] This represents a significant amount of investment by African and international operators, development organizations, and governments. Similar investments are taking place across Latin America and Asia–Pacific, where large increases in capacity are expected over the next few years. Critically, these investments are taking place in the current environment, with no imposed accounting rate system.

The following table highlights the parameters of some of the principal submarine cables (both recent and planned), showing the billions of dollars that have been spent to increase capacity in the past decade. This very significant investment will dramatically increase the amount of bandwidth available to under-served regions of the world. Interestingly, while most of the intercontinental cables connect the US or Europe to Latin America or Africa, three of them expected in 2014 will connect Latin America to Africa, which is likely to increase the quality and lower the cost of ISPs exchanging traffic between these continents and accessing each other's content.

Figure 4.12: Major submarine cable projects, 2010 – future [Source: Steve Song (http://manypossibilities.net/african-undersea-cables/), Press articles, 2012]

Cable	Destinations	Capacity	Year live / planned	Investment (USD million)
Main 1	Portugal, Ghana, Nigeria	1.92 Tbit/s (initial lit capacity 30 Gbit/s)	2010	240
EASSy	Sudan, Djibouti, Kenya, Tanzania, Comoros, Mozambique, Madagascar, South Africa	4.72 Tbit/s (lit capacity 60 Gbit/s)	2010	260
Glo-1	UK, Ghana, Nigeria	2.5 Tbit/s (lit capacity 640 Gbit/s)	2010	600
WACS	UK, Portugal, Canary Islands, Cape Verde, Cote d'Ivoire, Ghana, Togo, Nigeria, Namibia, Congo (Republic), Angola, Democratic republic of Congo, Angola, South Africa	5.12 Tbit/s	2012	650

[10] Source: http://manypossibilities.net/african-undersea-cables/, October 2011.

ACE	Mauritania, Senegal, Gambia, Guinea, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Benin, Nigeria, Cameroon, Equatorial Guinea, Gabon, DRC, Angola, Namibia, South Africa	5.12 Tbit/s	Expected Q3 2012	700
SAex	South Africa, Angola, Brazil	32 Tbit/s	Expected 2014	320
BRICS	South Africa, Brazil, India, Singapore, China	12.8 Tbit/s	Expected mid 2014	n/d
WASACE Africa	Brazil, Angola, Nigeria, South Africa	100 Gbit/s	Expected 2014	650
ALBA-1	Venezuela, Jamaica, Cuba	5.12 Tbit/s	2012	70
AM-1	Colombia, Mexico, Brazil, Guatemala, Dominican Republic, Brazil, US	n/d	2012	540
Seabras 1	Brazil, US	32 Tbit/s	Expected 2014	n/d
WASACE Americas	Colombia, Panama, Brazil, US	100 Gbit/s	Expected 2014	n/d
HANTRU 1	Marshall Islands, Guam, Micronesia	10 Gbit/s	2010	130
ICN	Vanuatu, Fiji	20 Gbit/s	2012	31
ASE	Singapore, Japan, Philippines, Malaysia, Hong Kong	15 Tbit/s	2012	430
Tonga Cable	Tonga, Fiji	20 Gbit/s	Expected 2013	34
ASSC-1	Australia, Indonesia, Singapore	6.4 Tbit/s	Expected 2013	300

Further, the widely spread ownership among the national and international operators that have predominantly made these investments is likely to create a significant amount of competition, not just between the new cables, but also between owners on each particular cable. This competition will put further downward pressure on bandwidth prices. This shows how the industry is bringing increasing benefits to the sector without the need to impose any accounting rate regime.

The following charts show the breakdown of investments into two cables: SEACOM and WACS.

Figure 4.13: Ownership breakdown of the SEACOM submarine cable [Source: TeleGeography; Analysys Mason, 2012]

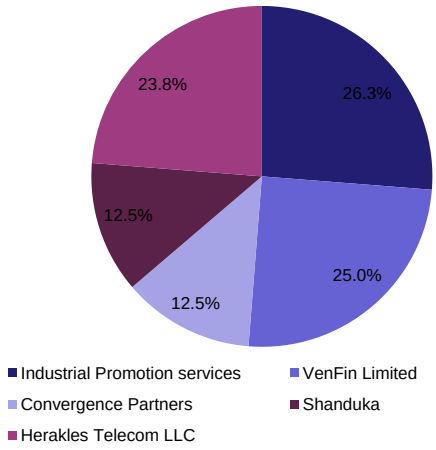
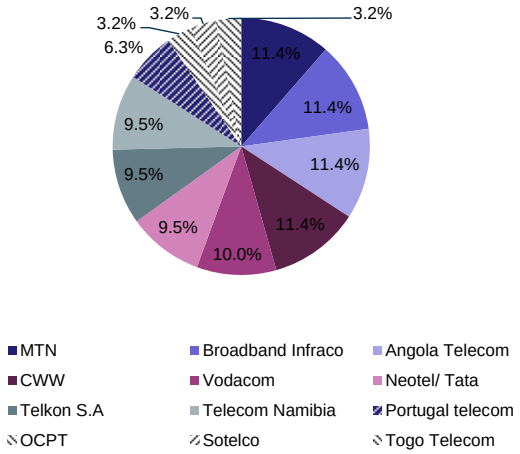


Figure 4.14: Ownership breakdown of the WACS submarine cable [Source: TeleGeography; Analysys Mason, 2012]



As a result of these investments in submarine cables, and the increase in competition between owners of capacity on them, the prices for international connectivity have dramatically reduced in the past few years in many countries. For instance, the graph below illustrates the price decline since 2008 for an international link between South Africa and the UK.

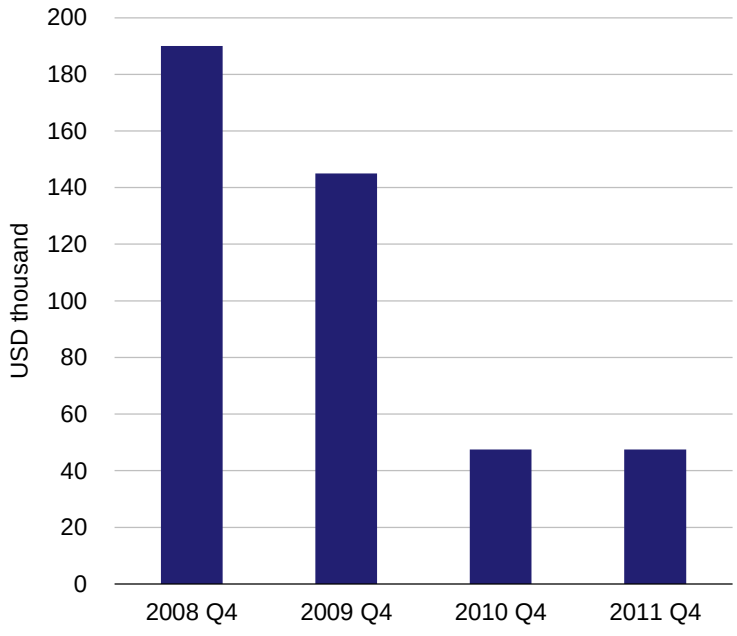


Figure 4.15: Median STM-1 lease prices for Johannesburg–London route, 2008–2011 [Source: Telegeography, 2012]

Note: Prices exclude local access and installation fees

These developments have had a significant impact on the cost of broadband access, by lowering the cost of international connectivity using submarine cable as opposed to satellite. The chart below shows the average monthly cost of broadband in Africa provided via satellite and submarine cable.

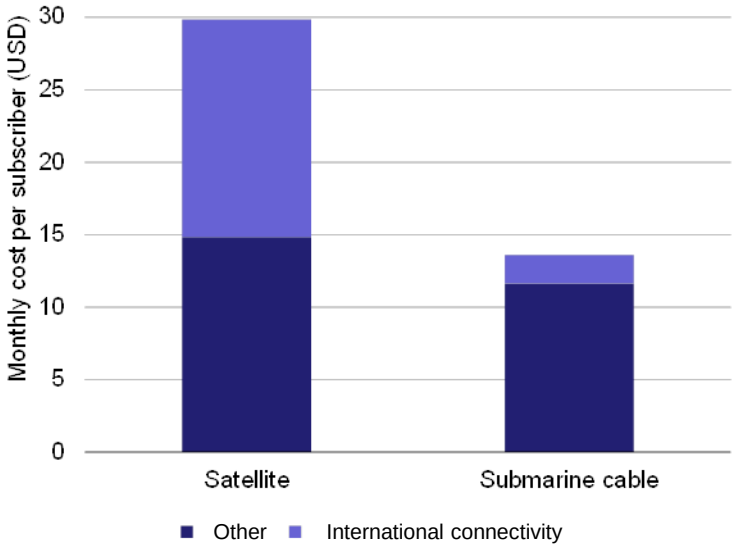


Figure 4.16: Cost of broadband in Africa provided via satellite and submarine cable [Source: Analysys Mason, 2011]

Thus, over the past few years the international connectivity situation has changed drastically, reflecting the flexibility of the Internet, investments made by a variety of players, and ultimately increased demand for Internet access in emerging markets. In countries that have received new international connectivity, much of the cost of providing Internet access is now domestic, relating to backhaul and last-mile access. The following chart breaks down the costs for a sample operator in Africa using submarine cable for international connectivity (compare with Figure 4.11 above). Thus, market forces have already pushed down prices across the delivery network in developing countries, and all evidence shows that this will continue in future as investments flow towards other parts of the network from national backhaul to last-mile access.

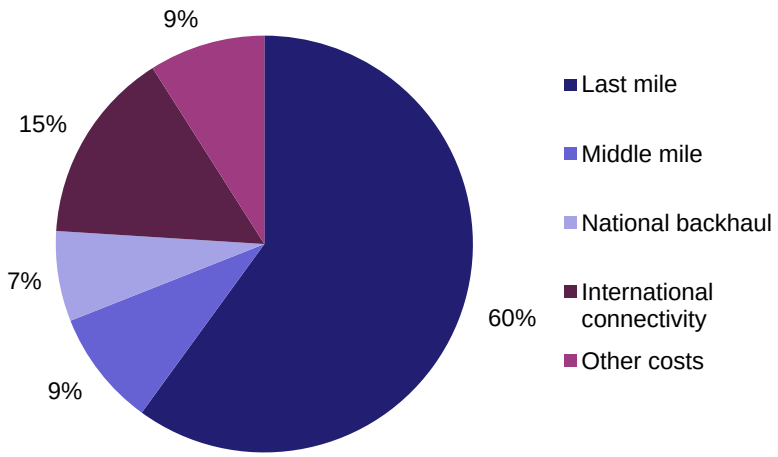


Figure 4.17: Costs of providing mobile broadband in Africa, using submarine cable for international connectivity [Source: Analysys Mason, 2011]

4.3.3 Terrestrial fiber

Further investments are also being made in terrestrial fiber across under-served regions: this includes both *cross-border* fiber, which is crucial to deliver traffic from countries with submarine landing cables to countries without, as well as *national long-haul* fiber, to deliver traffic from the international gateways to and between cities within a country. Cross-border connections are particularly helpful for land-locked countries such as Paraguay and Chad, for which these fiber links are the most efficient means to reach submarine capacity. Some examples of cross-border fiber networks are provided in the following table.

Figure 4.18: Examples of investments in terrestrial cross-border fiber [Source: Press articles, 2012]

Countries	Details
Nigeria, Benin, Toga, Ghana	A Nigerian IP Backbone provider deployed a fiber network to three neighbouring countries in 2009. This replaced satellite access in some parts of these four countries, while providing for fully redundant access to submarine cables in parts already served by fiber
Cameroon, Chad, and Central African Republic	The Central Africa Backbone is connecting these three countries in an initial phase of this World Bank/Africa Development Bank program. A further eight countries may also participate in a second phase of this project
Zimbabwe, Botswana, Mozambique, Namibia, South Africa, Zambia	Liquid Telecom, a subsidiary of Econet Wireless, is deploying a 4,000 km national fibre backbone to connect these countries with each other and capacity on submarine cables via South Africa and Mozambique
Burkina Faso, Côte d'Ivoire, Mali and Togo	ONATEL, the incumbent telecom operator in Burkina Faso, has built a backbone connecting to its three neighbors
Brazil, Venezuela	In February 2011, Venezuela's state-run telecom operator, Compania Anonima Nacional Telefonos de Venezuela (Cantv) finished connecting a fiber-optic cable that links the southern part of the country to northern Brazil
Bolivia, Paraguay	In 2011, Bolivian state-run telecom operator Entel and Paraguayan state-run telecoms operator Copaco signed a Memorandum of Understanding to establish a fiber-optic interconnection through the Chaco region on the border between the two countries. 322km of the network will cross Paraguayan territory, while 140 km will cross Bolivia
Colombia, Chile, Argentina, Brazil	Colombian backbone network operator Internexa has announced plans to invest USD40 million in fiber-optic infrastructure in Argentina. The network is intended to link Santiago de Chile with Buenos Aires and Rio de Janeiro. The total cost is projected to be USD150 million. In Colombia, Internexa operates a 6600 km fiber network linking the country's main cities
Thailand, Cambodia, Vietnam	In June 2012, Thai state-owned telecom TOT partnered with China Telecom to build two new international terrestrial high speed fibre-optic links to provide backup Internet gateway capacity for Thailand. The project aims to ease traffic congestion on Thailand's main international Internet gateway – a submarine fibre network connecting to Malaysia and Singapore, run by TOT's sister telco CAT Telecom

In addition, a number of domestic backhaul fiber networks are being deployed across a number of developing markets. Some examples are provided in the table below.

Figure 4.19: Examples of investments in national long-haul fiber [Source: Press articles, 2012]

Country	Details
South Africa	Starting in March 2009, Neotel has laid out 12,000 km of fibre, reaching 40 cities and towns; it plans to light up another 2,000 km by the end of 2012
Angola	In September 2011 Angola Telecom completed a national fibre-optic backbone that spans 10,000 km
Nigeria	Recent roll-outs include MTN (over 8,000 km), Zain and Globalcom. In 2010 Dancom started the construction of Nigeria's first open-access fibre-optic backbone network; over 1,400 km were installed in 2010-11 with another 750 km being planned for 2012
Namibia	Telecom Namibia has deployed about 8,000 km of fibre-optic cables and extended its network to the borders of Angola, Zambia, Botswana and South Africa. The network has a 10Gbit/s capacity, and Telecom Namibia is investing further to increase capacity on the existing fibre infrastructure to 40Gbit/s
Senegal	Orange/Sonatel has a network of more than 3,500 km of fibre-optic cable covering the 14 main towns. The network continues to be deployed, with 10Gbit/s capacity to be installed on all links by 2015
Uganda	MTN and UTL have their own national backbones and have built fibres connecting to Rwanda and Kenya. UETCL (a power utility) is selling dark fibre to the Kenyan border
Brazil	Funded by the National Research Council (CNPq) and with support from the UN Development Program (UNDP), RNP has started deploying a national backbone. In 2010, phase 6 of the backbone used around 30 leased wavelengths to link 24 cities with an aggregate capacity of 213Gbit/s
Mexico	Telmex's fiber-optic network is the largest in Mexico and reaches 68,000 km, stretching across the entire country. Other networks include Avantel, which has a fiber-optic backbone of 6,300 km and Bestel which has 4,200 km of backbone
Nicaragua	The market for backbone was relatively underdeveloped, as the state-owned Enitel had a monopoly. In March 2012, the state-owned electricity transmission company Enatrel was given permission to provide telecom services on a national or international level, thus allowing it to commercially expand its fibre-optic network and use extra capacity for backbone and backhaul
Indonesia	In March 2010, the Java backbones of Telkomsel and Natrindo Telepon Seluler were upgraded by 10Gbit/s, bringing capacity to 220Gbit/s. This was done in order to meet Telkomsel's traffic needs
Philippines	In 2011Globe Telecom made a USD70 million investment to launch its second fibre-optic backbone network. The 400Gbit/s network is 1,900 km in length and comprises submarine and cable links
Vietnam	In 2010 Vietnam Telecom National upgraded its fiber-optic backbone network from 10Gbit/s to 40Gbit/s, in response to increasing demand for mobile and broadband services in Vietnam
Malaysia	In May 2011 Maxis Berhad (a converged service provider) deployed Alcatel-Lucent's 100Gbit/s optical coherent network solution, making it the first 100Gbit/s single carrier with optical coherent technology in the Asia–Pacific region

According to *Africa Bandwidth Maps,* in 2010 the expenditure on long-haul terrestrial fiber in Africa was over USD12 billion, with over USD8 billion already spent on operational fiber, and the rest planned or proposed. In terms of cross-border traffic alone, the results have been significant, as shown in the chart below. In 2005 there was only an estimated 33Mbit/ of terrestrial cross-border capacity available in sub-Saharan Africa, but by 2011 this had grown to 30,960Mbit/s. This terrestrial cross-border capacity allows countries without a submarine cable landing station to access the new international capacity, while other countries can access multiple landing stations and begin to develop regional networks.

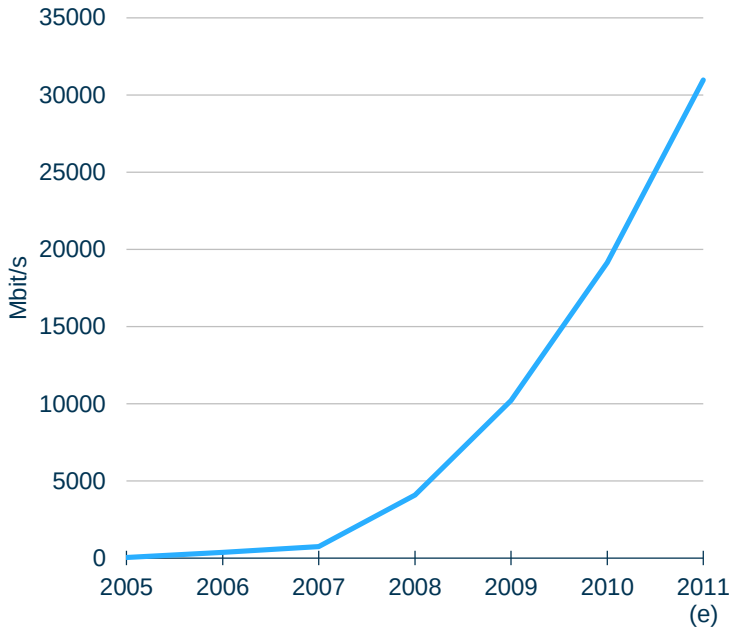


Figure 4.20: International Internet bandwidth in sub-Saharan Africa supplied by terrestrial cross-border networks [Source: Africa Bandwidth Maps, 2012]

4.3.4 Mobile broadband

As mobile is the dominant form of connectivity in many, if not all, developing countries, mobile broadband will likely be the dominant access technology in the future. While penetration rates for mobile broadband in Africa currently lag other regions (see Figure 4.21 below), the growth rates of this technology in Africa are fast compared with other regions (see Figure 4.22). At the same time, penetration is already high in the Americas, and growing fast in Asia–Pacific countries.

Figure 4.21: Mobile broadband penetration by region, 2007–2011 [Source: Analysys Mason, 2012]

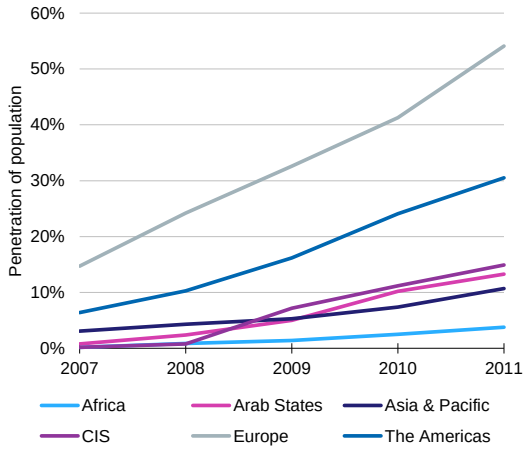
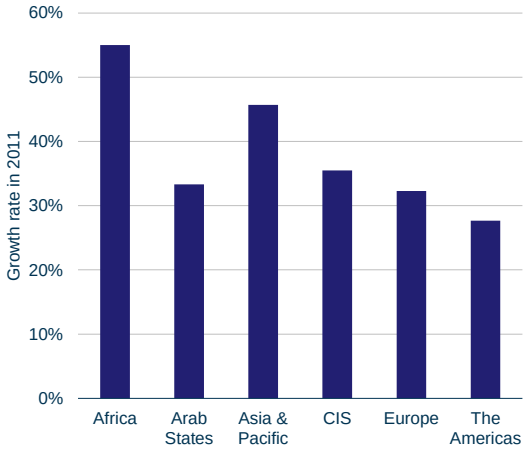


Figure 4.22: Mobile broadband growth rates by region, 2011 [Source: Analysys Mason, 2012]



Encouragingly, a number of national and international operators are making investments to provide mobile broadband access to end users in developing countries, including Orange, Bharti Airtel, Etisalat, Telefónica, América Móvil, and Celcom. Examples of these investments are provided below. This again demonstrates how the current system is encouraging operators to invest in bringing broadband to end users, without the need for intervention.

Figure 4.23: Examples of investments in mobile broadband access [Source: Press articles, 2012]

Operator	Country	Mobile broadband plans	Investment (USD million)	**Timeframe**
France Telecom (Orange)	Kenya	1,500 3G base stations	47	Mar 2011 – May 2011 (2 months)
MTN Group	Nigeria	Capacity upgrades, transmission capacity improvement, more base stations, fibre backhaul	1,300	Aug 2011 – Dec 2012 (1 year 5 months)
Bharti Airtel	Rwanda	Roll-out of 3G and mobile networks	100	Aug 2011 – Dec 2012 (3 years)
Bharti Airtel	Nigeria	Service improvements	600	Apr 2010 – April 2011 (1 year)
Etisalat	Nigeria	1,000 additional base stations to boost network coverage and enhance quality of service	194	May 2011 – May 2014 (9 months)

Operator	Country	Mobile broadband plans	Investment (USD million)	Timeframe
Vodacom	Tanzania	Investment to boost network coverage capacity, enhance mobile data service, and offer the M-pesa mobile commerce service	100	May 2011 – May 2014 (3 years)
Claro (América Móvil)	Argentina	Build 450 new cell sites and extend fiber-optic connections around the country	1,250	2011 - 2012
Telefónica Brazil	Brazil	Projects related to infrastructure, mostly to expand coverage and the network	3,400	2011
América Móvil	Colombia	Integrate platforms and optimize services	800	2012
Movistar (Telefónica)	Colombia	Extend and modernize infrastructure and platforms	533	2012
AIS	Thailand	Expand 2G network capacity and expand 3G services on existing networks	236	Q1 – Q3 2011 (3 quarters)
Chunghwa Telecom	Taiwan	Install over 1,000 cell towers which are compatible with HSPA+ services	160	2011 (1 year)
Celcom Axiata	Malaysia	Boost network coverage, capacity and quality to be LTE-ready	330	2011 (1 year)

4.3.5 Domestic and regional IXPs

In addition, as discussed earlier, IXPs are increasingly being formed in developing countries, filling a similar role to the one they play in developed countries, localizing the exchange of traffic and access to content. For instance, in Kenya the Telecommunications Service Providers Association of Kenya (TESPOK) recently launched the Kenya Internet Exchange Point (KIXP), where all ISPs meet to interconnect. This has had several noteworthy impacts:[11]

- The latency of local traffic exchange has been reduced drastically, from 200–600ms to 2–10ms on average: quick enough to make possible latency-sensitive services such as VoIP.
- The elimination of tromboning has saved local ISPs nearly USD1.5 million per year on international connectivity charges by taking advantage of the lower prices that resulted from the new submarine cables.
- The presence of effective IXPs induced Google to place a cache in Kenya, which has significantly increased the amount of locally distributed content (notably YouTube videos), now available at faster speeds. A large content delivery network is also about to make its own cache available through the IXP.

11 See "Assessment of the impact of Internet Exchange Points – empirical study of Kenya and Nigeria", Analysys Mason, April 2012 (http://www.internetsociety.org/news/new-study-reveals-how-internet-exchange-points-ixps-spur-internet-growth-emerging-markets).

- Improved access to local content at quicker speeds has increased usage, helping to increase the mobile data market by at least USD6 million per year in Kenya.
- Government services are also delivered via the IXP – notably, the Kenya Revenue Authority takes advantage of access to the IXP to allow for efficient online tax and customs payments.
- The IXP has also become a regional hub, serving an increasing number of routes to neighboring countries.

KIXP was a domestic initiative to address inefficient routing of traffic, but it has had the impact of improving the entire Kenyan ecosystem by localizing the exchange of traffic and access to content. This illustrates how countries can obtain significant benefits from the localization of content, including lower cost of international capacity, lower latency, and increasing inward investment. By deploying IXPs, countries such as Kenya are following those in Europe and Asia that took similar steps in response to the same stimuli. It is notable that these steps were taken by market actors in response to market conditions, without the involvement of regulators or policymakers. However, such localization of content does require general policies that welcome investment, along with liberalized sector policies that create competition and foster entry. Such policies are described further in Section 7.

4.4 Internet governance

The unprecedented success of the Internet was largely made possible by addressing governance issues in multi-national, multi-stakeholder forums which have evolved to reflect how the Internet has grown into a platform encompassing many aspects of business, government, and civic life, as well as its intrinsically borderless nature. However, one constant factor throughout the evolution of Internet governance has been that the expansion of the underlying infrastructure, along with the interconnection between networks, has largely been driven and governed by market forces. As discussed above, this reliance on commercially negotiated interconnection arrangements has served customers well, and has led to the growth of Internet traffic through Europe and Asia, and more recently developing countries, as increased connectivity is followed by IXPs facilitating local exchange and delivery of content. We have not identified any market failure at the international level that would delay or prevent this progress from continuing to increase the global number of Internet users from 2.2 billion today to the projected number of 3.5 billion in 2020.[12]

4.4.1 Multi-stakeholder Internet governance

Internet governance is broad and, depending on the topic, divided between a number of governmental and non-governmental bodies – both national and international – that address a growing variety of issues. These issues can be grouped into three broad categories:

[12] Source: ITU.

- *Technical standards,* which ensure that the Internet continues to function and evolve – addressed by several nongovernmental and intergovernmental international bodies with input from governments, companies and other stakeholders.

- *Resource management* to distribute unique domain names and IP addresses – controlled by non-governmental international bodies with limited government involvement.

- *Policy-making* to address a variety of issues unique to the Internet (such as cyber-security), and to apply general laws to the Internet (such as intellectual property rights) – managed by national and international governmental bodies with multi-stakeholder input.

A number of relevant bodies are addressing these issues, and this gives stakeholders, ranging from individuals to national governments, a number of means to influence governance. These institutions include the following:

Figure 4.24: Major Internet governance institutions [Source: Analysys Mason, 2012]

Organization	Issues	Foundation	Participation
Internet Governance Forum (IGF)	A broad variety of issues	Established by the UN in 2006	Multi-stakeholder
Internet Corporation for Assigned Names and Numbers (ICANN)	Domain names	Joint project agreement with US Department of Commerce	Multi-stakeholder (companies, governments, etc.)
Internet Assigned Numbers Authority (IANA)	IP addresses, domain names, IP symbols and numbers	Part of ICANN	Multi-stakeholder (companies, governments, etc.)
Business Action to Support the Information Society (BASIS)	General promotion of multi-stakeholder model, as well as specific key issues such as data protection and privacy	International Chamber of Commerce (ICC)	ICC members from business
International Telecommunications Union (ITU)	Worldwide standards; improvement of telecom infrastructure in the developing world	UN agency	Governments, with multi-stakeholder participation
Internet Society (ISOC)	Technical standards, public policy, development of Internet	Independent non-governmental organization	Multi-stakeholder
Internet Engineering Task Force (IETF)	Technical standards	Chartered to ISOC	Multi-stakeholder
UN Commission on Science and Technology for Development (UN CSTD)	A broad variety of issues, including recent work advising improvements to the IGF	Subsidiary body of the UN Economic and Social Council (ECOSOC)	Governments, with multi-stakeholder participation

In summary, there are currently many means for governments, businesses, and civic society to shape the evolution of the Internet and online policies. Notably, the astounding success of the Internet is correlated with a governance centered on an inclusive multi-stakeholder model. A traditional regulatory regime similar to the one governing telecommunications (specifically in relation to interconnection between networks) has not been applied to the Internet, and radically changing course by applying such a regulatory model would lead to negative consequences for developing countries.

4.4.2 IP interconnection is not regulated

It is noteworthy that in spite of the fact that the Internet shares much of the infrastructure that is used for telephony in both the core and access networks, and indeed many operators provide both voice and data services, the regulatory approach is significantly and appropriately different. In many countries at least one telecom operator is designated as dominant, and is potentially subject to a number of possible retail and wholesale regulations, notably with respect to retail prices and interconnection. Further, even in countries with no dominant operator, telecom operators may still have the regulatory obligation to interconnect and are subject to related regulations with respect to non-discrimination. On the other hand, in almost all countries these regulatory obligations do not extend to ISPs, even with respect to interconnection obligations.

A significant reason for a different approach to the Internet is that, in contrast to telephony, the period of commercialization of the Internet coincided largely with the liberalization of the telecom market in many countries. As a result, there was typically no dominant Internet provider, and thus interconnection between competitive Internet providers was determined by commercial considerations. In particular, two forms of interconnection, peering and transit, emerged between and among ISPs, who provide access to end users, and Internet backbone providers, who provide core network services.

As a backbone provider's network consists of connections to its own customers (typically ISPs and large enterprises), in order to sell access to the entire Internet it must connect to other backbone providers. Providers of a similar size will typically enter in a bilateral relationship called *peering*, whereby each backbone exchanges traffic between its own customers and the customers of the other backbone. This is typically (but not always) settlement-free, meaning that neither backbone provider pays the other for the exchanged traffic. Therefore, a backbone provider will only enter into a peering relationship with another backbone when it is mutually beneficial, and many have developed and published criteria governing their peering decisions. In general, however, backbone providers seek an equal economic exchange through peering relationships that will provide balanced traffic delivery. Where there is an imbalance, such as regarding the ratio of traffic exchanged between providers, commercial flexibility should continue to prevail to allow peering agreements where payments are collected once certain thresholds are surpassed.

ISPs sell Internet access to residential end users and smaller enterprises. In order to offer their clients a global reach to the Internet, ISPs enter into a *transit* arrangement with a backbone provider. In return for transit fees, the backbone provides the ISP with access to the entire Internet, via its other transit customers as well the customers of other backbones with which it peers.

In the following, we provide two measures of the extent to which the unregulated commercial interconnection arrangements that support the expansion of the Internet continue to function well, showing no evidence of market failure or any other problem requiring change to these arrangements.

First, a recent study by the Packet-Clearing House analyzed 142,210 peering agreements. According to the study, "We collected our data by voluntary survey, distributed globally through all of the regional Network Operators Groups between October 2010 and March 2011. The responses we received represented 4,331 different ISP networks, or approximately 86% of the world's Internet carriers, incorporated in 96 countries, including all 34 OECD member countries and seven of the 48 UN Least Developed Countries."[13] The results of the survey showed that only 698 of the peering agreements were based on written contracts, representing just 0.49% of all the contracts.

In other words, the vast majority of current international and domestic peering agreements are not just commercially negotiated, but are not even formalized on paper. This is a significant difference from interconnection agreements between telecom operators, whose parameters are typically regulated with respect to a general obligation and non-discrimination requirements. Dominant telecom operators are often required to formalize their interconnection agreements into a Reference Interconnection Offer (RIO), which can be quite detailed. For instance, the RIO of the Saudi Telecom Company (STC), the Saudi incumbent, consists of a 39-page primary document with an additional nine annexes, covering a large range of topics, including services, operation, network design, billing, and prices.[14]

Second, as an indicator of how well this unregulated system works, in spite of the continual massive increases in demand and increased bandwidth of content, as documented above in Section 4.1, we note that transit prices have fallen significantly, demonstrating how competition and technical innovation have driven down costs. This is illustrated by Figure 4.25 below.

13 Source: "Survey of characteristics of Internet carrier interconnection agreements", Bill Woodcock & Vijay Adhikari, May 2011 (http://www.pch.net/docs/papers/peering-survey/PCH-Peering-Survey-2011.pdf).

14 See http://www.stc.com.sa/cws/portal/en/business/bus-wholesale/stc-lnd-whlslr-news_and_acti/stc-ref-iner-offer.

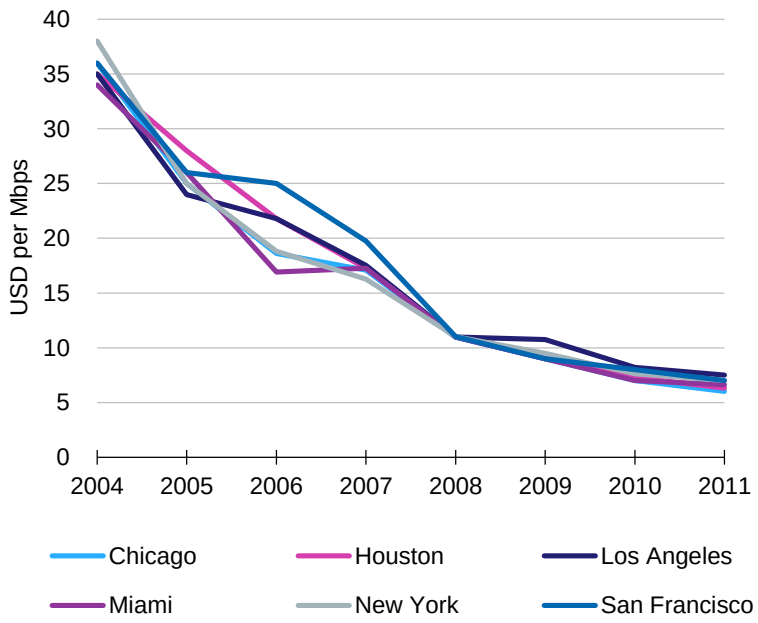


Figure 4.25: Median global transit prices per Mbit/s, Gigabit Ethernet [Source: Telegeography]

Since its commercialization, the Internet has shown phenomenal growth and has facilitated the numerous changes described above – notably the globalization of the Internet and the increase of new services such as video – in an unregulated framework. As discussed in the next section, any attempt to impose traditional telephone settlements on the Internet is likely to significantly impact the development of the Internet in the future.

4.5 Conclusion

In summary, the Internet has accommodated significant changes in traffic while market forces have driven globalization from its historical base in the US throughout the developed and now the developing world, largely based on mobile access. Against this backdrop, multi-stakeholder institutions ensure that technical standards are in place to address new network and user needs; that scarce resources are efficiently and fairly distributed; and that policy addresses traditional offline concerns, as well as emerging online concerns relating to the increasing reliance on the Internet as a platform for commerce, governance, and social life. At the same time, traditional interconnection regulations applied to telecom operators have not been applied to Internet providers, whose interactions are instead governed by commercial arrangements. We conclude that the Internet has grown so quickly and adapted to change so frequently *because* of, and not in spite of, this lack of traditional regulation. The Internet proposals that seek to alter the Internet's financial arrangements would likely result in less investment in infrastructure, increase cost to consumers, and less efficient routing of traffic.

5 The Internet and the international voice network have fundamental differences

The current International Telecommunication Regulations (ITR) treaty was developed at the 1988 World Administrative Telegraph and Telephone Conference.[15] Its purpose was to facilitate global interconnection and interoperability of international telecom networks, by establishing regulations for the international exchange of telecom traffic. The regulations, which have not been revised since then, address high-level issues such as charging and accounting, liability, and taxation. The treaty provided telecom carriers a baseline global framework to assist interconnection and establish procedures for the bilateral inter-carrier arrangements required for international voice traffic. In particular, Article Six of the ITR, entitled *Charging and Accounting*, provided the guidelines upon which the international accounting rate system is based.[16]

This international treaty was adopted in the pre-Internet and pre-liberalization era, when many telecom operators were state-owned monopolies. Specifically, it was adopted at a time when only three countries had introduced competition into the international telecom market: the UK (1984),[17] the US (1984),[18] and Japan (1985).[19] Moreover, only those three countries plus Chile,[20] Belize,[21] and Hong Kong had privatized their incumbents (all in 1988).[22] At this time (1988) the backbone of the Internet was not yet commercialized and had just been upgraded to only 1.5Mbit/s bandwidth, while the World Wide Web had not yet been invented.[23]

In this environment, with a limited and known set of international operators, almost exclusively owned by the very governments negotiating the ITRs, and very little Internet usage, the treaty could easily encompass all of international telecommunications and ensure that the operators offering international

15 See http://www.itu.int/osg/spu/stratpol/ITRs/mel-88-e.pdf.

16 See id., Article 6.

17 Source: 23rd Pacific Trade and Development Conference Business, Markets and Government in the Asia Pacific, 1996. See http://www.trp.trpc.com.hk/papers/1997/privtier_2004.pdf

18 Source: A short history of the telephone industry and regulation, 2002. See http://som.csudh.edu/cis/lpress/471/hout/telecomhistory/

19 Source: Economic Research Institute, "International Comparison of Privatization and Deregulation among the USA, the UK and Japan," December 1995. See http://www.esri.go.jp/jp/archive/bun/bun150/bun141a-e.pdf

20 Source: ITU "World Telecommunication Development Report," 2002. See http://www.itu.int/ITU-D/ict/publications/wtdr_02/material/WTDR02-Sum_E.pdf

21 Source: Diagonal areas in Latin America and the Caribbean. See http://www.eclac.cl/publicaciones/xml/2/11672/Chap3.pdf

22 Source: Evolution of The Telecommunications Industry, 2000. See http://www.telecomvisions.com/articles/pdf/FransmanTelecomsHistory.pdf

23 Source: Los Nettos "Los Nettos Regional Network - the T1 years." See http://www.ln.net/about/timeline/19881995.html

services could interconnect around the globe, and would get a share in the revenues for the resulting services.

In this section, after describing the architecture of the public switched telephone network (PSTN), upon which the ITR treaty is based, we show that the Internet is fundamentally different, making it significantly more difficult to apply any accounting rate regime. In Section 5, we then show how the PSTN architecture has changed since the ITR treaty was adopted, allowing for significant avoidance of settlements, and explain the implications of applying the accounting rate regime to the Internet where opportunities to avoid any settlements would be yet greater.

5.1 The international accounting rate regime and the PSTN architecture

5.1.1 Voice routing and charging

The international accounting rate regime is built upon the architecture of the PSTN at the time that the ITR treaty was adopted in 1988. The fundamental charging principle governing international voice calls at the retail level is calling-party-pays (CPP). Under CPP the calling party is charged for placing the call, while the recipient of the call is not charged for receiving the call. Meanwhile, the originating operator uses the collection charge to pay any wholesale rates, including for international transit and/or termination rates to the terminating operator. While competition has lowered the collection charge for international calls in many countries, there has been no change to this fundamental charging principle.

The ability to impose CPP is based on the routing of PSTN calls.

Traditional voice calls carried as circuit-switched TDM traffic involve the establishment of a dedicated and continuous communications channel (circuit) through the network between the origination and termination end-points, which remains open for the duration of the call. The result is that traffic between the end points can be measured and billed by highly developed and expensive circuit switches. Because of the detailed information about each call collected and recorded by these switches, the retail or collection charge can be based on a variety of factors, including the destination of the call, its duration, and often the day and time that the call was made.

The ability to measure and bill minutes is the foundation for the accounting rate regime

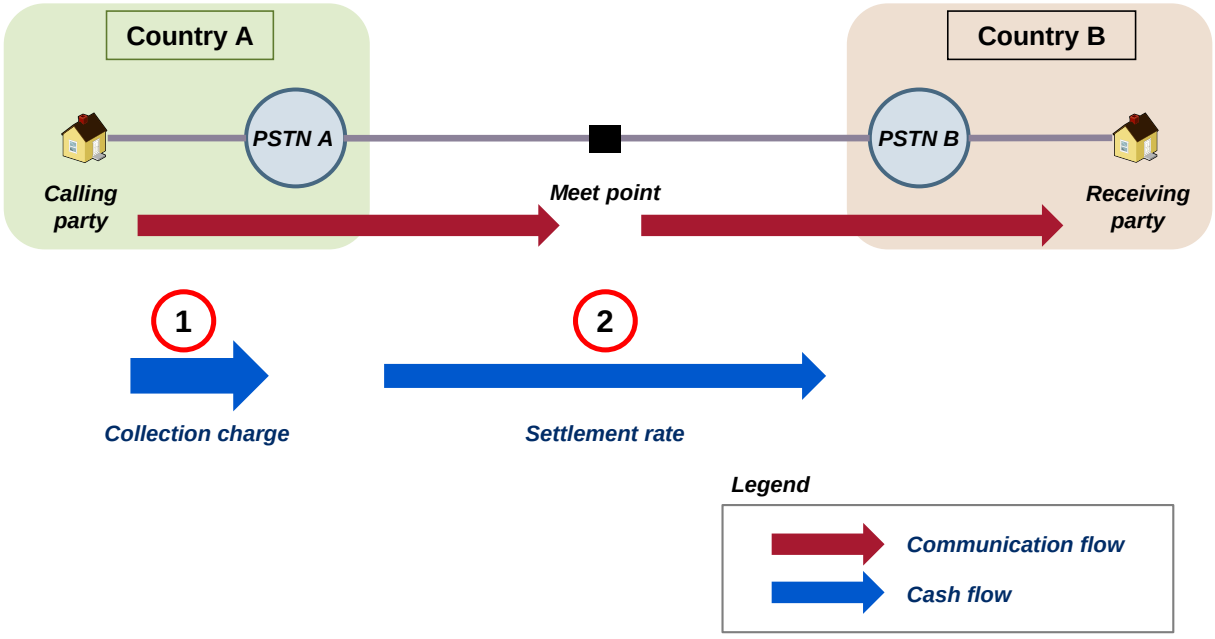
The accounting rate regime imposes settlements on calling minutes between countries. Without the ability to track calling minutes and attribute them to operators at either end of the call, it would not be possible to impose settlements, as we will see in the next section.

Below, in Section 4.3, we will contrast the basis for imposing CPP on the routing of PSTN calls, with the challenge and risk of imposing a similar model on the sending of Internet traffic.

5.1.2 The international accounting rate regime

The global telecom network is created by interconnection between international operators, in which international calls involve at least two networks for the completion of the call. The figure below illustrates the operational and financial relationships under the accounting rate regime, when an end user in Country A is making a voice call to another end user in Country B.

Figure 5.1: Illustrative typical traffic flow and settlement flow for traditional voice traffic between two countries [Source: Analysys Mason, 2012]



As illustrated in this diagram, for each call:

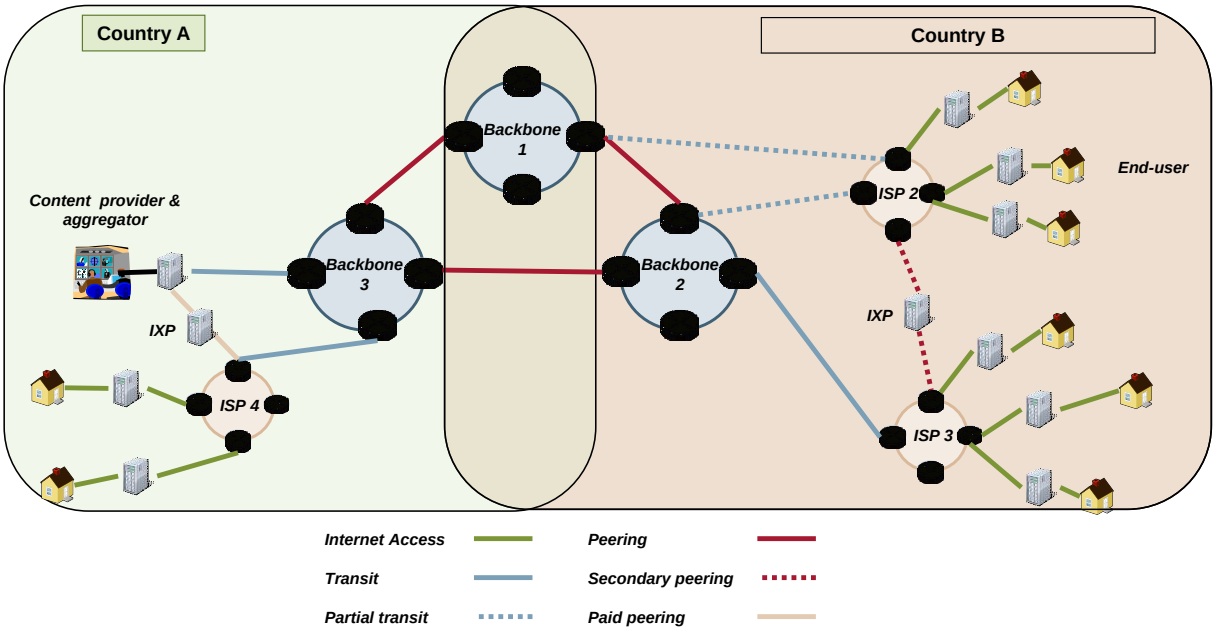
- The originating telecom carrier (PSTN A) charges end users the retail price, known as the *collection charge* (1). This charge covers the costs of carrying the traffic from the end user to the international meet-point.
- Under the CPP arrangement, the terminating carrier (PSTN B) does not charge its end user for receiving the call. Instead, PSTN B charges the international carrier a wholesale price, known as the *settlement rate*, for terminating the call from the international meet point to the end user in Country B (2). This rate is half of the negotiated *accounting rate*.
- This model allows the two operators to agree on the termination of incoming traffic in their respective countries based on the assumption that all international circuits are jointly owned by these carriers on either side of a meeting point halfway between the countries, and that the costs on either end are symmetrical, with the payments to each operator based on the number of out-of-balance calls and the settlement rate.

This regime was designed in the context of simple relationships between incumbent monopoly operators, where settlements between them could be paid based on out-of-balance minutes, in accordance with bilateral arrangements, including operators sharing the cost of the international circuits equally. However, as described below, the assumptions that form the basis of the system have become largely inapplicable to voice traffic arrangements in today's international telecom marketplace, and have never applied to the Internet.

5.2 Differences between the PSTN and the Internet

There are a number of significant differences between the voice and Internet architectures, which would make it difficult to implement any CPP-based accounting rate regime on the Internet, and simultaneously make it easy to arbitrage any resulting regime. In particular, in comparison to the relatively simple architecture governing traditional voice traffic when the ITR treaty was updated in 1988 (illustrated in Figure 5.1 above), the Internet architecture is much more distributed, as seen in the following figure.

Figure 5.2: Illustrative Internet architecture [Source: Analysys Mason, 2012]



As seen even in this simplified example, content that is routed from Country A to Country B can pass through a number of interconnections between operators, including peering and transit connections and variations thereof, while also potentially passing through multi-national operators operating in both countries and possibly originating from a third country. This significantly complicates the administration of any accounting rate regime. Overall, the differences between international PSTN and the Internet relate to the routing of Internet traffic, and payments for the traffic.

Unlike traditional voice, which is based on circuit-switching, Internet traffic is based on packet switching

Packet-switching divides the data into IP packets that are transmitted through the network independently, meaning that different parts of the same transmission can take many different routes from origination to destination. This is accomplished by having each router along the path choose the path along which to forward the packets closer to the destination, with no regard to the point of origination. Further, as discussed below, individual transmissions are not metered. This means that there would be significant technical challenges in attempting to subject that traffic to any accounting rate regime.

Charging principles for the Internet are also fundamentally different from voice

Typically, end users pay a flat fee for Internet access, which depends on the speed of the connection and sometimes a fee based on the amount of traffic used. However, neither the access fee nor any volume-based fee depend on the destination or origination point of the traffic generated by the end user, nor typically the date and time that the traffic is generated. Adding any such considerations would represent a serious departure from the status quo, and if it was even feasible it would reduce consumers' interest in accessing data from expensive locations – which could include the locations of operators to which their provider pays settlement rates.

At the wholesale level, all Internet traffic is routed network-to-network rather than country-to- country

Many networks are multinational: each backbone provider or ISP must bring its traffic to a designated point of presence to exchange traffic with another network or networks, and that designated place may not be within the same country. At that point, the traffic is exchanged in bilateral transit or peering arrangements which are commercially negotiated between the parties. Transit arrangements depend on the volume of traffic delivered, but not on the country destination of the traffic. Peering arrangements also depend on the amount of traffic exchanged, and as long as it is mutually beneficial can involve national, regional, or global traffic. In no case is traffic metered by individual transmission, which is the basis for the international voice system.

A final significant difference from the PSTN results from the interactive nature of the Internet

For the PSTN, the direction of the telephone call determines the direction of the wholesale call termination payment. But because Internet users can cause traffic to move to or from their home country, the direction of Internet traffic provides a much less reliable basis on which to determine who should pay the cost of users' activities on the Internet. For example, an Internet user in Country A may send a video to another user in Country B, and thus the user in Country A initiated the transmission. Alternatively, a user in Country B may download a video from a server in Country A, and thus the user in Country B initiated the transmission. However, it is technically difficult to determine whether the video transmission was 'pushed' or 'pulled' from Country A to B, and thus, from the

point of view of applying settlements, the same charge would have to be applied regardless of who initiated the transmission.

These differences from the voice system make it very difficult – both conceptually and technically – to impose any form of settlements on international Internet traffic. In particular, a number of issues would need to be addressed, including the following:

- Internet traffic is not easily measured or billed, as it is in telephony. As there is no dedicated circuit for an Internet transmission, it is difficult to measure how much of the traffic that entered one country originated from any other country, and any such measurement would likely involve significant difficulty and added cost. In addition, it is not clear what form an accounting rate regime would take: Would it be bilateral, between different countries and only covering traffic between those countries; multilateral, between all countries; or unilateral, only covering transmissions to certain countries?
- Further, the origination point for up to 98% of Internet traffic is not set, and thus content can move quickly to avoid settlement rates. The likely result, whereby content moves to the lowest-cost country of origination (described below), would lead to disputes over the 'true' point of origination, and the resulting settlement rates. Put differently, if a YouTube video is loaded into the cloud in the US, and then stored in a server in the UK, from which it is saved in a cache in South Africa and then sent to Botswana, what would be the applicable settlement fee – that from South Africa, the UK, or the US?
- In addition, even if the origination point of the traffic can be determined, it is difficult to ascribe value to an Internet transmission, because of the aforementioned difficulty in determining who initiated a transmission, and for that matter, the significance of having initiated a transmission. For instance, if a user purchases and downloads a video, which party would be responsible for the resulting settlement: the buyer who initiated the transaction, or the seller who sent the video? This differs from telephony, where the principle for international calls is that the caller who initiated the call generally pays for it, while exceptions such as collect calls are clearly identifiable.
- Finally, the Internet starts from a base of competition, rather than monopoly, and this is reflected in pricing and other commercial arrangements. In addition to the general benefits of competition, which are already delivering infrastructure and growth around the world, competition makes settlements more difficult to impose. For instance, would accounting rates cover peering relationships, which are typically settlement-free, and often informal arrangements with no contract? Or would settlements only be imposed on transit relationships? The inevitable disputes would also need to be resolved. Among other impacts, this would likely end the current simplicity in which over 99% of peering arrangements are not even formalized in a written contract.[24]

[24] See Section 4.4.2.

There are a number of questions that would need to be resolved in order to impose any accounting rate regime, and given the complexity of the Internet in comparison to the PSTN in 1988, it may not be possible to resolve these questions, at least without adding enormous costs to the price of transmission and thereby transforming the Internet into a very different service. In particular, given the number and variety of providers in the competitive market, the cost and complexity of imposing settlements would increase, as a system must be imposed to collect and distribute the settlements between providers. Further, efforts to impose any technology needed to accomplish traffic measurement and billing may add significant overheads, and possibly also restrict the flexibility that gives the Internet its resilience. Finally, once imposed the system would have an impact on the development of the Internet, as described in the next section.

5.3 Conclusion

The international telecom system of 1988 was able to accommodate accounting rates, which were relevant in the pre-Internet and pre-liberalization era where nearly all telecom operators were state-owned monopolies, and network switches were developed so that voice minutes could be measured and then billed directly to end users. The ITR treaty ensured that telecom operators could interconnect around the globe, and would get a fair share of revenues for the resulting services. On the other hand, we conclude that the Internet presents significant difficulties because of the nature of its traffic and billing arrangements. In particular, there are significant differences between circuit-switched telecommunications and packet-switched Internet, which make applying any form of the ITU accounting regime to the Internet much more problematic. Nor is such a move necessary: we have seen that the Internet is working and there is not a market failure that needs to be addressed with regulation, unlike the situation that was addressed in 1988 when the accounting rate regime was implemented to govern interconnection between monopoly telecom operators.

The differences between voice and Internet traffic can be summarized as follows; each of these differences highlights the fundamental challenge of attempting to retrofit modern Internet commercial charging arrangements with legacy voice accounting rate arrangements.

Figure 5.3: Differences between voice and Internet traffic [Source: Analysys Mason, 2012]

Characteristic	Telephony	Internet
Traffic origination	An international call must originate with a caller in one country and terminate with a caller in another country (regardless of routing)	Approx. 98% of Internet traffic (video, file transfers, etc.) can be stored in multiple locations and thus can move and originate from servers in multiple alternative countries
Routing	Telephone calls are routed over a dedicated circuit between end-points, which enables a call to be measured and billed	IP routes packets independently, based on the destination, and thus the ability to measure traffic depends on where it is measured

Characteristic	Telephony	Internet
Payment regimes	Traditionally, calling party pays (CPP), with the originating network paying settlements to the terminating network and any transit fees to intermediate networks	End users typically pay a flat fee based on bandwidth and possibly usage; ISPs may pay transit based on capacity, or use settlement-free peering
Value	It is easy to determine who initiated a calls, and well accepted that the caller pays for the call, and the calling network pays settlements to the terminating network	It is harder to determine who initiated a transmission, and even then it is not conceptually clear who should be responsible for paying any resulting settlements on the traffic
Billing	Billing is per minute, based on (a) the origination and termination point of the call (including whether the call went to a mobile); and (b) the time and day that the call was made	Billing is typically based on capacity rather than traffic quantity; billing is not based on where the traffic originated or terminated or on the time or day of the transmission

In particular, the different routing of Internet traffic makes the traditional accounting rate regime an inappropriate compensation mechanism for Internet traffic. Traditional voice calls carried as circuit-switched TDM traffic involve the establishment of a dedicated and continuous communications channel (circuit) through the network between the two end-points that remains open for the duration of the call. The accounting rate regime is based on the assumption that the international circuits used to provide the dedicated channel used for a voice call are jointly owned by the carriers at each end of the international route and that the costs at each end are approximately symmetrical. Thus, the settlements to compensate these operators for the costs of terminating these calls are determined by the number of conversation minutes sent in each direction.

But since Internet traffic transmission does not use any dedicated connection, and is instead based on packet switching which sends data through the network in the form of multiple IP packets that can take many different non-dedicated paths from origination to destination, where even the exchange point can vary, the bilateral cost-sharing assumptions that underlie the accounting rate regime have little relevance in this different context.

There have been significant changes in telecommunications, including the introduction of competition, private data networks, and voice over IP, which have put the accounting rate regime under significant stress, as shown in the next section. Given the differences in architecture, applying any form of settlements to the Internet would be even more difficult, and would have the potential to harm the successful Internet model that continues to expand and adapt through the operation of market forces.

6 The Internet model will continue to thrive in a commercially driven environment

We have argued that any attempt to bring the Internet under the ITU accounting rate regime ignores the success and evolution of the Internet to-date based on market-based interconnection. In this section we now describe how the accounting rate regime is increasingly difficult to impose even on telephony – which is more amenable to the imposition of settlements – due to a number of changes, and then describe how it would be yet more difficult to apply to the Internet.

6.1 Changes to the PSTN since 1988

The ITU accounting rate regime was designed when the vast majority of operators were state-owned monopolies, data networking was much less prevalent, and VoIP did not exist. Since 1988, telecom liberalization and privatization, technological change, and new services – including the growth of the Internet – have led to a very large portion of international voice traffic avoiding the payment of settlement rates altogether, and have greatly reduced the level of settlement rates in virtually all countries. For example:

- The introduction of competition in some countries led to lower collection rates in those countries. Call-back services then developed to allow consumers in other countries to make calls at those lower rates.

- The widespread use of international private leased circuits (IPLCs) led to efforts to reroute traffic using international simple resale (ISR), thereby lowering settlement payments. The advent of telecom competition and liberalization also allowed telecom operators to have end-to-end ownership of international circuits, and to terminate traffic through domestic interconnection arrangements in foreign countries.

- The use of "least cost routing" (also known as hubbing, refile or reorigination) became widespread – an arrangement under which international calls are sent via third-country carriers that offer the lowest termination rates to the destination country. This is available from a large number of wholesale carriers as well as through on-line, real-time spot markets, such as Arbinet, which allow carriers to deliver outbound traffic to New York Los Angeles, London and Hong Kong for world-wide termination at current market rates. TeleGeography estimates that in 2010, 61% of international voice traffic was terminated via the international wholesale market.

- VoIP led to bypass of settlements by allowing calls to be sent over the Internet to destination countries where they are terminated as local calls. TeleGeography reports that in 2011, 28% of international traffic was terminated via VoIP arrangements.

- Even where international voice traffic is still terminated through bilaterally negotiated arrangements between telecom operators at each end of the international route, those arrangements rarely follow the traditional international accounting rate regime, under which each operator pays a settlement rate comprising *half* the agreed accounting rate. Instead, the rates at each end of international routes are frequently asymmetric, reflecting the different market circumstances in each country. Less than 2% of the international voice traffic of US operators, for example, is now terminated under traditional settlements arrangements.[25]

As a result of these changes, the traditional international accounting rate regime, and its underlying assumptions regarding the use of jointly owned circuits and symmetrical costs recompensed by an equal settlement rate paid at each end of the route, is no longer relevant to most international voice traffic. Instead, virtually all international voice traffic is now subject to market-based termination rates that in competitive markets are often similar to the termination rates paid for domestic voice traffic, while the international circuits used to transport this traffic are often owned end-to-end by a single operator.

As a technical matter it is already more difficult to apply a settlement regime to the Internet than it is to voice, and that is before the inevitable commercial reactions to any such regime by affected providers. Based on experience in both national and international telephony, any attempt to impose settlements would lead some providers to take actions to lower their settlement fees, while others would take actions to increase their settlement earnings – these actions would not help to increase Internet access and usage, but instead would be likely to hamper the growth of the Internet. This could have a particularly harmful effect on developing countries. We examine these issues in the next section.

6.2 Application to the Internet

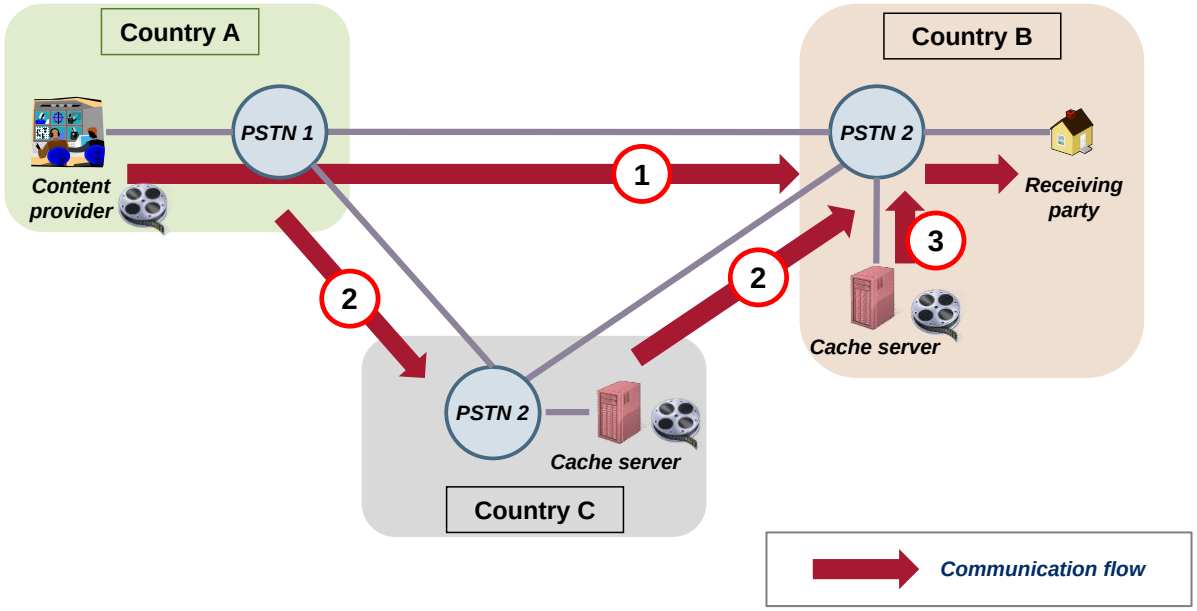
Overall, as described earlier, imposing a settlement regime on the Internet is likely to be complicated and costly to do, given the inherent architecture of the Internet and the dynamic industry structure. Further, the result would be to impose artificial restrictions on traffic flows, inducing providers to consider the accounting rate regime when they decide where to locate web servers, content, and ultimately infrastructure.

25 Source: International Settlements Policy Reform, 26 FCC Rcd. 7233, para. 6, 2011 (Note: only 38 US international routes, constituting just 1.8% of total US international minutes, remain subject to the FCC's international settlements policy).

Replacing the current peering and transit arrangements, which do not vary by destination country, with destination-country-specific settlement payments would probably require the introduction of destination-country-specific end-user fees for Internet access, similar to end-user fees for international voice calls, in place of the flat fees for Internet access that end users pay today. Otherwise, providers could readily incur liability for settlement payments for which they did not receive sufficient compensation from end users. Any such development would require extensive user-metering and billing systems similar to those used for telephone traffic, and could effectively end browsing practices as they exist today. With the advent of "per click" charges, and because no user could be certain that any unfamiliar website was not located in a high-cost destination that would result in high charges, there would likely be a significant reduction in Internet usage and the curtailing of many of the benefits brought by the Internet over the past 20 years.

As with international voice traffic, Internet traffic flows would be likely to change in response to the introduction of any accounting rate regime, as ISPs, backbone providers and content providers sought to avoid outbound payments and increase inbound payments. The Internet provides far greater potential opportunity to engage in such activities than the voice system: for example, while it is possible to change the route, and protocol, of voice calls to reduce or avoid settlements (as discussed in the previous section), it is not possible to change the intrinsic principle that voice traffic between two countries must originate with a caller in one country and terminate with a caller in the other country. In contrast, the vast majority of Internet traffic consists of data traffic that is intrinsically portable. As a result, a significant portion of international Internet traffic can be rerouted or transformed into domestic or regional traffic. The diagram below illustrates the possibility of different origination points for Internet traffic. An Internet user in Country B may download a video from the original server in Country A (1), from a cache server in Country C (2), or from the one localized in Country B (3).

Figure 6.1: Illustrative diagram of possibilities for origination point for Internet content [Source: Analysys Mason, 2012]



Thus, the introduction of an accounting rate regime for Internet traffic would surely impact the routing of traffic, depending on the economic incentives created by the new regime. Potential impacts include the following:

- First, operators might be induced to maintain their customers' websites abroad. One of the significant benefits of establishing an IXP is to make it attractive for domestic websites to 'return' and be hosted at home, in order to increase their performance and lower costs. However, given that foreign websites will generate a source of incoming settlements, the incentive to keep them abroad would increase.
- At the same time, foreign operators, in order to compensate for the settlements, would likely raise the price of hosting websites serving countries with high settlement rates, which might lead websites to develop less content targeted at a particular country in order to limit their costs. While this could be seen to increase the incentives to locate content in the target country in order to avoid settlements, that is often not efficient, particularly for small or undeveloped markets from which access to a regional server may be sufficient.
- In addition, it is likely that infrastructure investment decisions would be impacted, as providers would be reluctant to invest in providing infrastructure to a particular country to which it is expensive to deliver traffic. With respect to developing countries with infrastructure needs, while investment is currently strong (as detailed above), the situation is fluid and the new regime might result in less international capacity being built to countries where settlements would have to be paid on the resulting traffic, thus limiting traffic and growth.

- A final significant concern is the possibility that huge volumes of Internet traffic could be artificially generated in order to arbitrage a rate-regulated model, to generate inbound payments, alter traffic balances, or otherwise unfairly leverage any accounting rate regime that may be applied to the Internet. IP-based technologies would facilitate such conduct to a far greater extent than the circuit-switched voice system. As a result, entities that believe they would be net recipients of settlements, based on current projections of traffic flows, might find themselves net payers as a result of the manipulation of traffic flows by other players.

In summary, aside from the intrinsic difficulties of successfully imposing regulations on international flows of Internet traffic, there could be unintended consequences that would harm the internet if such a system were imposed. These could include fraudulent actions to inflate termination revenues, avoidance of serving markets with high fees, and discouragement of investment in facilities.

7 Recommendations for expanding the growth of the Internet in developing countries

Instead of imposing the international settlement structure – which is increasingly difficult to maintain even for voice – on the Internet, policies could focus directly on developing a robust Internet ecosystem in target countries. This requires, as a prerequisite, widespread Internet access, which in turn requires investment in network infrastructure, from international connectivity through Internet access; based on experience, this is best encouraged within a market-driven regime. In addition, the health of the ecosystem improves with increased demand for services.

7.1 Promoting network infrastructure

While it is true that investments are already flowing into the telecom networks in developing countries, as discussed above, additional investment can further increase the health of the ecosystem.

- *Mobile broadband access* – The cost of deploying mobile access networks is clearly lower than fixed access, and the lower economies of scale support multiple competing networks. However, regulators can further reduce deployment costs by removing roadblocks such as high permit costs for towers; increasing access to key spectrum bands; and also allowing operators to share passive infrastructure, including towers and backhaul.
- *National backbones* – There is limited supplier choice in some countries, forcing competing operators to purchase access at above-cost prices. For instance, a recent World Bank report[26] observes that in Africa, "governments continue to constrain investment in this area either through the outright support or control of a monopolistic operator or through regulatory and licensing restrictions that make it unprofitable for companies to develop backbone networks. Yet competition is feasible and profitable here, too, as evident in countries—such as Kenya, Nigeria, and Sudan—where backbone operators have been allowed entry and have established networks." As discussed below, liberalization and allowing foreign investment can improve national backbone coverage.
- *Cross-border connections* – Difficulties in connecting data networks across borders and restrictive landing station regulation keep the costs of international connectivity high in some countries, preventing all operators from benefiting from the new submarine cables. For example, the same World Bank report states that in Zambia, "at the end of 2009 the international facilities segment of the market was, in theory, open to competition, but the price of an international voice gateway license was as high as $12 million. In contrast, a public infrastructure provider license has a one-

[26] Source: Africa's ICT infrastructure, "Building on the Mobile Revolution", Mark D. J. Williams, Rebecca Mayer, and Michael Minges, The World Bank, 2011

time entry fee of just $100,000 in Uganda. This explains why, by 2009, a competitive international services market had developed in Uganda whereas in Zambia, there was still only one international gateway operator—the state-owned Zambia Telecommunications Company Ltd. (Zamtel)."[27] In addition to liberalization, removal of roadblocks such as license fees can increase investment.

- *Internet Exchange Points* – A lack of local hubs in many countries maintains inefficient and costly routing of traffic, and reduces the overall transmission quality, according to a recent Internet Society paper on the benefits of IXPs in emerging markets (Kenya and Nigeria).[28] Such hubs, when established, not only host content locally, significantly lowering the cost of delivering high-bandwidth video and promoting the development of locally created content – but also lower the latency of connections, facilitating VoIP and other latency-sensitive services. Regulators should remove roadblocks to the establishment of IXPs, such as any licensing requirements.

Two sets of overlapping actions can help increase investment in the network: (1) general liberalization of telecommunications, and (2) the removal of barriers to foreign investment and ownership. We discuss these below.

7.1.1 Telecoms liberalization

As demonstrated in numerous studies, establishing policies that focus on increasing the level of competition in the telecom market is a prerequisite for developing information societies, and plays a key role in attracting sustainable investment into the ICT sector. Telecoms liberalization brings advantages through different mechanisms:

Liberalization stimulates the provision of high-quality and low-cost communications, and the spread of ICT

As explained in two World Bank reports, "by opening their communications markets through well-designed reforms, governments can create competitive markets that grow faster, lower costs, facilitate innovation and respond better to user needs".[29] Also, "the introduction of competition in international communications lowers the input costs for firms (lower cost of international calls, access to global data networks), and spurs productivity gains (better integration in the client-supplier chain). These two factors improve the competitiveness of export-oriented forms and stimulate economic growth."[30]

27 Source: Africa's ICT infrastructure, "Building on the Mobile Revolution", Mark D. J. Williams, Rebecca Mayer, and Michael Minges, The World Bank, 2011

28 Source: Assessment of the impact of Internet Exchange Points – empirical study of Kenya and Nigeria, Analysys Mason, April 2012 (http://www.internetsociety.org/ixpimpact)

29 Source: Information and Communications for Development, Global trends and policies, the International Bank for Reconstruction and Development / The World Bank, 2006

30 Source: Competition in international voice communications, Report No. 27671, The World Bank, Policy division, Global ICT department, January 2004

Liberalization encourages investments in network infrastructures, creating new business development opportunities

As mentioned in another World Bank report, "the first step [in extending communication and information services] is to allow markets to work. Competitive, private-led markets go a long way toward making communication and information services available to the entire population. Reforms in the telecommunication sector open the way."[31] Additionally, "there is plentiful evidence that countries that have introduced private competition under capable regulators have seen faster rollout of services and lower costs. Independent regulation and competition together raise private investment by 50 percent. In turn, private investment is related to higher teledensities and greater efficiency in the sector. Competition can also reduce prices by as much as 20 percent. Regarding the Internet and e-commerce, cross-country studies strongly suggest that rollout of affordable infrastructure is the most important factor, after income per capita, in explaining take-up."[32]

Liberalization increases the efficiency of incumbent carriers

Conversely to the generally accepted idea, telecom liberalization is not necessarily a threat to incumbent carriers, and in the long term liberalization can actually increase their efficiency. As described in another World Bank report, "the desire to protect the incumbent operator is commonly cited as a reason for governments' reluctance to introduce competition in international voice communications […] However, international experience shows that incumbent operators can adapt, successfully, to the changed conditions in the telecom market following the introduction of competition in international voice communications."[33] For instance, in the UK and in Malaysia, "competitive pressures in international voice communications created incentives for both [BT and Telekom Malaysia] to launch new services. This benefited the consumer as well as the financial health of the companies and countries. Both operators were able to safely maintain financial profitability, and the states were able to collect additional revenue."[34]

Additionally, "privatization of the incumbent (usually fixed-line) telephone company into a competitive regime contributes to leveling the playing field for competitors, redirects government efforts towards policy and regulation, increases the efficiency of a major operator, and provides additional revenue

31 Source: Information and Communications for Development, Global trends and policies, the International Bank for Reconstruction and Development / The World Bank, 2006

32 Source: Financing Information and Communication Infrastructure in the Developing World, World Bank Working Paper No. 65, 2005

33 Source: Competition in international voice communications, Report No. 27671, The World Bank, Policy division, Global ICT department, January 2004

34 Source: Competition in international voice communications, Report No. 27671, The World Bank, Policy division, Global ICT department, January 2004

for private financing of investment."[35] "Countries with greater private involvement in the incumbent […] see higher rollout of services, more efficiency, and higher investment flows."[36] Lastly, "because of their strong cash flows and good business fundamentals, incumbent carriers are often very attractive to financial investors."[37]

7.1.2 Removal of barriers to Foreign Direct Investments (FDI) and foreign ownership

Lowering barriers to foreign direct investment (FDI) can also increase investment and competition in the telecom market. In particular, it has been shown that:

Removing restrictions on FDI increases the competitiveness of both incumbents and new entrants

Removing restrictions on FDI reduces the cost of capital and stimulates improvements in management and technology, for both incumbents and new entrants. In fact, "since 1997, many countries making GATS commitments in telecom services have experienced more rapid growth in fixed line penetration, mobile subscribers and telecom-sector revenues than their similarly-situated neighbors."[38] Further, "restrictions on foreign investment […] limit the abilities of local companies to be effective participants in global telecom alliances. This in turn limits the ability for strategic equity investments, sharing of technologies and know-how, and the economic scope and scale that often accompanies these alliances." FDI restrictions "have a negative effect on both the ability to gain access to capital, and the cost of what is available, particularly for smaller and newer players in the telecom sector."[39]

Removing restrictions on FDI generates investments flows into the ICT sector

According to the World Bank, "in an industry as capital-intensive as telecom, access to capital is key to ensuring the deployment and expansion of a robust network." FDI has "typically been the driver of sector growth in liberalizing countries" and has brought "new management approaches, technology, and skills transfer to the host countries. […] As the market grows, becomes more competitive, and matures, private domestic investment follows and often overtakes FDI."[40]

35 Source: Financing Information and Communication Infrastructure in the Developing World, World Bank Working Paper No. 65, 2005.

36 Source: Financing Information and Communication Infrastructure in the Developing World, World Bank Working Paper No. 65, 2005.

37 Source: Information and Communications for Development, Global trends and policies, the International Bank for Reconstruction and Development / The World Bank, 2006.

38 Source: Telecommunications Trade Liberalisation and the WTO, 7 Info 3, Bressie, Kende & Williams, 2005.

39 Source: Capital Flows and Cost of Capital: The Importance of Liberalized Investment Rules for a Competitive Telecommunications Sector, Procter & Olivier, 2002.

40 Source: Information and Communications for Development, Global trends and policies, the International Bank for Reconstruction and Development / The World Bank, 2006.

> Moreover, according to the same report, "governments have realized that any restrictions they place on investment (be it foreign or domestic) raises the cost of financing (and ultimately of services), thus making investment less likely. […] In most cases, foreign ownership restrictions limit takeover risk and hence management accountability, and reduce investment incentives, thereby inhibiting effective, profit-oriented management. […] Policy makers in developing countries should further reduce foreign ownership restrictions in the telecom sector to reap the benefits FDI brings in terms of lower cost of capital and higher productivity, coverage, and quality of services."

Countries can achieve lower barriers to FDI as an internal policy change to achieve these and other goals, as well as part of external WTO (World Trade Organization) commitments.

7.2 Policies to increase demand

In addition to promoting investment in network infrastructure, other policies can help to promote key aspects of developing a robust Internet ecosystem.

- *Content providers* – Content is critical to demand for Internet access. Actions can be taken to help attract content providers, who are also key tenants for building up a local IXP. General actions include making it easier to establish a business presence in a country, while more specific actions include minimizing the restrictions on content, and ensuring clear and reasonable rules limiting the liability of intermediaries. Additionally, the generation of local content is particularly important for countries where English is not widely understood, in order to help promote the use of the Internet and of the domestic IXP.

- *Government applications* – Governments can also act to increase demand for Internet access by introducing their own online applications. In addition, government servers can act as an important 'anchor tenant' for a domestic IXP. For instance, the Kenya Revenue Authority (KRA) takes advantage of the Kenya IXP (KIXP) to gather tax revenues; in turn, access to the KRA's servers is an important driver for ISPs to become members of the KIXP.[41]

- *Equipment costs* – The cost of broadband equipment such as PCs, tablets or smartphones is in unaffordable for average households in many low-income countries, and remains a barrier to Internet service adoption. While many of these costs reflect the international cost of equipment,

[41] See: Assessment of the impact of Internet Exchange Points – empirical study of Kenya and Nigeria, Analysys Mason, April 2012 (http://www.internetsociety.org/ixpimpact).

governments often impose significant taxes on equipment such as handsets that increase their overall cost.[42]

7.3 Conclusion

In conclusion, we would note in particular that all of the actions described above address issues that the application of the settlement regime on the Internet would not address. In particular, Internet services and applications will continue to increase in bandwidth and/or become more sensitive to latency, and this must be addressed by increasing national connectivity, and providing more local and regional hubs to store traffic. Shifting costs for international transit is unpractical and may serve to reduce investment. Even in the best case, however, the settlements are not directly targeted towards promoting investment in national infrastructure and hubs, nor to stimulating demand for Internet services, and thus there is no assurance this will take place.

[42] See: Global Industry Leaders' forum, Discussion Paper, Taxing telecommunications/ICT services: an overview (Draft paper), ITU, 2011.

8 Conclusion

This paper demonstrates that any adaption of the accounting rate regime to the Internet is not only unnecessary, but could harm the development of the Internet in developing countries. There is a significant amount of evidence that the Internet model is working well today. The Internet has evolved in several important ways over the past decade: content has evolved from relatively static text and web pages to multimedia high-bandwidth content with requirements for low latency; usage has rapidly globalized from an initial base in developed countries; and access has shifted from fixed to mobile devices. In response, the architecture of the Internet has adapted in order to address the challenges from the new traffic, as content has become more portable and IXPs have developed to host and distribute this content.

The same market forces that have promoted the development of the Internet in developed countries are now at work in the developing world. For instance, according to TeleGeography, the amount of international Internet bandwidth serving African countries has increased from 1.21 Gbit/s in 2001 to 570.92 Gbit/s by 2011, as a result of a number of new and competing submarine cables that began service in 2010. Further investments have taken place to deliver traffic within and between African countries, to provide regional IXPs where traffic can be exchanged and content can be accessed, and to deploy mobile broadband networks to deliver Internet access to end users.

While the growth in the importance of the Internet has led to a greater focus on Internet governance, one constant factor throughout the evolution of the Internet has been that the expansion of its underlying infrastructure, and the interconnection between networks, has been governed by market forces rather than government regulation. The enduring reliance on commercially negotiated interconnection arrangements has led to the growth of Internet traffic through Europe and Asia, and more recently developing countries, as increased connectivity is followed by IXPs facilitating local exchange and delivery of content.

The international accounting rate regime developed in 1988 was adapted to the international telecom system of the pre-Internet and pre-liberalization era, where many telecom operators were state-owned monopolies and voice minutes could easily be measured and billed. However, there are significant differences between circuit-switched telecommunications and packet-switched Internet traffic, which make applying any form of the ITU accounting regime to the Internet much more problematic than it already is to apply to telephony.

In particular, the different routing of Internet traffic makes the traditional accounting rate regime an inappropriate compensation mechanism. Traditional voice calls carried as circuit-switched TDM traffic involve the establishment of a dedicated and continuous communications channel (circuit) through the network between the two end-points that remains open for the duration of the call. The

settlements payments to compensate operators for the costs of terminating these calls are determined by the number of conversation minutes sent in each direction. But since Internet traffic transmission does not use any dedicated connection and is instead based on packet switching – which sends data through the network in the form of multiple IP packets that can take many different non-dedicated paths from origination to destination – the bilateral cost-sharing assumptions that underlie the accounting rate regime have little relevance in this different context.

As telecom markets have liberalized, the traditional international accounting rate regime and its underlying assumptions regarding the use of jointly owned circuits and symmetrical costs recompensed by an equal settlement rate paid at each end of the route, is no longer relevant even to the great majority of international voice traffic. Operators are able to reduce the amount of traffic subject to settlements, and the remaining international voice traffic is now subject to market-based termination rates that in competitive markets are often similar to the termination rates paid for domestic voice traffic.

As with international voice traffic, Internet traffic flows would likely change in response to the introduction of any accounting rate regime, as providers sought to avoid outbound payments and increase inbound payments. The Internet provides far greater opportunities to engage in such activities than the voice system: for example, much Internet content is portable, and could move between countries in response to any asymmetric termination rates. As a result, there could be unintended consequences that could harm the Internet if such a system were imposed. These could include fraudulent actions to inflate termination revenues, avoidance of serving markets with high fees, and discouragement of investment in facilities. The results could disproportionately impact infrastructure investment in those countries that impose the highest settlement fees.

Instead of imposing this international settlement structure – which is increasingly difficult to maintain even for voice – on the Internet, policies could focus directly on developing a robust Internet ecosystem. This requires as a prerequisite widespread Internet access, which in turn requires investment in network infrastructure, from international connectivity through Internet access. Actions could include removing roadblocks to investment, including any restrictions on foreign investments; further liberalization of telecom markets; and promoting domestic demand for Internet services.

These solutions would address issues that the application of the settlement regime on the Internet would not address. In particular, Internet services and applications will continue to increase in bandwidth and/or become more sensitive to latency, and this must be addressed by increasing national connectivity and providing more local and regional hubs to store traffic. Shifting costs for international transit is unpractical and may serve to reduce investment. Even in the best case, however, the settlements are not directly targeted towards promoting investment in national infrastructure and hubs, nor to stimulate demand for Internet services, and thus there is no assurance this will take place.

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About the author

Michael Kende, Partner at Analysys Mason

Michael Kende is a partner and co-head of the policy and regulation division at Analysys Mason. Michael is an economist by training, with a Ph.D. from MIT. After MIT, he spent five years as a professor of Economics at INSEAD, a business school near Paris, before joining the Federal Communications Commission. At the FCC, Michael was the Director of Internet Policy Analysis, where he was responsible for managing a wide range of policy analyses and regulatory decisions on Internet policy, broadband deployment, and mergers. At Analysys, Michael has worked with operators and regulators in six continents, providing advice on a variety of Internet issues including Internet backbone interconnection, Internet Exchange Points (IXPs), mobile and fixed broadband deployment, Voice over IP and IPTV. His clients have included the World Bank, the IDA in Singapore, OSIPTEL in Peru, the Botswana Telecommunications Authority, AT&T, and the European Union.

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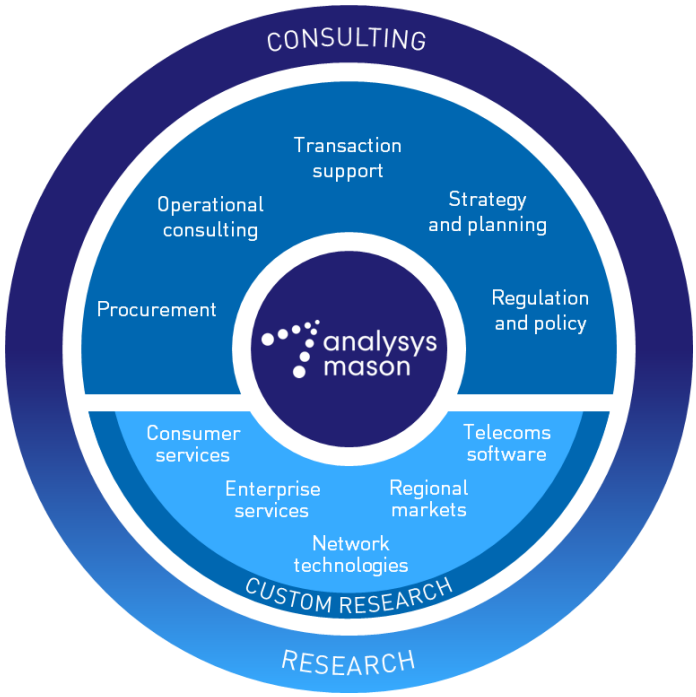

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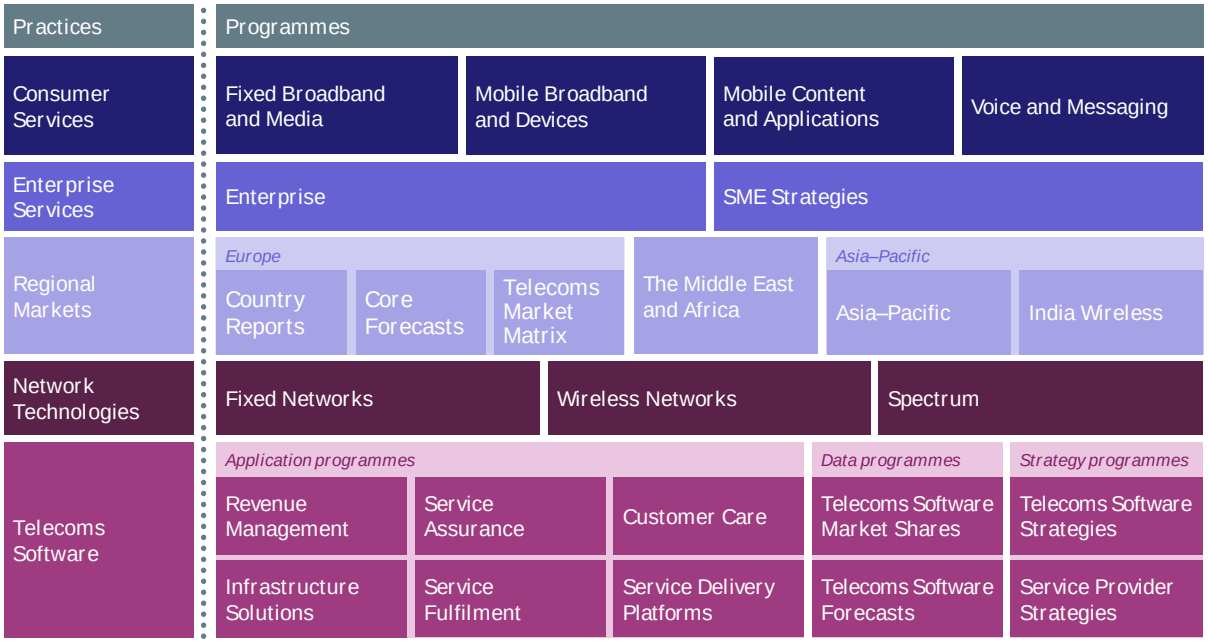

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