

Presentation for the International Telecommunication Union (ITU)

Overview of recent changes in the international IP interconnection ecosystem

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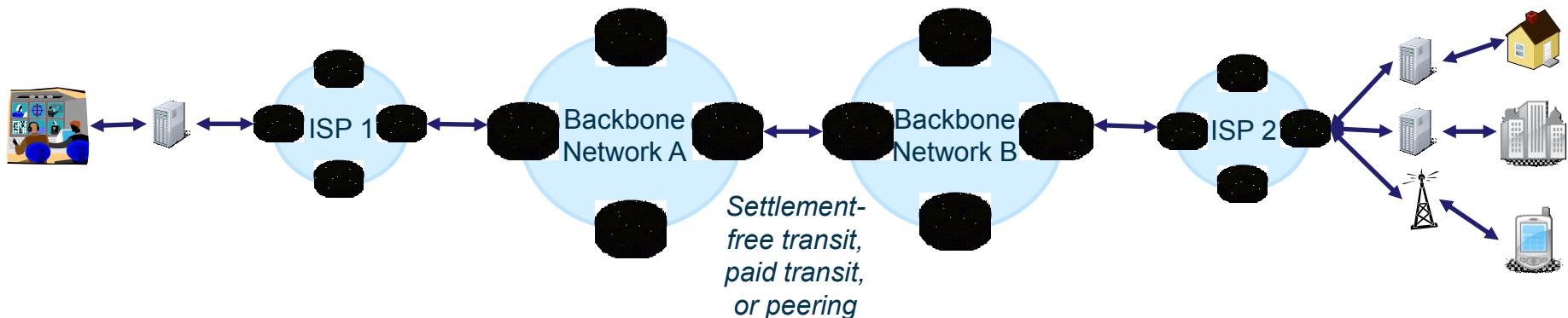
**ITU Regional Seminar on Costs and Tariffs for Member Countries of the
Regional Group for Asia and Oceania (SG3RG-AO)
Bali, Indonesia, 28-30 May 2012**

Introduction

- Last year marked the 15th anniversary of the commercialization of the Internet backbone. This paper focuses on two underlying trends since then:
 - the Internet has globalized, first from the US to the rest of the developed world, and then beyond to emerging markets
 - Internet traffic has increased by many orders of magnitude, based both on the increased numbers of users as well as the increasing amount of premium content including video
- The paper describes how interconnection arrangements have evolved in response to these trends:
 - Internet exchange points (IXPs) have helped to localize traffic and increase the efficiency of the Internet
 - countries with successful IXPs have transitioned from accessing Internet traffic as a ‘spoke’ to becoming a ‘hub’ for traffic in other countries
 - we highlight successful case studies and policies that countries can adopt to become a hub, and the impact for countries without those policies

The commercial Internet is relatively young

- The National Science Foundation Network (NSFNET) backbone service was decommissioned in favor of the commercial Internet on April 15, 1995:
 - the NSFNET was used by regional networks to exchange traffic
 - in its place, four network access points (NAPs) across the country were designated for traffic exchange
 - interconnection was not regulated – in its place commercial arrangements known as peering and transit were negotiated between different providers



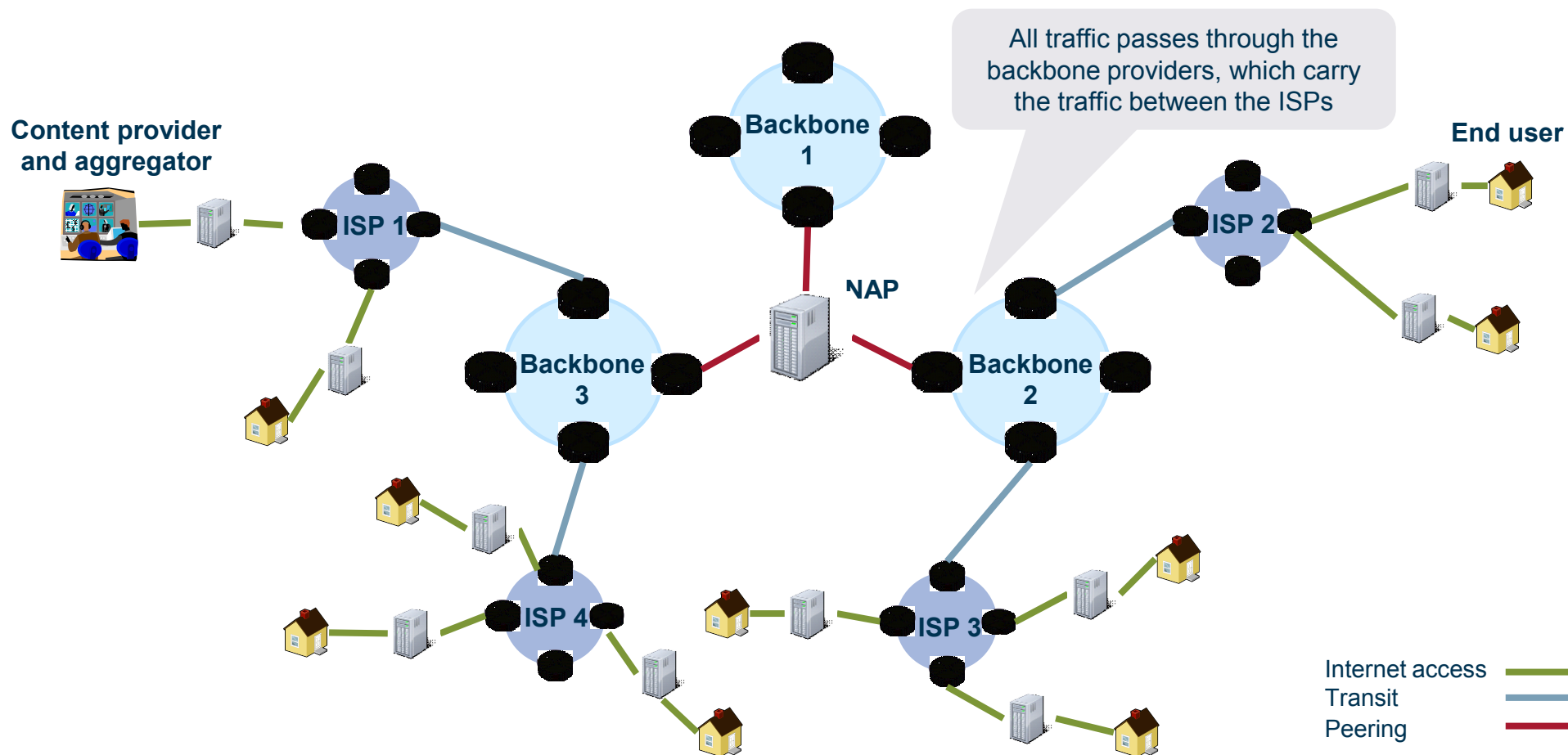
- The Internet was much different on that day:
 - Netscape had just been introduced
 - the NSFNET backbone was just 45Mbit/s
 - the Internet was very US-centric

In 1995 the Internet was very US-centric for a number of reasons

- The US was the historical home of the Internet:
 - 70% of Internet users were in the US in 1995, along with much of the content
 - up to 60% of European traffic routed through the US
- Much of the European traffic was *tromboning* through the US back to Europe:
 - all European ISPs had to connect to the US to access users and content anyway
 - the lack of liberalization in Europe made national and inter-European links very expensive for direct connections. For instance, in 1998 leased lines prices for a 2 Mbit/s link were
 - London – Paris: \$38,000 / month
 - London – Virginia: \$30,000 / month
- In addition to tromboning, the European traffic to the US had two sources:
 - accessing content (including European content that was hosted in the US)
 - natural traffic flows between the US and Europe (e.g. email)

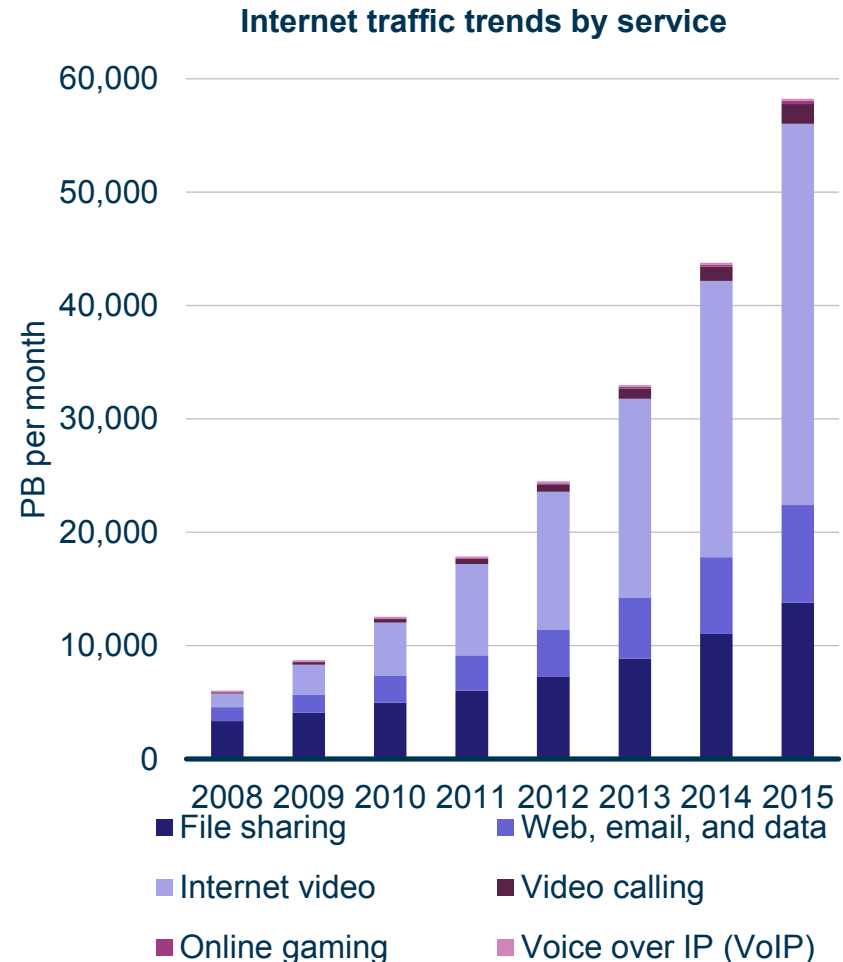
The early Internet was a hierarchy with Internet backbones at the top

Representation of relationships between Internet players in 1995



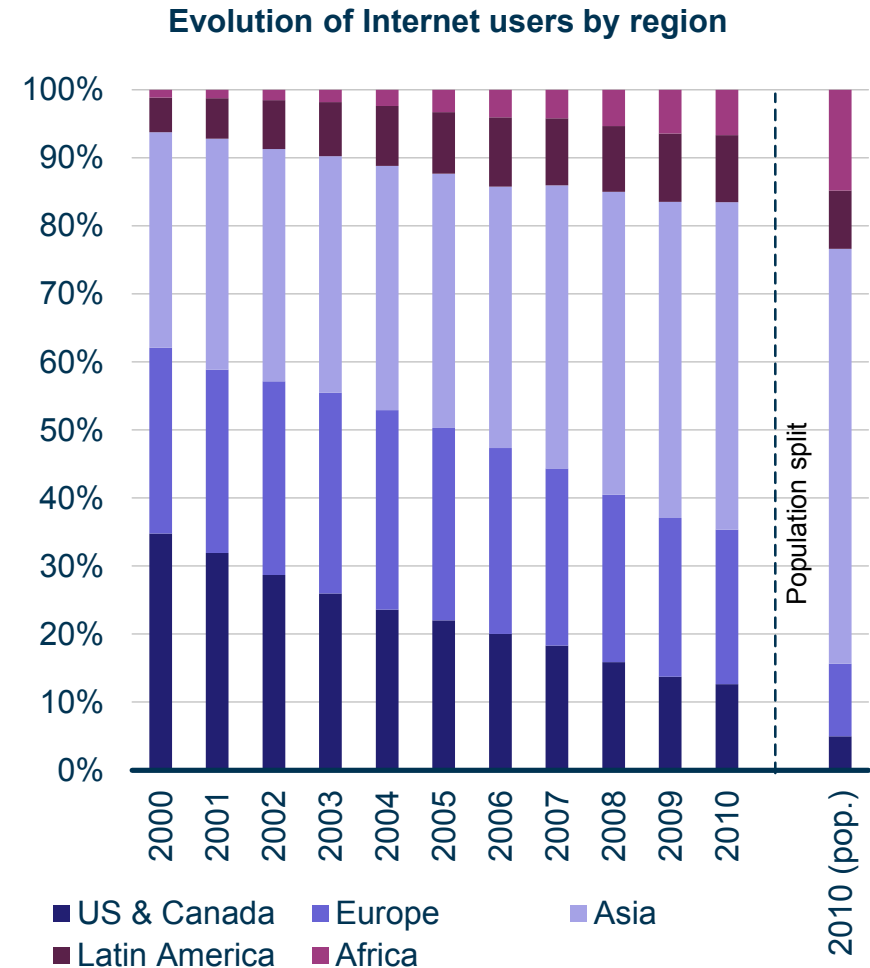
The Internet began to evolve quickly [1/2]

- Usage has changed significantly over the past ten years:
 - traffic used to be relatively static – text, email, file-sharing etc.
 - dynamic multimedia traffic now dominates with a significant amount of video and gaming
- Two trends are particularly relevant with respect to international traffic flows:
 - applications such as voice over Internet Protocol (VoIP) are very sensitive to latency, but relatively low bandwidth
 - applications such as video streaming are high bandwidth, but less sensitive to latency (with buffering)



The Internet began to evolve quickly [2/2]

- Usage began to better reflect population distribution:
 - in 2000 Internet usage was heavily concentrated in developed countries, with a far higher percentage coming from the US and Canada than reflected in the population split
 - this reflected the greater availability of PCs and fixed access in developed countries
- The usage trend has shifted significantly in the past ten years:
 - usage in Asia and Africa now more closely reflects the population split
 - this results from mobile access, as well as greater availability of shared access



The historical architecture was not sustainable

- The US-centric approach imposed increasing costs:
 - as developed countries liberalized, the cost of national and regional links fell relative to the cost of links to the US
 - the latency of access through the US became increasingly noticeable
- The Internet began to outgrow the NAPs:
 - traffic was exchanged via public peering, involving a shared switch that soon congested as traffic volumes began to multiply
 - the owners of the NAPs included operators who were not perceived as neutral in selling access
- There were three changes in the architecture:
 - interconnection evolved from NAPs to IXPs
 - the IXPs began to develop outside the US
 - some countries sought a policy response to pricing (e.g. ICAIS)

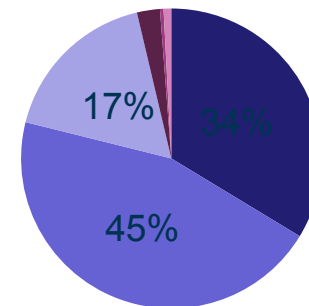
Interconnection migrated from NAPs to IXPs

- IXPs emerged in place of NAPs:
 - a wide variety of activities are possible, including direct peering and the sale of transit
 - these are large data centers open to all parties including ISPs and content providers
- IXPs address the issues raised by NAPs:
 - IXPs are neutral, and many are non-profit associations owned and operated by their members, housed within larger commercial data centers (such as owned by Equinix)
 - within the data center, large providers use direct cross-connects to engage in private peering to avoid congestion
- IXPs also act to flatten the hierarchy of the Internet:
 - the data center hosts content providers and ISPs who can use the IXP to peer directly with one another
 - the members of the IXP can also purchase domestic or international transit services within the data center

Content also began to migrate to IXPs

- High-bandwidth content tends to be ‘portable’:
 - according to Cisco, over 96% of content consists of video, file sharing, and web pages
 - unlike voice, such content can be moved from the origination point
- New technology such as caches allow content to be distributed:
 - entire websites or popular pages can be stored closer to end users
 - this lowers the bandwidth costs while also improving quality of service
 - content distribution networks (CDNs) such as Akamai will manage content on behalf of providers
- IXPs provide a natural location to store content where it can be efficiently accessed by multiple ISPs

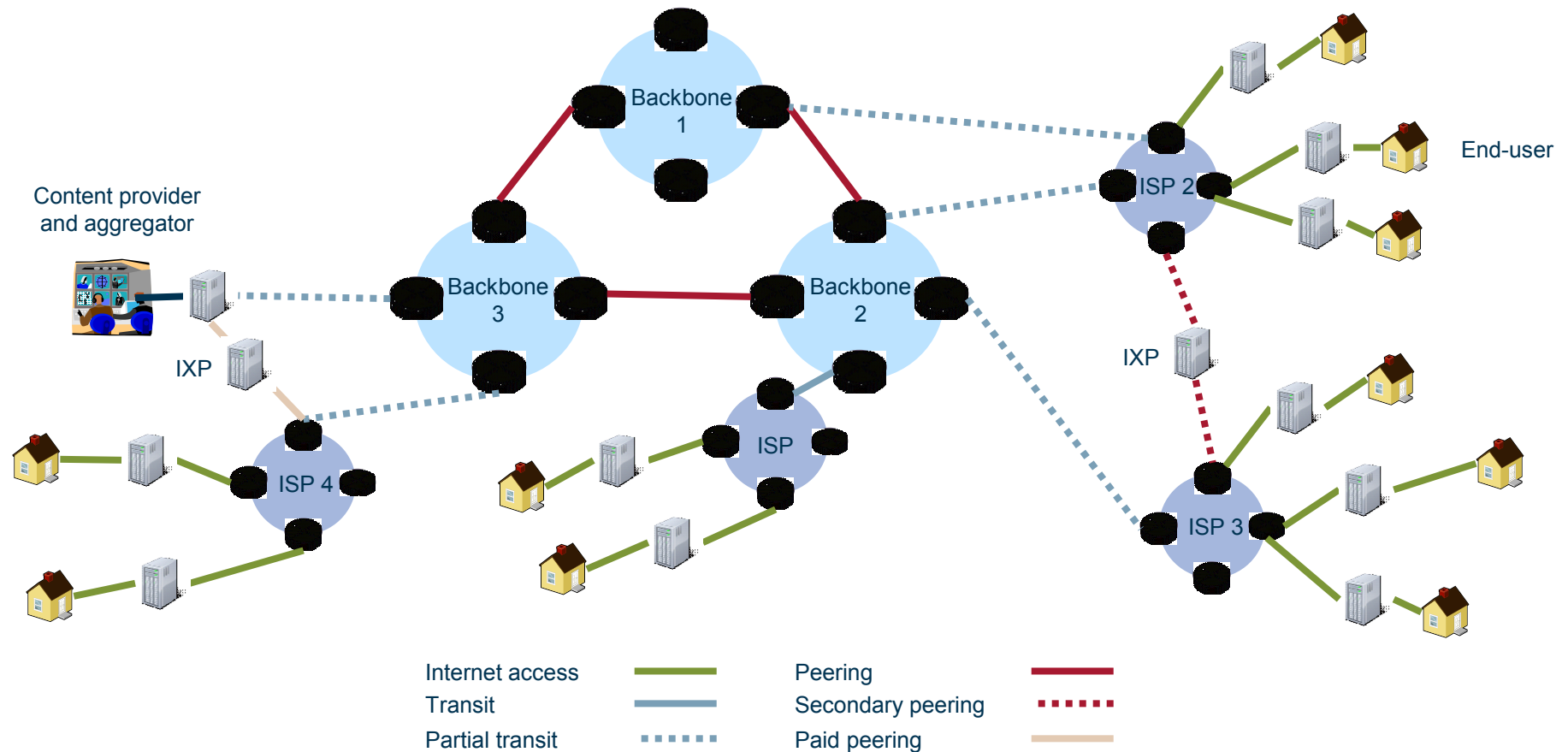
Traffic shares by application



- File sharing
- Internet video
- Web, email, and data
- Video calling
- Online gaming
- Voice over IP (VoIP)
- Other

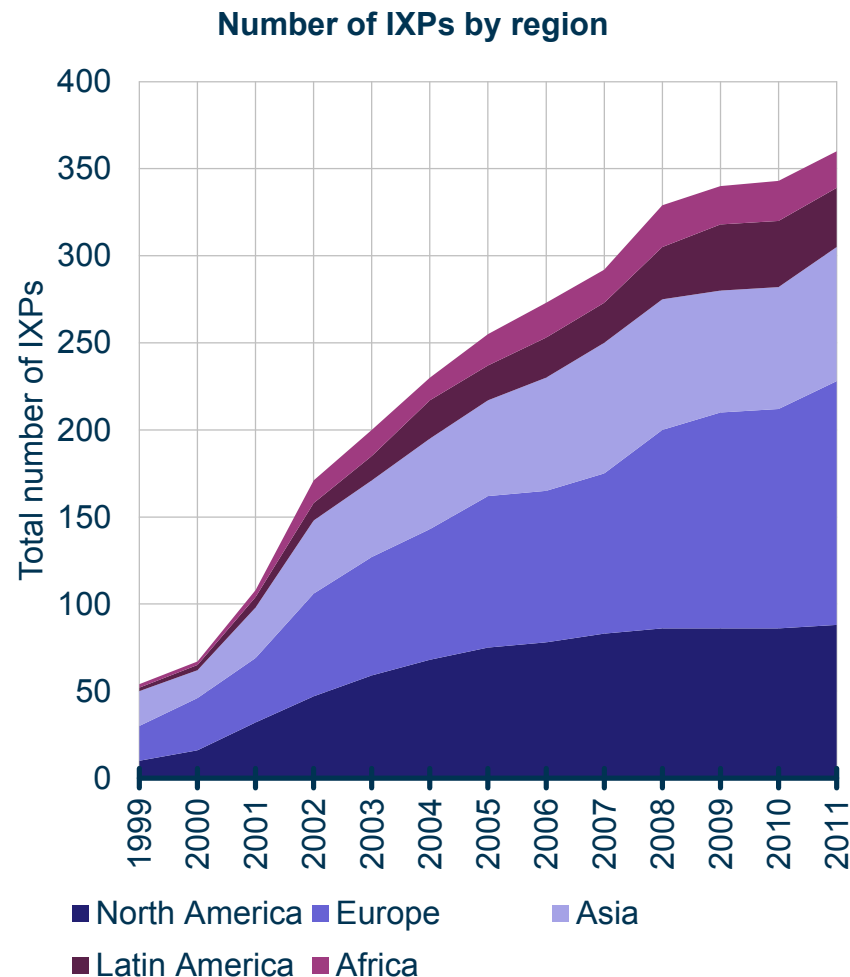
As a result of IXPs, the backbone is far less hierarchical today

Representation of relationships between Internet players today



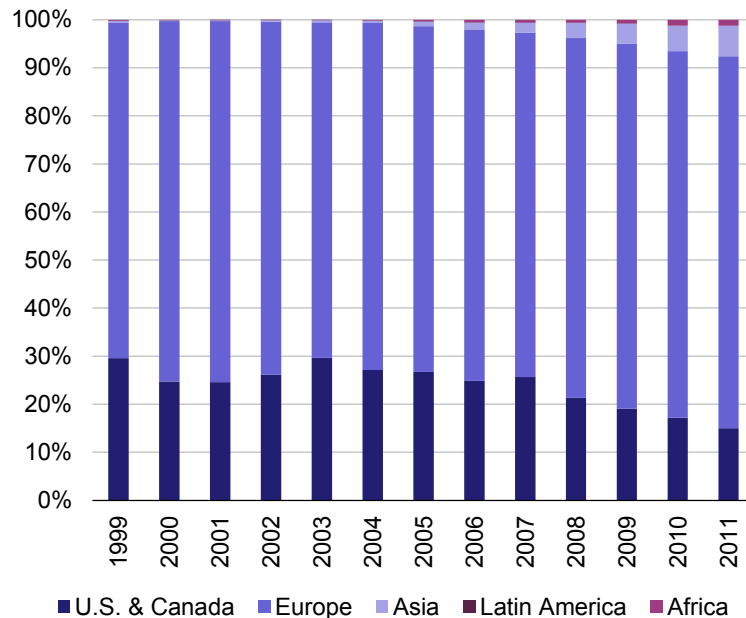
There have been three phases of globalization

- *US-Centric phase*, for historical reasons starting with the commercialization of the Internet
- *OECD-Centric*, focused on developed countries in Europe and Asia:
 - the Amsterdam Internet Exchange (AMS-IX) is a good example of a successful IXP.
 - founded in 1994, it now connects more than 390 members, who own and operate the exchange as a non-profit
- *Rest of World (ROW) centric*, focused on emerging markets:
 - in Africa only two countries had IXPs before 2002, which has risen to 20 by the end of 2010



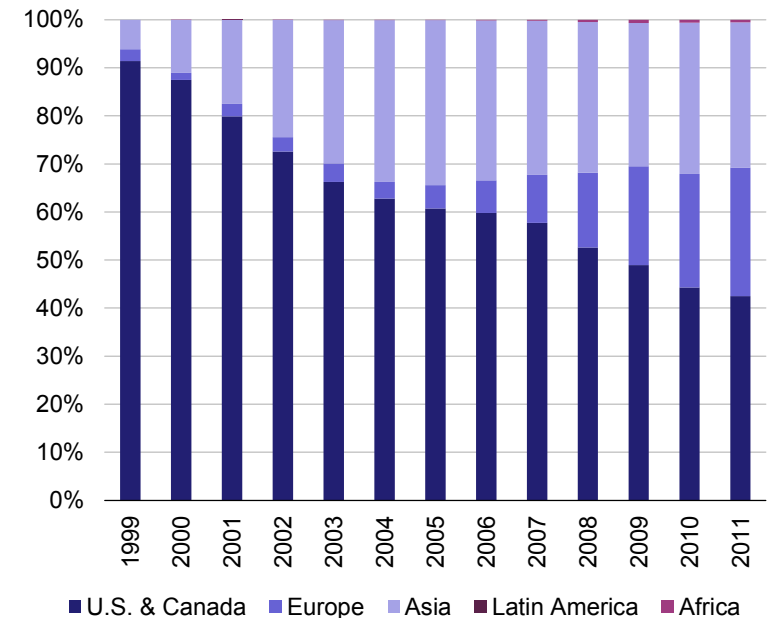
The *OECD-Centric* phase has drastically reduced the reliance on the US in Europe and Asia

International Internet bandwidth from European countries, by region



- The early IXPs in Europe were setup before 1999, significantly reducing tromboning before this dataset starts
- Nonetheless, the reliance on the US has now fallen to about 15% of bandwidth, while Asia is increasingly a destination

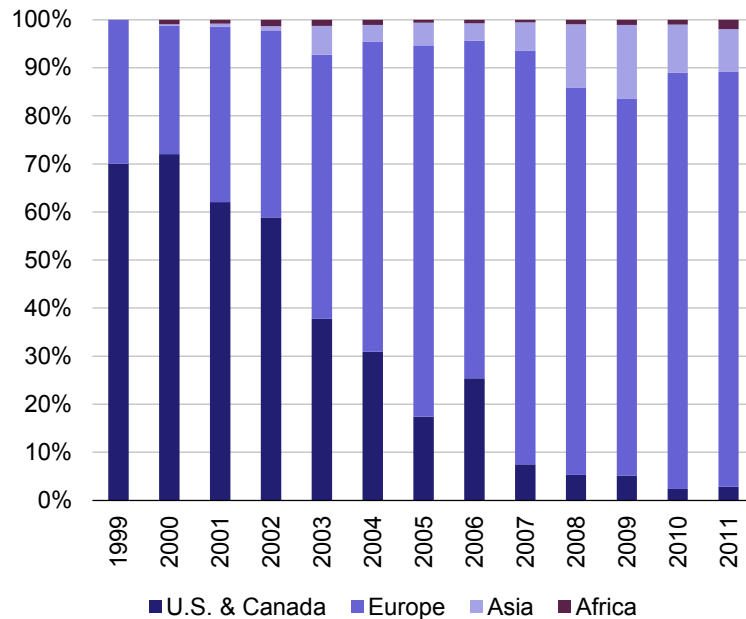
International Internet bandwidth from Asian countries, by region



- Asia had a later start in localizing traffic, but has now reduced reliance on the US for Internet bandwidth by half
- Intra-Asian traffic has increased as more traffic localizes, while Europe is increasingly a destination for traffic exchange

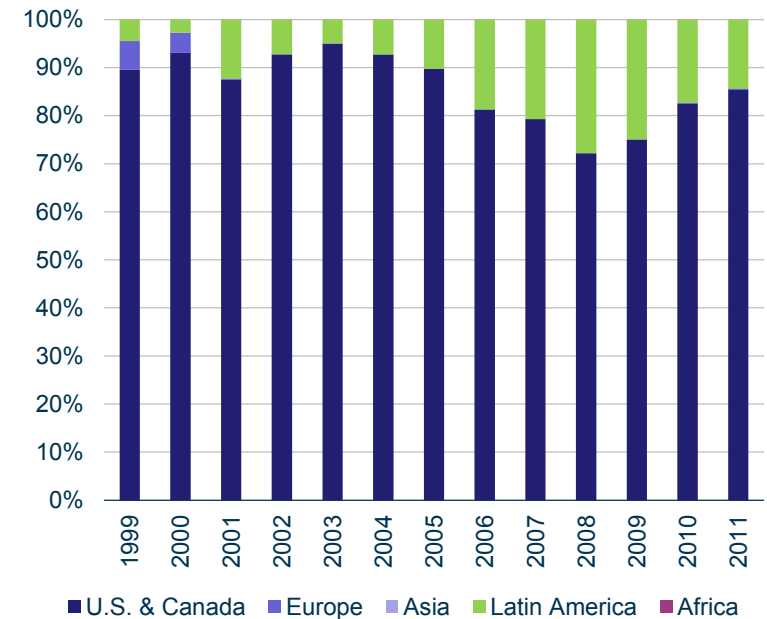
The *ROW* phase has not had as great an impact on international bandwidth to date

International Internet bandwidth from African countries, by region



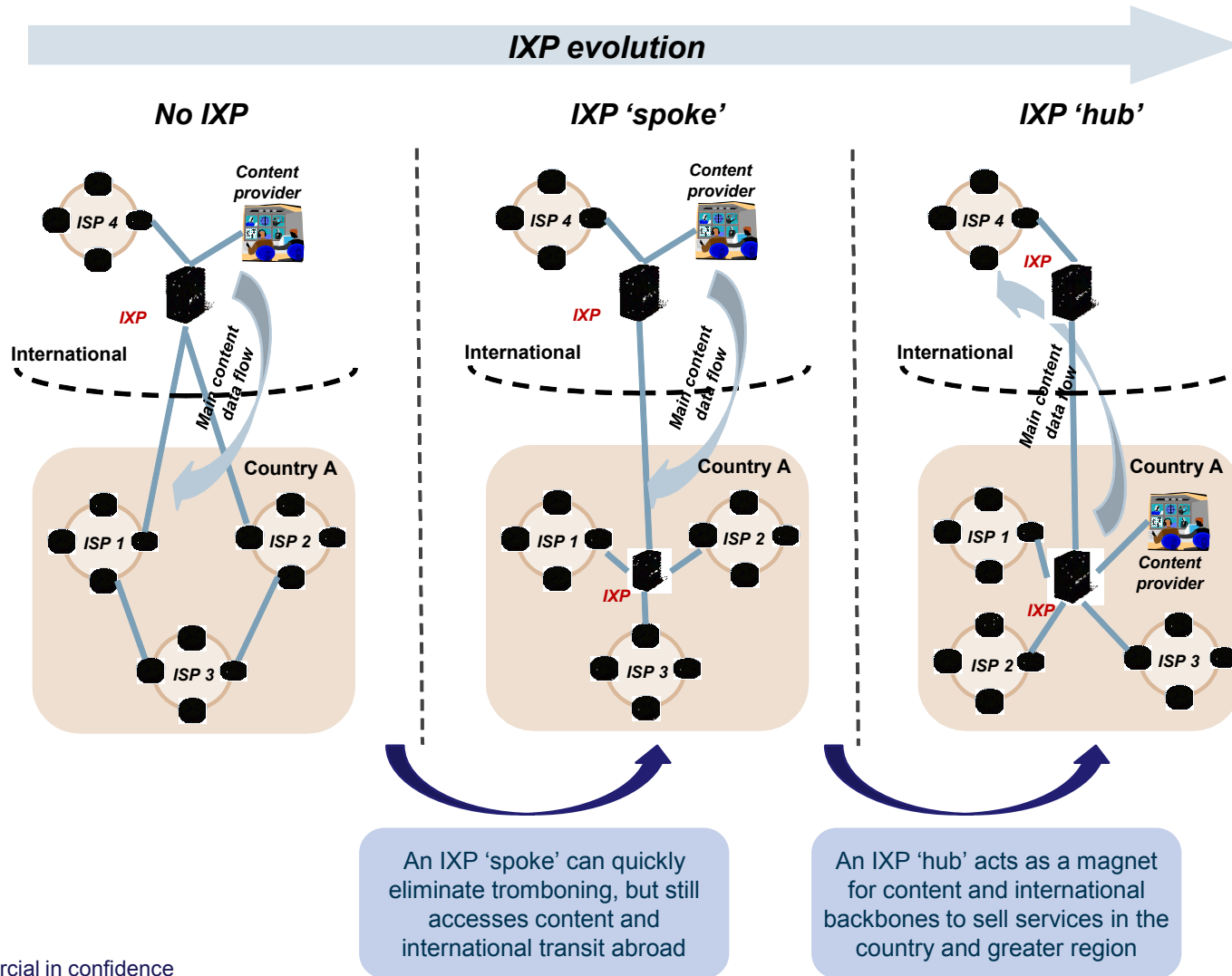
- African reliance on the US for Internet bandwidth has reduced drastically
- However, the reliance has shifted to Europe, which demonstrates both the adaptability of the Internet structure but also the need for continued localization in Africa

International Internet bandwidth from Latin American countries, by region



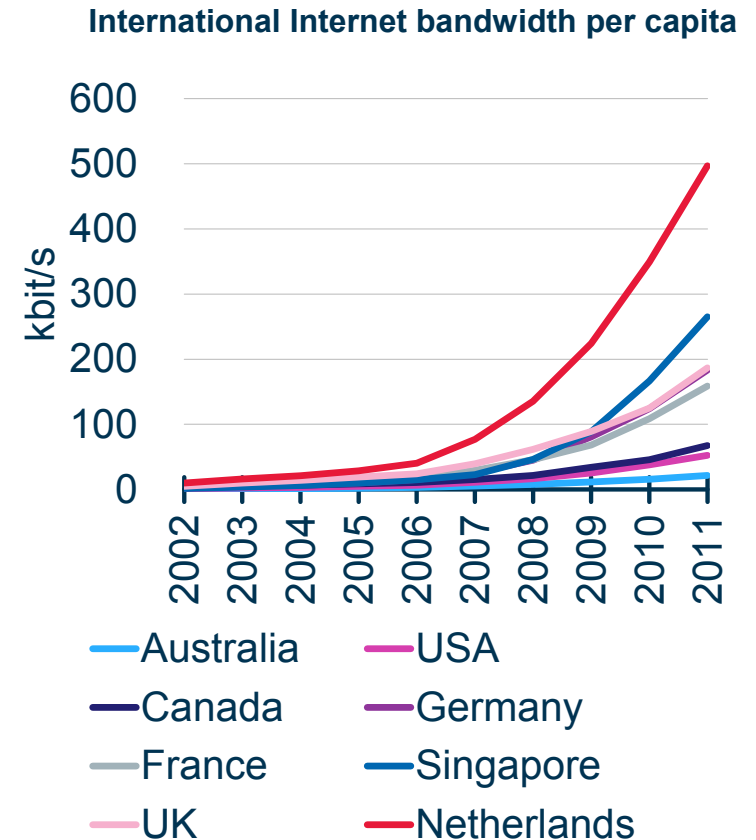
- Latin American reliance on the US has begun to fall, but is still above 80%
- Unlike the African situation, intra-regional traffic is growing, but still demonstrates the need for continued localization

A successful IXP can evolve from acting as a 'spoke' to a 'hub'



The evolution to IXP 'hub' may require broad policy changes, with corresponding benefits

- Creation of an IXP:
 - there are many examples of ISPs acting together to create an IXP, with little or no regulatory intervention
 - the ability of that IXP to attract FDI and become a hub largely lies outside of the control of the IXP and likely even the regulator
- Broadly speaking, two sets of factors impact the evolution of the IXP into a hub:
 - first, foreign providers will look at the general business environment
 - second, providers look at sector policies including international liberalization, and licensing requirements and obligations
- The impact of AMS-IX in the Netherlands is noticeable in terms of bandwidth per capita (see *right*)

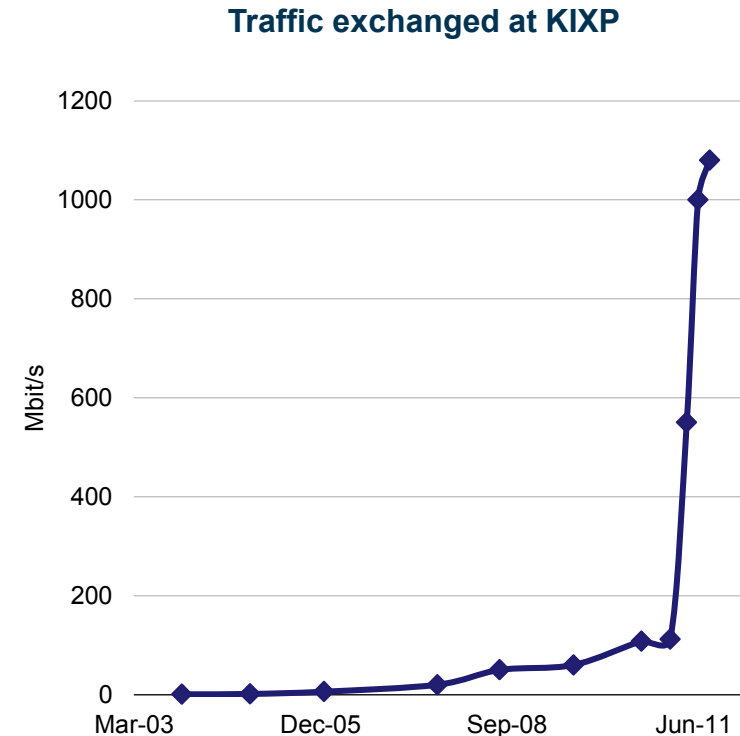


A recent study for the Internet Society shows the benefits of an IXP in developing countries

- An association of ISPs in Kenya (TESPOK) setup the Kenya Internet Exchange Point (KIXP) in Nairobi in early 2000:
 - the immediate benefit was to eliminate reliance on satellite for tromboning, reducing latency and cost significantly
 - the incumbent challenged the IXP with the regulator, but was ultimately denied
- The growth in the IXP has been significant:
 - there are now 28 members peering at KIXP, including all major operators, a government network, and several DNS servers
 - KIXP is one of the fastest growing IXPs in the world, peaking at up to 1Gbit/s traffic recently
- The IXP of Nigeria (IXPN) was established in 2006 in Lagos:
 - the stated objective was reducing reliance on international transit for exchanging local traffic between members
- The growth has been significant:
 - there are now more than 30 members exchanging traffic in IXPN
 - traffic peaks at over 300Mbit/s
- Growth has been slower than in Kenya:
 - not all major operators are members and traffic levels are lower
 - the key reason appears to be that the high cost of national backhaul restricts the benefits of avoiding international tromboning

The impact of having local content is particularly significant

- Google installed a Google Global Cache (GGC) in Kenya:
 - the cache was initially provided to one operator in Nairobi, under the condition that the contents would be made available to all members of KIXP
 - the cache retains static content after it has been downloaded in Kenya, such as YouTube videos
- The cache was installed in April 2011:
 - as shown on the right, traffic through KIXP spiked immediately
 - this increase mostly reflects users' increased usage of Google content, notably an increased willingness to stream YouTube videos based on lower latency of access
 - mobile operators who charged by the MB experienced increased revenues along with lower costs



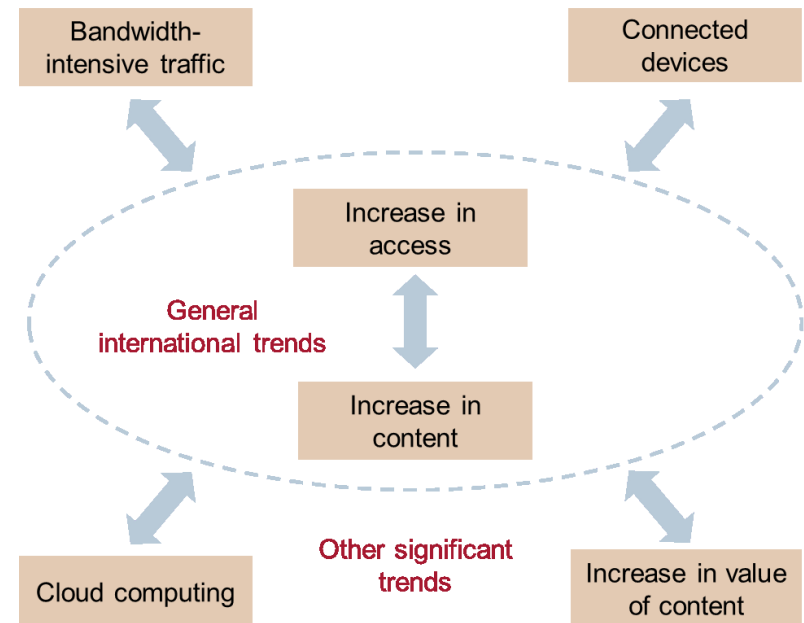
The benefits of the IXPs are broadly felt in Kenya and Nigeria

Benefit	KIXP	IXPN	Summary
Latency	Reduced from 200–600ms to 2–10ms	Reduced from 200–400ms to 2–10ms	Noticeable increase in performance for end users
Local traffic exchange	1Gbit/s peak	300Mbit/s peak	Savings on international transit of over \$1 million per annum in each country
Content	Google network present locally, along with rehosting of domestic content	Same as in Kenya	Increase in usage and corresponding revenues for mobile data traffic
e-government	Kenya Revenue Authority gathers taxes online	Usage by education and research networks	Social benefits from e-government access to IXPs
Other benefits	An increasing amount of regional traffic exchanged at KIXP	Financial platforms hosted locally	Further economic benefits resulting from IXPs

The impact of Internet trends only highlights the need for Internet hubs in emerging markets

- The trend is towards an increasing reliance on Internet access and content:
 - increasingly personal and business content and applications are moving into the cloud
 - increasingly these are designed for access by mobile devices
- Policy solutions should focus on creating local hubs, rather than simply lowering the cost of acting as a spoke:
 - as the bandwidth of access and content increases, international access costs will continue to rise
 - in addition, access to local or regional hubs will reduce latency and improve the resiliency of access

Summary of Internet trends



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