Anchoring the African Internet Ecosystem: Lessons from Kenya and Nigeria's Internet Exchange Point Growth

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Executive summary

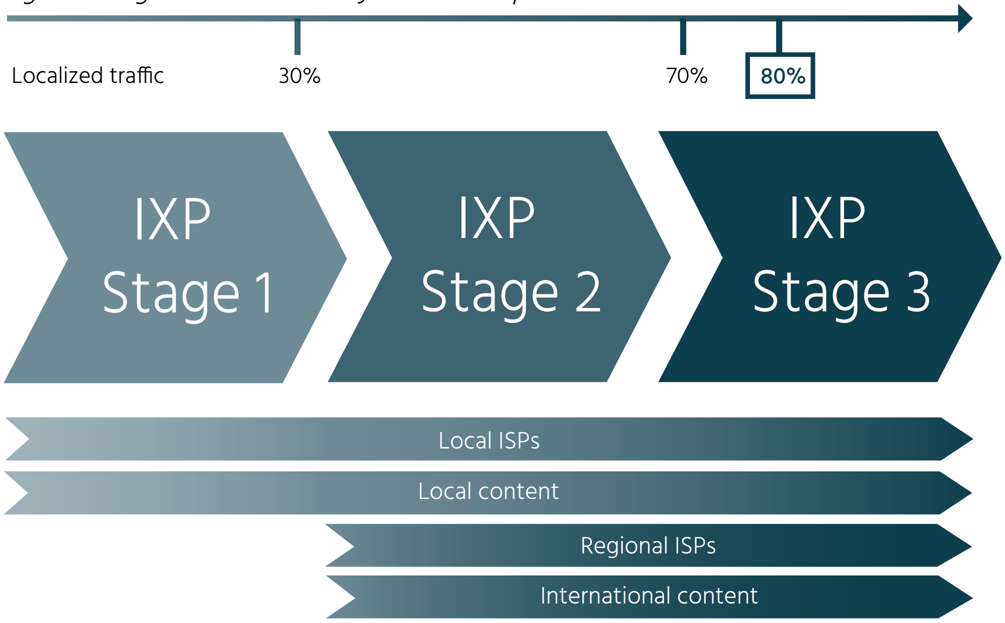
In 2010, the Internet Society's team in Africa set an ambitious goal that 80% of African Internet traffic would be locally accessible by 2020.

Internet Exchange Points (IXPs) are key to realizing this goal in that they enable local traffic exchange and access to content. To document this role, in 2012, the Internet Society commissioned a study to identify and quantify the significant benefits of two leading African IXPs at the time: KIXP in Kenya and IXPN in Nigeria. The Internet Society is pleased to publish this update of the original study. In it, we highlight the significant advances made in both countries since 2012 and provide specific recommendations for all countries seeking to strengthen their Internet ecosystem and Internet communities.

The rapid pace of Internet ecosystem development in both Kenya and Nigeria since 2012 underscores the critical role that IXPs and the accompanying infrastructure play in the establishment of strong and sustainable Internet ecosystems.

This development produces significant day-to-day value—the present COVID-19 crisis magnifies one such benefit in the smooth accommodation of sudden increases of traffic due to the unprecedented increase in reliance on the Internet since social distancing and lockdowns began.

Figure 1. Stages of Internet Ecosystem Development



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In 2012, in both Kenya and Nigeria, approximately 30% of each country's traffic was localized. The Internet Society refers to this as Stage 1 Internet ecosystem development, at the cusp of moving into Stage 2 (Figure 1). Each country possessed a strong base for growth, including an existing IXP that was well-managed and trusted by local stakeholders. Both countries had static international content available via a Google Global Cache, but no other locally available content. However, each had the necessary foundation of trust and collaboration and the corresponding Internet infrastructure to grow as a hub.

Today, both countries have reached Stage 2 of development, with nearly 70% of traffic localized—and they are poised to move to Stage 3. The growth of the IXPs in each country was exponential, as were the cost savings from exchanging traffic locally rather than using expensive international transit. In Kenya, KIXP grew from carrying a peak traffic of 1 Gigabit per second (Gbps) in 2012 to 19 Gbps in 2020, with cost savings quadrupling to USD six million per year. In Nigeria, IXPN grew from carrying just 300 Megabits per second (Mbps) to peak traffic of 125 Gbps in 2020, and the cost savings increased forty times to USD 40 million per year.

Getting to this point meant following a systematic path of stakeholder relationship building and infrastructure development. The IXPs transformed into multisite and multicity IXPs with at least one node in a carrier-neutral data center, while maintaining their roles in developing and sustaining trust and collaboration among their members. Each IXP also dropped mandatory peering requirements to encourage new members to join and make selective peering agreements. As a result, all of the large international content providers added at least one edge cache in the country, and many also added a point of presence (PoP). The respective governments also played a role by developing the Internet sectors and adopting data-protection policies, thereby reinforcing an environment of trust and welcoming further local-content hosting.

Looking ahead

Progressing into Stage 3 of development and achieving the ITE program's goal of 80% of African Internet traffic being locally accessed will require a number of recommended actions, which will benefit the individual stakeholders as well as the broader ecosystem.

- Awareness of the benefits of local content hosting and peering at the IXP among a broad range of stakeholders must be raised, which can be achieved via targeted capacity building and information exchange, led by, or with the participation of the IXPs.
- In particular, local content developers who currently host their content outside the country, should host it inside the country to benefit from lower latency and thereby also increase local traffic.
- In addition, smaller Internet service providers (ISPs) should connect to their local IXPs in order to widely peer with other members and thereby increase the efficiency of their interconnections.
- Aggregation of demand for backbone capacity and local content hosting can help lower costs for smaller ISPs and local content developers respectively, to help enable them to connect to their local IXPs.
- Domestic backbone infrastructure must also extend beyond the main landing point for submarine cables and main population center into other population centers, to further lower the cost of exchanging traffic and accessing content locally.
- Finally, an environment of trust and collaboration is key to the successful growth of any technology infrastructure. Stakeholders must communicate and connect as equals, working together toward common stated goals and outcomes.

The Internet Society offers this history of positive steps in Kenya and Nigeria, as well as these recommended actions (page 29), as a blueprint for other African countries to develop and strengthen their Internet ecosystems. Together, as countries began to localize increasing amounts of content, the 80/20 goal of the Internet Society and African Internet community will be realized.

Background: A vision for Africa

In 2010, the Internet Society's team in Africa launched the organization's Interconnection and Traffic Exchange Program[1] with the goal of "80/20 by 2020," in other words, that 80% of African Internet traffic would be locally accessible by 2020.

IXPs are integral to meeting this goal by both localizing traffic exchange between ISPs in a given market and by helping to attract content providers to provide more-efficient content delivery. It soon became clear, however, that the presence of IXPs alone is not sufficient to reach the goal of localizing 80% of African Internet traffic. Meeting a goal of such magnitude also requires that countries have strong enabling environments, and develop collaboration and trust among their Internet organizations and the people working for those organizations. This kind of trust is fostered via community mobilization, capacity building, and training.

In 2012, in order to both increase the incentives for developing and strengthening IXPs across Africa and encourage more documentation about the positive impact of IXPs, the Internet Society commissioned a study to identify the benefits of two leading African IXPs: the Kenya Internet Exchange Point (KIXP) and the Internet Exchange Point of Nigeria (IXPN)[2]. The study was groundbreaking in that it was the first to quantify the economic benefits of an IXP. And while the benefits were significant at the time, they also were limited by the very small amount of locally hosted content in sub-Saharan Africa. Kenya and Nigeria each had one Google Global Cache of static international content, such as YouTube videos; other content, including locally developed content, was still hosted outside the African continent.

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To address the issue of local hosting of content, the Internet Society followed the Kenya/Nigeria study with two reports on Rwanda: an assessment of the economic benefits of locally hosting content, and a case study on the effects of returning Rwandan websites and hosting them "at home" in Rwanda[3,4] Each underscored an issue replicated across much of sub-Saharan Africa: local developers realized savings by hosting content and services in Europe or the United States, which imposed on ISPs significantly higher costs for delivering the content back to Rwanda. Both reports included strong recommendations for increasing local content hosting.

1. Interconnection and Traffic Exchange (ITE) Program Brochure, https://www.internetsociety.org/resources/doc/2015/interconnection-and-traffic-exchange-ite-program-brochure/

2. Michael Kende and Charles Hurpy, "Assessment of the Impact of Internet Exchange Points – Empirical Study of Kenya and Nigeria," Report for the Internet Society, April 2012, https://www.internetsociety.org/wp-content/uploads/2017/09/Assessment-of-the-impact-of-Internet-Exchange-Points-–-empirical-study-of-Kenya-and-Nigeria.pdf

3. Michael Kende and Karen Rose, "Promoting Local Content Hosting to Develop the Internet Ecosystem" (Internet Society, January 2015), https://www.afpif.org/wp-content/uploads/2017/10/Promoting-Local-Content-Hosting-to-Develop-the-Internet-Ecosystem.pdf

4. Michael Kende and Bastiaan Quast, "The Benefits of Local Content Hosting: A Case Study" (Internet Society, May 2017), https://www.internetsociety.org/wp-content/uploads/2017/08/ISOC_LocalContentRwanda_report_20170505.pdf

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Eight years have passed since the first IXP study, and the Internet ecosystems in Kenya and Nigeria have grown significantly.

Both countries have experienced an increase in the number of Internet users and the amount of Internet usage, an increase in international and domestic Internet capacity, a local presence of the largest international content providers and content delivery networks, and corresponding growth in the number of IXPs.

The value of these IXPs, as well as the ecosystems of access and content that has risen around them, has been validated by the current COVID-19 crisis. The growing reliance on the Internet to replace face-to-face interactions during lockdowns and social distancing has increased use of the IXPs and produced large spikes in peak throughput that would have been difficult to accommodate without the IXPs inherent resilience and local capacity.

The Internet Society is pleased to publish this update of the 2012 study. It contains descriptions of the many changes that have occurred in the two countries, actions taken by stakeholders to promote those changes, and recommendations designed to further the growth of each country's Internet ecosystem.

We share these insights with the following goals:

- to inspire stakeholders in other countries to help strengthen their IXPs and surrounding ecosystems,
- to ensure that the latest and most effective practices are shared across the industry, and
- to promote that countries, including Kenya and Nigeria, take stock of their progress toward the joint Internet Society and African Internet community goal of 80/20 by 2020.

Finally, it is our sincerest wish that the positive outcomes highlighted in this study generate greater community conversation around a new vision beyond 2020.

Introduction: How to get there from here

IXPs are meeting points through which networks exchange Internet traffic. By enabling local traffic to remain local, they effectively lower the cost and latency of exchanging traffic and accessing content.

In summary, their use facilitates a cheaper, better, and faster Internet. The Internet Society has long supported and actively promoted both the development and ongoing enhancement of IXPs as critical aspects of a country's Internet infrastructure and proven tools for building technical capacity.

IXPs can play a central role in the evolution of a country's Internet ecosystem, and that has certainly been the case in both Kenya and Nigeria.

The general benefits of IXPs, as measured in the Internet Society's 2012 study, all flow from one fundamental fact: without an IXP, ISPs must use their international Internet Protocol (IP) transit to exchange global Internet traffic, content hosted abroad, and local traffic. The costly process, in which local traffic flows to an interconnection point outside the country and back again, is commonly called tromboning (after the shape of the musical instrument).[5]

IXPs enable local traffic to be exchanged locally rather than tromboning. This leads to the three economic benefits summarized in the 2012 study (Table 1).[6] By exchanging traffic locally, ISPs saved on significant, recurring, and expensive international IP transit costs; latency fell significantly; and this lower

Table 1. Summary of 2012 Study Results (Source: Analysys Mason, Internet Society, 2012)

	Kenya	Nigeria
Peak IXP traffic	1 Gbps	300 Mbps
Peering Networks	25	35
Benefits		
1. Cost savings per year	US$1,440,000	US$1,080,000
2. Latency reduction	From 200–600ms to 2–10ms	From 200–400ms to 2–10ms
3. Increased revenues	US$6 million	Low, given traffic levels

5. For a review of traffic patterns, including tromboning, and the impact on latency, see Josiah Chavula and Amreesh Phokeer, "Revealing latency clusters in Africa," African Network Information Centre (AFRINIC) blog post, 31 July 2019, https://afrinic.net/revealing-latency-clusters-in-africa

6. Michael Kende and Charles Hurpy, "Assessment of the Impact of Internet Exchange Points – Empirical Study of Kenya and Nigeria," Report for the Internet Society, April 2012, https://www.internetsociety.org/wp-content/uploads/2017/09/Assessment-of-the-impact-of-Internet-Exchange-Points-–-empirical-study-of-Kenya-and-Nigeria.pdf

latency increased the usage of the content, thereby increasing the revenues of those ISPs selling data packages to users.

The growth of the IXPs in each country was exponential since 2012, as were the cost savings from exchanging traffic locally. In Kenya, KIXP grew to 19 Gbps in 2020, with cost savings quadrupling to USD six million per year. In Nigeria, IXPN grew to peak traffic of 125 Gbps in 2020, and the cost savings increased forty times to USD 40 million per year. We will now detail the significance of this growth, and the lessons that can be learned.

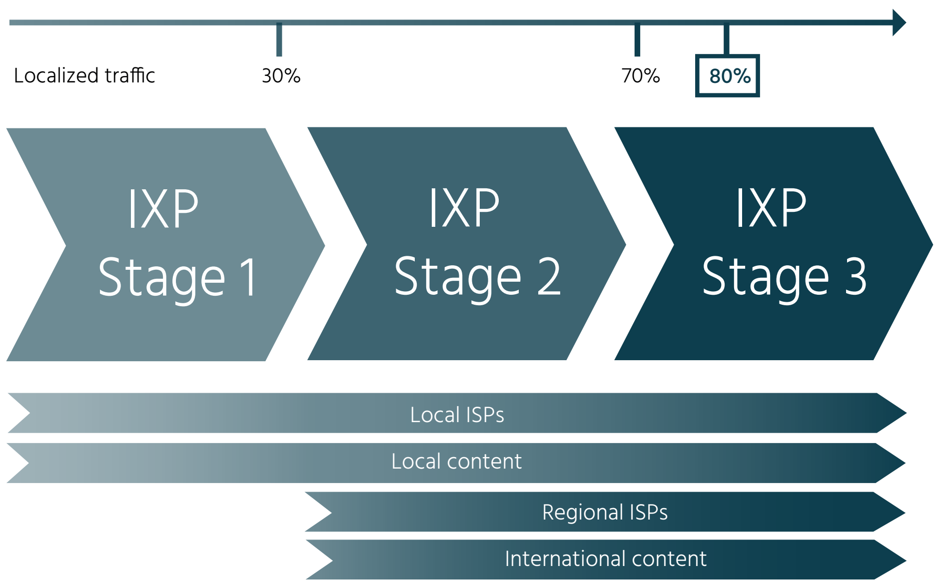
The three stages of Internet ecosystem development

The role of an IXP has multiple dimensions. An IXP can exchange traffic among access providers, and between content providers and access providers. It can enable exchange of local traffic and access to content, and can deliver benefits to local Internet subscribers (end users) and organizations. As an IXP grows, it can become a hub for exchanging and accessing cross-border traffic within its subregion, as well as international traffic and content. Based on the experiences observed in Kenya, Nigeria, and other countries, the Internet Society has identified three evolutionary stages of an Internet ecosystem (Figure 2).

Stage 1. The IXP mainly is used to exchange local traffic between local access providers. Benefits include lower costs for the access providers, lower latency of traffic exchange from not having to trombone traffic, and greater network resilience from not relying on international connections for local traffic exchange. In addition, end users benefit from lower latency and greater resilience, and may share in the cost savings reaped by the ISPs. Stage 1 localizes approximately 30% or less of total traffic, as it does not involve significant amounts of content.

Stage 2. International content is made available locally, attracted by the IXP and its member networks. The benefits build on those gained in Stage 1, including increased cost savings and lower latency in accessing content, as well as greater resilience. The decreased latency in accessing content increases the usage of that content, which also increases the revenues of those ISPs that sell data packages. In addition, the lower costs of accessing content are likely to be passed on to end users. And ISPs from the region begin to connect to the IXP to access cross-border, subregional, and international content. Stage 2 localizes approximately 30% to 70% of total traffic.

Figure 2. Stages of Internet Ecosystem Development



Stage 3. Local content is hosted locally, rather than in data centers located abroad. This builds on the gains of locally hosting international content and helps to promote a digital economy by providing additional opportunities for local content developers and the companies that host them.[7] End users benefit from more relevant local content. Stage 3 localizes 70% or more of total traffic.

Note that the aforementioned percentages are approximate, and depend on the individual country and type of content. For example, international content may have more relevance in English-speaking countries than it has in other countries.

As shown below, in the 2012 report, both Kenya and Nigeria had achieved Stage 1 and were on the cusp of Stage 2 with very little localized content. Today, both countries have achieved Stage 2 and are on the cusp of Stage 3 with essentially all consequential, international content hosted locally. In order to fully achieve Stage 3, local content must be developed and hosted locally, as well.

The economics of content hosting and delivery

In order to understand the development of the Internet ecosystem, it is important to understand the evolving economics of content. During the past ten to fifteen years, two important shifts in Internet traffic flow have emerged. The first shift is a significant increase in the availability of content and services; the largest source of content by traffic volume being video, which requires vast amounts of bandwidth in order to reach the end user. The second shift is the true globalization of the Internet. Today's Internet is challenged to efficiently deliver massive volumes of content across the globe.

To answer that challenge, content delivery networks (CDNs) emerged to help deliver content closer to end users. Early CDNs, such as Akamai, were independent companies that delivered content on behalf of clients. More recently, content providers—such as Google, Facebook, and Netflix—are deploying their own CDNs to deliver their content.

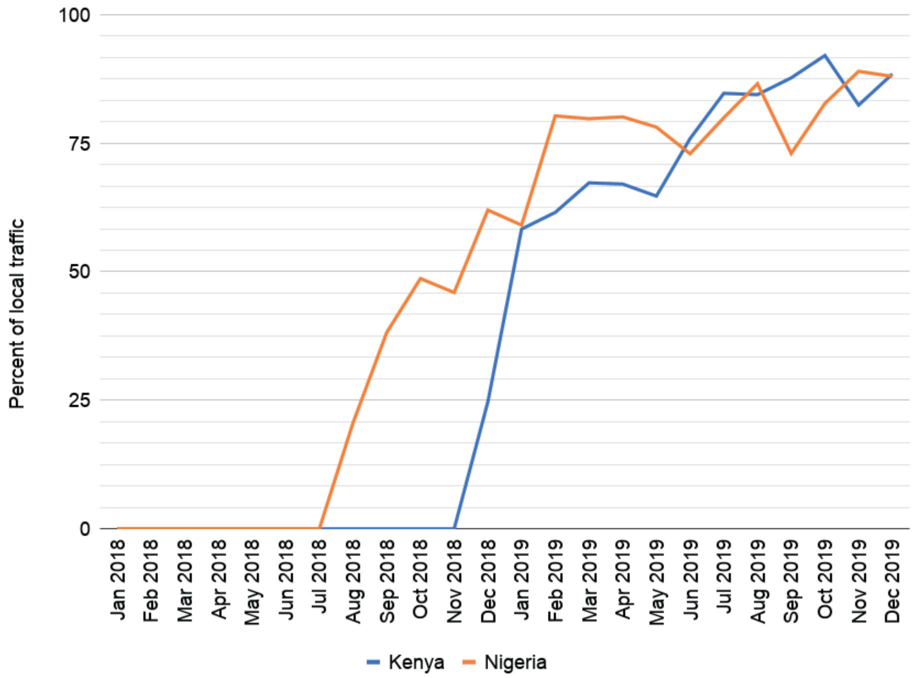
To understand content traffic flows, it is important to distinguish between static and dynamic content. Static content does not change over time, so it can be stored in multiple locations beyond where it was generated. Videos are a significant type of static content, including user-generated videos and commercial videos, such as television shows and movies. Dynamic content continuously changes with user requests, and, therefore, it cannot be stored. Direct communications between end users, such as social media messages, online gaming, and video calls are examples of dynamic content.

CDNs deploy caches in order to store popular static content in multiple locations. These caches are often called edge caches, as they reside at the edge of a CDN network—as close to the end user as possible. Content can be pushed or pulled into the edge cache. A CDN may push popular content into the edge caches to take advantage of times when there is low traffic. For instance, Netflix may push its video library into an edge cache overnight. Or, an end user may pull content into an edge cache. For example, when a user in a particular country downloads a video, the video is stored in an edge cache as it is being delivered to the end user. The next time another end user wants to watch that video, it is served from the edge cache, rather than the initial international point.

Regardless of whether content is pushed or pulled into an edge cache, its local availability saves ISPs from relying on international IP transit to repeatedly import the same content for future requests. Sometimes an edge cache is hosted by an IXP, in which case the cost of the international IP transit capacity for filling the cache is shared among the ISPs using the IXP. As the amount of traffic grows, each ISP may have its own edge cache that it pays to fill. In both cases, ISPs reap significant savings.

7. For more information on building a local digital economy, see Michael Kende, "Promoting the African Internet Economy" (Internet Society, 22 November 2017), https://www.internetsociety.org/wp-content/uploads/2017/11/AfricaInternetEconomy_111517.pdf

Figure 3. Percentage of Traffic Served Locally, January 2018–October 2019 (Source: Large CDN, 2020)



Another way a content provider may build out its network in a country is by deploying a PoP in the country that both delivers dynamic content and services, and fills edge caches with static content. In this case, the content provider peers with ISPs at the PoP, either through the IXP or directly. This both improves the delivery of content to end users and provides end users with direct access to content-provider services. The content provider arranges its own capacity to deliver the content, either buying it from other providers or, increasingly, building its own capacity. This model offers local ISPs significant cost savings, while also improving the quality of content and service delivery.

Figure 3. shows the benefits of deploying a PoP in Kenya and Nigeria. In both countries, the percentage of traffic served locally goes from zero to 80% in slightly more than six months. Note that the increase is not solely due to international traffic being replaced by local traffic. In the year after the PoP was deployed, monthly traffic grew nearly 140% in Nigeria and nearly 160% in Kenya—due in part to the significant drops in latency from accessing locally available content.

Content providers and their CDNs benefit from the significant economies of scale available to large international providers who build or access hyperscale data centers that store and process content, build or access submarine capacity to deliver that content, and then make it available locally in edge caches or PoPs. Local content providers, data centers, and hosting providers do not yet have this level of scale, compared to the scale available to content providers from Europe or the United States. As a result, most local content cannot be affordably hosted locally, thereby limiting the growth of both local content providers and the local ecosystem. This is a significant roadblock to fully developing the Internet ecosystem.

Table 2 . The Internet Ecosystem in Kenya, 2012–2020 (Sources: ITU, TeleGeography, KIXP, and CDN websites)

		2012	2020
Internet	Internet users: Fixed bb subscribers: Mobile bb subscribers: 500 MB prepaid (cap): Average download speed:	8.8 % .13% .42% US$5.92	17.8% (2017) .72% (2018) 41.92% US$2.42 (2017) Fixed: 18.17 Mbps Mobile: 21.65 Mbps
IXPs	**KIXP nodes (2000)** Number of peering networks: Peak traffic: **Asteroid IXP (2020)** Number of members: Peak traffic:	Nairobi, Mombasa 25 1 Gbps	Nairobi, Mombasa (2) 56 19 Gbps Mombasa 10 ~350 Mbps
Infrastructure	Submarine cables Intl b/w per user (bit/s): IP Transit average price Mbps (GigE, CDR = 1000):	SEACOM (2009) TEAMS (2009) EASSY (2010) LION1 (2012) 13,932 US$262.50	SEACOM TEAMS EASSY LION2 DARE1 (2020) Peace Cable (2021) 2Africa (2023) 386,743 (2017) US$25.53
Data Centers	Carrier-neutral	Internet Solutions	Cloudpap East Africa Data Center Gestalt Gild Kisumu Mombasa 1 Safaricom
Content Delivery Networks	International	Google Global Cache	Akamai Amazon Web Services Cloudflare Facebook Google Caches Google Edge PoP Microsoft Netflix

Success stories: Kenya and Nigeria today

Since 2012, both countries have experienced profound growth across all aspects of their Internet ecosystems, including their IXP, Internet access, and content infrastructures.

Following are more detailed descriptions of their parallel evolutions.

Kenya

During the past eight years, the percentage of Kenyan mobile broadband subscribers has increased 100-fold to nearly 42% of the population, while the price of data has decreased by 50% (Table 2).

International Internet bandwidth per user have increased by a factor of 25, its price has decreased by 90%, and, as of the writing of this study, two additional submarine cables are being built into Mombasa.[8]

The number of carrier-neutral data centers in the country has increased from one to six, most notably adding Africa Data Centres (ADC) in Nairobi, and iColo in Mombasa and Nairobi; and Google's local presence was joined by PoPs and edge caches from every major CDN. As a result, KIXP has grown from 25 to 56 peering networks, and traffic exchanged through the IXP increased from 1 Gigabit per second (Gbps) in 2012 to a peak of nearly 20 Gbps[9] in 2020. As much as they have grown, the measured traffic levels understate the total amount of traffic exchanged. A significant amount of traffic is exchanged through private network interconnects (PNIs) at ADC Nairobi, which hosts the exchange, and in Mombasa, where some of the CDNs are collocated.

KIXP has added a node in Mombasa, and the original node was moved to ADC Nairobi. KIXP Mombasa now has independent IXP locations at iColo MBA–1 and Telephone House, and KIXP Nairobi has become a distributed IXP with a primary peering location at ADC Nairobi and an alternative peering location at Internet Solutions' Chancery Building facility (Table 3). As per best practice, the Nairobi and Mombasa IXP fabrics are not linked, and networks in each city arrange their own transport to peer at the other city's IXP.

Table 3. KIXP Date Center, Membership, and Traffic Statistics, 2020 (Source: KIXP website)

City	Data center	Members	Peak traffic
Nairobi	ADC Nairobi	50	19.33 Gbps
	Chancery Building	2	n/a
Mombasa	Telephone House	4	n/a
	iColo	5	383.5 Mbps

8. The PEACE Cable by PEACE Cable company, which by 2021 will connect East Africa to Europe and Asia; and 2Africa by a consortium including Facebook, which by 2023 will connect Europe to most of Africa

9. KIXP data predate the COVID-19 crisis, during which peak traffic levels rose to 25 Gbps, with at least one spike of more than 50 Gbps.

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One factor in the increased growth of KIXP is that the mandatory multilateral peering agreement (MMLPA) requirement that was in place in 2012 no longer applies. This makes the IXP more attractive to a wider variety of members, as members are no longer required to peer with all members, but instead can pick and choose their peering partners.

A number of CDN PoPs are directly or indirectly connected to the IXPs in Mombasa and Nairobi, thereby providing ISPs with easy access to content. Current members of the exchange include Amazon, Facebook, Google, and Microsoft. Because members are not acting as local operators by selling services directly to end-users, they can install equipment without a license.

According to African Route-collectors Data Analyzer (ARDA)[10], Kenyan ISPs and regional and international networks are all reachable through the IXP or the hosting data center. In some cases, regional networks and ISPs are connected indirectly via regional carriers, such as Liquid Telecom that has backbone capacity in all of the countries of the East African Community, Egypt, and South Africa. It has plans to extend to Nigeria. Other international carriers include China Telecom, Hurricane Electric, PCCW, and Swisscom. Within the region, KIXP and its hosting data centers are appealing as a hub, because they offer diverse submarine-cable capacity landing in Mombasa, plus access to CDNs and other international content and services (For more information about KIXP, see Annex A).

An additional IXP, Asteroid, received a Kenyan license in 2020. It has a node in the iColo data center in Mombasa, where KIXP also has a node[11]. Asteroid is considerably less costly than KIXP—a 1 Gbps port speed at Asteroid costs $120 per month versus $450 at KIXP, and it offers a well-developed product supported by an intuitive, peering-oriented software platform used by other Asteroid IXPs. Potential plans include evolving the iColo node into a regional IXP providing access to networks from diverse locations in Africa and beyond.

Several stakeholders indicated that they would welcome a new regional IXP, and that they hoped KIXP would respond to a new level of competition with lower prices or new offerings.

10. The African Route-collectors Data Analyzer is an initiative aimed at advancing Internet measurements in Africa. Overall, the project seeks to leverage and support the deployment of globally recognized measurement infrastructure, tools, and services at defined vantage points in order to enhance the visibility of Internet packet flow and traffic exchange in the African region. https://arda.af-ix.net/ARP/index.php

11. See https://www.asteroidhq.com/ixp-locations/4

Table 4 . The Internet Ecosystem in Nigeria, 2012–2020 (Sources: ITU, TeleGeography, IXPN, and CDN websites)

		2012	2020
Internet	Internet users: Fixed bb subscribers: Mobile bb subscribers: 500 MB prepaid (cap): Average download speed:	16.10% 0.01% 6.79% US$12.75	42% .04% 30.68% US$3.27 Fixed: 11.93 Mbps Mobile: 16.04 Mbps
IXPs	**IXPN nodes (2006)** Number of peering networks: Peak traffic: **WAF-IX nodes (2018)** Number of members: Peak traffic:	Lagos 30 300 Mbps	Lagos (4), Abuja, Port Harcourt, Kano 71 125 Gbps Lagos 15 ~11 Gbps
Infrastructure	Submarine cables Intl b/w per user (bit/s): IP Transit average price Mbps (GigE, CDR = 1000):	SAT3 (2002) Glo-1 (2010) Main One (2010) 5,341 US$450	SAT3 Glo-1 Main One WACS (May 2012) ACE (December 2012) Glo-2 (2020) Equiano (2021) 2,255 US$27.45
Data Centers	Carrier-neutral		Excelsimo Galaxy Backbone ICN ipNX Layer3 Madallion Comm MDXi data centers (2) Rack Centre
Content Delivery Networks	International	Google Global Cache	Akamai Amazon Web Services Cloudflare Facebook Google Caches Google Edge PoP Limelight Microsoft Netflix

Nigeria

Similar to Kenya, Nigeria's Internet ecosystem has blossomed in the past eight years.

The percentage of Nigerian Internet users has increased from 16% to 42% of the population; and there has been a substantial increase in mobile broadband subscribers, based in part on a considerable drop in the price of data.

In terms of submarine cable capacity, two cables were lit shortly after the 2012 report was released; two more are scheduled to be operational soon, including one owned by Google. The average cost of international IP transit has decreased substantially—from US$450 to US$27.45. And where there were no carrier-neutral data centers in 2012, there now are a number of them, including several hosting nodes of IXPN in Lagos (Table 4).

Today, IXPN covers seven nodes: four in Lagos and one each in Abuja, Port Harcourt, and Kano. The Lagos nodes connect both to each other and to the nodes in the other three cities. Membership is spread across the nodes, with 38 in the largest Lagos node and from 3 - 18 in the three nodes outside the city. Connectivity is sufficient among the nodes in Lagos, but the cost of intercity capacity means that connectivity to the nodes outside Lagos is weak. While the connections between cities represent a departure from typical practices for an IXP, they are accepted specifically because of the challenges in intercity capacity. (For more data on IXPN, see Annex B.)

Table 5. IXPN Data Center, Network, and Traffic Statistics, 2020 (Source: IXPN website)

City	Data center	Peering networks	Peak traffic
Lagos	ICNL	2	125 Gbps
	Medallion	38	
	MDXI	11	
	Rack Centre	18	
Abuja	Medaillion	12	590 Mbps
Kano	Kano	3	60 Mbps
Port Harcourt	ICNL	4	0

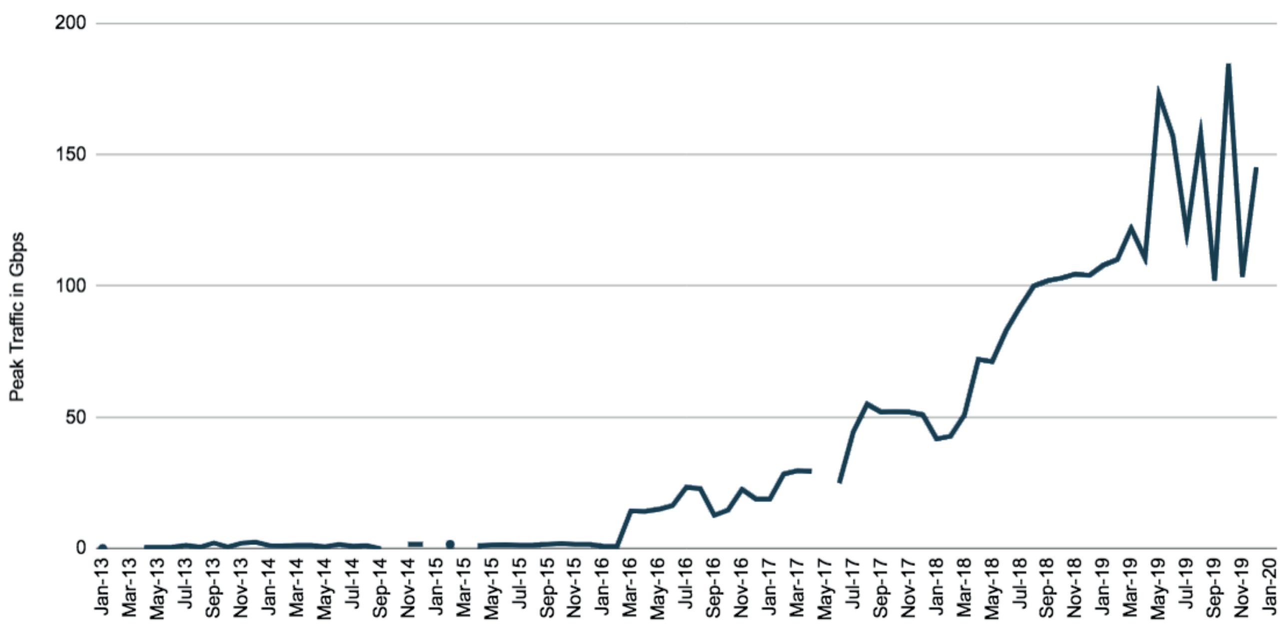
Nigeria's increase in traffic is even more remarkable than that in Kenya—from 300 Mbit/s traffic in 2012 to a peak traffic rate of 125 Gbps[12] in 2020 (Figure 4).

Several key factors contributed to Nigeria's rapid increase in Internet traffic. First, content providers are spread across the hosting data centers in Lagos, a configuration that by design promotes use of the IXP to connect between data center nodes rather than use PNIs within the data centers. Second, a requirement to have a Nigerian license to connect to the IXP is no longer applied, thereby enabling regional traffic to be exchanged via the IXP. In addition, as in Kenya, in 2019 IXPN lifted its MMLPA—peering networks are no longer required to peer with each other. This enabled a more flexible use of the IXP; new networks are more likely to join when they could choose with whom they could interconnect.

Today, IXPN peering networks boast international content providers Akamai, Facebook, and Google as members in Lagos; as well as international carriers China Telecom, Glo, and Main One. Early, positive experiences accessing content via IXPN convinced international content providers to increase their presence in Nigeria and helped build the level of content available in the country today.

Finally, in 2018, the West African Internet Exchange[13] (WAF-IX) opened in Lagos with a primary goal of helping content providers deliver content from their PoPs in Nigeria throughout the West African region. As an initiative of Main One and with the support of Asteroid, the new exchange is positioned to accomplish this by leveraging the submarine capacity of Main One and adding future nodes in Ghana, the Ivory Coast, and Senegal.

Figure 4. IXPN Peak Traffic in Gbps, January 2013–January 2020 (Sources: Euro-IX, IXPN websites)



12. IXPN data predate the COVID-19 crisis, during which one spike of peak traffic reached nearly 200 Gbps.
13. See https://wafix.net/

Results that stand the test of time

The main benefits of the IXPs in Kenya and Nigeria that were quantified in 2012—decreased latency, cost savings, and increased revenue for ISPs—not only hold true today, they are magnified by an exponential increase in demand.

Decreased latency

In both countries, the latency of traffic exchange remains less than 10ms, and as low as 2ms. This is a direct result of no longer exchanging traffic or accessing content in Europe or beyond—no longer traversing that length of fiber and its high number of network hops. The lower latency now applies to all the international content newly available locally in both countries.

Cost savings

The savings yielded by the IXP in Kenya are significant. In early 2020, almost 20 Gbps of traffic passed through KIXP, where the port charge of US$0.45 per month per Mbps (for a 1 Gbps port) is considerably less costly than using international IP transit at more than US$25 per Mbps (for 1 Gbps capacity). The result is a savings of at least US$6 million per year for the peering networks. This savings is at least four times greater than what was experienced in 2012, despite the far lower cost of today's international capacity.

This figure likely understates the cost savings for three reasons. First, significant traffic is exchanged at ADC Nairobi and in Mombasa collocation points using PNIs, and these savings are not included, despite being at least an indirect result of KIXP. Second, when local ISPs exchange traffic among themselves at the IXP, savings are doubled—one of them saves from not using IP transit for the outbound exchange, and the other saves from not using IP transit for the inbound exchange. Finally, the cost of using international transit to exchange traffic is not just the savings per Mbps of transit; the ISP may buy excess international capacity to get longer-run discounts, and to exchange traffic internationally needs to pay for colocation and cross-connect fees at a foreign data center and access to an IXP.

The savings in Nigeria are even greater. In early 2020, the port charge at IXPN is US$0.428 per month per Mbps (for a 1 Gbps port), while the cost of international IP transit is US$27.45 per Mbps per month (also for 1 Gbps capacity). To be able to access traffic or content at the IXP thus costs about US$27 less per Mbps per month than it would by accessing it abroad, and given the amount of traffic exchanged, this is a savings of over US$40 million per year. Although the cost of IP transit is much lower than it was in 2012, there is so much more traffic through the IXP that the savings have multiplied roughly 40 times from 2012.

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Increased revenue

Finally, the IXP is likely to help increase ISP revenues. As noted, lower latency increases usage, which increases data revenues. However, it is hard to attribute any increase in usage to any particular new source of localized content, and then to quantify the benefits. Nonetheless, in both countries the majority of international content is now localized, and thus benefits directly or indirectly from the IXP.

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Breaking records: The INEOS 1:59 Challenge

In October 2019, Kenyan athlete Eliud Kipchoge successfully broke the two-hour time barrier for running the marathon distance—a feat once thought impossible. The run was called the INEOS 1:59 Challenge, and the event was specially created for the challenge and held during the early hours in Vienna, Austria. Because this was not a scheduled race, it was not broadcast on television. Still, millions of proud Kenyans were able to watch the groundbreaking event both live and on video afterwards.

YouTube live-streamed the event via its PoP in Kenya, which in turn distributed the content via KIXP. In commemoration of the event, Safaricom, Kenya's biggest telecoms provider, offered a free bundle of YouTube data (1.59GB) to its more than 33 million subscribers, enabling them to stream the event for free. Ben Roberts, chief technology innovation officer of Liquid Telecom, a pan-African purveyor of high-speed connectivity, data centers, and digital services, celebrated the event by tweeting that Liquid Telecom had streamed the highest-ever amount of YouTube traffic in the country.

Thanks to the strength and maturity of the Kenyan Internet ecosystem, millions of Kenyans were able to celebrate the feat of their countryman and bask in national pride.

Change factors: Replicable steps toward measurable outcomes

There were a number of significant changes in each country. The headline change is a shift from the end of Stage 1 of development in 2012 to the end of Stage 2 in 2020.

Overall, in both countries the ratio of localized traffic flipped from approximately 30% local and 70% international at the time of the first study, to 70% local and 30% international in 2020. In this section, we share the factors and insights—for IXPs, the industry, government, and users—that raised each country's Internet ecosystem to where it is today.

The role of the Internet Exchange Point

One constant across the two countries is in the governance of the IXPs. Both have the same chief executive officers (CEOs) as they did in 2012: Fiona Asonga at KIXP and Muhammed Rudman at IXPN. Both CEOs are overseen by a board of members, and both have built strong teams that help them to operate and develop their IXPs. A number of stakeholders in Nigeria commented positively on the strong and steady leadership at IXPN. The importance of solid management and governance cannot be understated—it is a critical component of attracting networks to the IXP, due to the trust needed to rely on the IXP for traffic exchange.

Each IXP took a number of proactive and replicable actions in order to expand its membership and increase its traffic volume.

1. Both IXPs removed their MMLPAs.

By removing their MMLPAs, each IXP enabled operators to select with whom they peered.

Under an MMLPA, a large operator cannot both sell transit and peer with the same, smaller ISP. Having to choose between selling transit or mandatory peering with a customer may inhibit large ISPs from joining an IXP. Likewise, the largest ISP in a country may avoid joining an IXP with an MMLPA so as to avoid having to peer with the country's smallest ISPs, even if it was not selling them transit. By removing their peering requirements, and initiating self-selective peering models, both IXPs experienced an increase in member numbers.

2. Each IXP manages its growth along multiple dimensions.

Each IXP established multisite locations in the same city and IXPs in new, local markets. This included—perhaps most important—a move to at least one carrier-neutral data center.

Data centers can host an IXP's peering infrastructure, where peers can easily connect to ISPs, CDNs with an edge cache, and content providers with a PoP. Note that if an ISP and a content provider are in the same data center, when their traffic increases to more than 1 Gbps to a single ISP, they may move to a PNI, in order to connect directly rather than via the IXP.

In Kenya, PNIs are commonly used in ADC Nairobi, where the KIXP node is hosted. This is the main node in Nairobi, and, as a result, all of the ISPs and many of the content providers also are located in ADC Nairobi. While this reduces the amount of traffic going through the IXP, it does not diminish its value. On the contrary, KIXP acts as a magnet to help attract stakeholders to ADC Nairobi. Any form of local interconnection is important, including private interconnection. There is always a role for KIXP; for example, smaller networks may not be able to afford multiple PNIs, and other networks will still connect to the IXP for its resilience.

The use of PNIs is less common in Nigeria, primarily because the three main IXPN nodes are distributed across three data centers in Lagos, and the main content providers are distributed across those data centers. This makes it possible for ISPs to use the IXP to connect to content providers in other data centers. At least one large ISP uses a PNI to one of the large content providers, as they are in the same data center, but it also connects to the content provider via IXPN for resilience and to share the load between the connections.

Still other CDNs are accessed via IXPN, particularly by the smaller ISPs, who are attracted by the cost savings of using one connection to the IXPN, rather than multiple PNIs to connect with content providers. PNIs incur monthly cross-connect fees in data centers, an additional operating expenditure that smaller operators may find discouraging. To provide the benefits of a PNI without the cost, the IXPN is planning to install technology that enables virtual local area networks (VLANs), in order to effectively enable virtual PNIs through the IXP.

Tip: IXPs should consider that a potential effect of establishing a multisite IXP in several data centers is increased traffic across the IXP, as providers move away from PNIs to use the multisite IXP. This growth in traffic may increase operating expenses, and should be accounted for in the plan.

3. Both IXPs have nodes in other cities.

In addition to their presence in the main cities of Kenya and Nigeria, both IXPs have nodes in other, smaller cities. Given the differences in geography, the impact of this is different in the two countries. In Kenya, submarine cables land in Mombasa—486 kilometers (km) from Nairobi, the country's capital city and business hub. In Nigeria, the submarine cables land in Lagos, the country's main city and business hub, 699 km away from its capital city of Abuja. In both countries, intercity backbones are expensive, and the challenge of transporting traffic from the coast to the inland cities remains.

In Kenya, KIXP has nodes at one of the landing stations in Mombasa and at a data center in Mombasa, where several content providers have established PoPs. KIXP does not have capacity between KIXP Nairobi and KIXP Mombasa, nor does it have capacity between the two IXP nodes in Mombasa. This reflects an international best practice to avoid situations in which an IXP competes with carriers linking two cities. In order to bring content from content provider PoPs in Mombasa, ISPs in Nairobi have the following options:

- If they have their own capacity, they can use it to transport the content directly.
- They can purchase transport to get to the PoPs in Mombasa.
- They can pay an ISP to bring the content to them in Nairobi.

Every option adds cost, given the relative expense of domestic backbone capacity. However, this cost is decreasing, as more capacity is being built between the cities.

In Nigeria, IXPN has capacity that connects its nodes in Lagos to Abuja. The cost of connectivity between Lagos and Abuja is twice the cost of Lagos to London for the same capacity, according to one ISP. Given the considerable cost, there is not sufficient capacity to transport all the content, so quality of service is frequently either poor or expensive to provide or both. The same is true for the other population centers of Nigeria, including Kano and Port Harcourt, where IXPN also has nodes. This limits the value of IXPN nodes outside Lagos, and means that ISPs must access the traffic in Lagos. As it is also expensive for providers to transport content between the cities themselves, there is a significant gap in the connectivity between cities. An alternative would be for the CDNs to put edge caches in other cities, notably Abuja. This would alleviate the strain on the IXP's capacity, although there would still be the need for more intercity capacity.

While it is common for IXPs to connect multisite IXPs within a city, as is done in both Kenya and Nigeria, it is neither typical nor best practice for an IXP to provision capacity to connect cities, as is done in Nigeria. This is seen as providing telecom services in competition with the services of some of the IXP's own members. In this case, however, a number of the stakeholders in Nigeria accepted that the country's overall lack of capacity presented a unique challenge, one which the IXP was helping to alleviate. To help prevent crowding out of carriers, IXPN enacted a rule that members are not allowed to exchange their own traffic between cities using IXPN capacity.

4. Both IXPs exchange regional traffic.

By exchanging regional traffic, both IXPs are able to leverage access to content and the availability of capacity at the landing stations. In the case of Kenya, this represents progress, as it was already being used for regional traffic in 2012. Today, the country enjoys significantly more content, as well as regional cross-border fiber to neighboring countries. Nigeria, however, had no regional traffic by design in 2012, as a local license was required to exchange traffic. This requirement was removed in 2018, and, today, regional ISPs are able to access traffic at the IXP.

5. Both IXPs assist with capacity building.

Capacity building is a significant factor in improving connectivity in each country. Both IXPs assist with capacity building in an effort to teach ISPs and others about the benefits of peering at their exchanges, an effort that is furthered by the demonstrable benefits felt by all players in the ecosystem. The Internet Society assists in these efforts in a number of ways, including papers such as this one, local and regional workshops, support of Network Operator Groups (NOGs), local peering road shows, and the organization of the African Peering and Interconnection Forum[14] (AfPIF).

6. IXP competition is emerging in both countries.

In both countries, new IXPs are being developed with the involvement of emerging provider Asteroid. In Kenya, Asteroid received an IXP license similar to the one that KIXP has, and offers lower-priced domestic services and regional connectivity. In Nigeria, the carrier MainOne has started the West African IX (WAF-IX) with the support of Asteroid. WAF-IX is aimed at regional traffic exchange using the MainOne

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14. The African Peering and Interconnection Forum addresses the key interconnection, peering, and traffic exchange opportunities and challenges on the continent and provides participants with global and regional insights for maximizing opportunities that will help grow Internet infrastructure and services in Africa. It celebrated its 10-year anniversary in 2019. https://www.afpif.org/

subsea cables along the coast connecting Nigeria to neighboring countries. In both cases, the emergence of a new IXP shows the maturation of each country's overall ecosystem and its growing role as a regional hub for fiber capacity and content.

The role of the industry

The industry has played a significant role in the evolution of the Internet ecosystem in both countries. This is true for Internet access infrastructure as well as content.

In terms of access infrastructure, new submarine cable cables have been and continue to be deployed as capacity prices fall, which has lowered the cost of IP transit to fill edge caches and enabled international content providers to build out PoPs in the countries. Internet access is also more available and affordable, increasing the demand for Internet services and creating economies of scale for providers. These actions all contribute to an enabling environment for improvements in the Internet ecosystem.

In terms of content infrastructure, in both countries at least one carrier-neutral data center has been built. Such data centers are typically served by multiple fiber providers, so that there is competition and redundancy in accessing the data center. In turn, these data centers serve at least two roles.

1. At least one node of each IXP is hosted in a carrier-neutral data center, as part of a mutually beneficial relationship. The data centers clearly benefit, because it helps to attract ISPs and content providers to host in the data centers. As a result, typically the data centers provide the IXP with free space in the data center and possibly other services. The IXP benefits from the free collocation, as well as proximity to peering networks.
2. The international content providers benefit from the neutrality of the data center in terms of fiber access, as well as access to ISPs and the IXP.

The decision of the international content providers to place edge caches and PoPs in the countries has directly driven the shift to more localized traffic. It is the business of the independent CDNs to distribute their clients' content closer to end users, and an element of that is building out edge caches into countries with sufficient demand, including Kenya and Nigeria.

More recently, however, the largest content providers, including Facebook, Google, Netflix, and others, have begun to build out networks to deliver their own content. Google was early with the Google Global Cache (GGC) program, which represented the first international content presence for both Kenya and Nigeria eight years ago. More recently, others, including Google and Facebook, are building out PoPs and deploying caches. In order to enhance content delivery to the PoPs, these same companies are beginning to invest in submarine cable capacity, with Google's Equiano cable due to come online in Nigeria in 2021, and the recently announced 2Africa cable, built by a partnership including Facebook, will circle Africa, connecting Kenya, Nigeria, and a number of other countries to Europe and the Middle East.

These network build outs clearly benefit the greater Internet ecosystem. The networks help to reduce the latency of delivering traffic to ISPs in the countries, and help to reduce cost for the ISPs. This, in turn, promotes usage of the content. In addition, moving the content closer to the countries increases the resilience of the network, for instance allowing content to be served from the local caches if a subsea cable is cut, although the content may not be refreshed as efficiently.

End users benefit from better access to content, and the costs savings for ISPs may be passed on in the form of lower data prices, larger data packages for the same price, or availability of extra capital for expanding last-mile access. Kenya already enjoys special data pricing of services such as Facebook, WhatsApp, and YouTube—usage of these services does not count against the subscriber's data plan. This is made possible by a local presence, where ISPs can access the edge cache or PoP directly using peering instead of expensive international IP transit.

The role of the government

Government policy and regulation has a significant impact on the development of a country's Internet ecosystem. The regulator can determine the nature of entry and competition in telecom markets, including fixed and mobile broadband and backhaul, and the subsequent level and focus of investment in those markets. In addition, government policy directly effects the willingness of content providers to host content in a country. Finally, broader policies effect the affordability of services.

Open markets

In terms of telecom regulations, both countries have open markets, enabling multiple submarine cable landings by diverse owners, backhaul deployments, and mobile broadband services. In terms of KIXP, Kenya requires a license, which is fairly unusual among African countries, but there appear to be few obligations or impacts of the license, and a second license was recently granted to Asteroid. Both countries help to promote regional use of the IXP by not requiring ISPs from abroad to obtain licenses to exchange traffic at the IXP—a license would only be needed to sell services in either country, as with any other operator.

Data protection

In terms of content, Kenya passed a data protection act in November 2019, an important milestone for creating online trust and helping to attract content providers.[15] It is compliant with the European Union General Data Protection Regulation (GDPR), which will enable personal data on EU citizens to be hosted and/or processed in Kenya, once the law is implemented. In Nigeria, the National Information Technology Development Agency (NITDA) issued the Nigeria Data Protection Regulation (NDPR) in January 2019, which applies to content hosted or processed by Nigerian citizens or residents[16].

Internet adoption and usage

A government can heavily impact Internet adoption and usage, thereby creating the supply of, and demand for, traffic through an IXP. For example, it may make Internet access more affordable by removing high taxes in order to lower the cost of devices and Internet service. Or, by lowering the cost to deploy networks and provide service for operators, thereby making it easier to import equipment and obtain access to rights-of-way. Kenya already has been making efforts to lower the costs of both access and devices.

The remaining roadblocks to moving into development Stage 3 are common ones. First, as noted, local content is often hosted abroad, which keeps available content from localizing. For Nigeria, this includes enterprise and government content that, if hosted locally, could add to economies of scale to drive down costs. What's more, the cost of intra- and intercity capacity is still quite high, which leaves the small ISPs located outside the cities where the content is hosted at a disadvantage. Efforts to increase Internet adoption and usage outside the main cities would broaden the benefits and generate more economies of scale.

Localized content

Governments can play an important role in localizing content. As noted in the 2012 report, the Kenya Revenue Authority was an early participant at KIXP, providing all ISPs with good connections to the Authority, which reported significant benefits for individuals and enterprises filing taxes. Since then, Kenya has been implementing a digital economy blueprint that will strengthen its digital growth.[17] The government has significantly increased its number of online services to more than 200, thereby increasing the value of the KIXP for others and creating demand for local hosting and development. These services are increasingly in the cloud and must be locally hosted, which helps create demand for local data centers.

15. See Data Protection Bill, 2019, http://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/2019/TheDataProtectionAct__No24of2019.pdf
16. See https://nitda.gov.ng/wp-content/uploads/2019/01/NigeriaDataProtectionRegulation.pdf
17. See https://www.ict.go.ke/wp-content/uploads/2019/05/Kenya-Digital-Economy-2019.pdf

Kenya's mandated migration of television broadcast channels from analog to digital enabled a more efficient use of spectrum, which paved the way for more than 50 new channels and had an unintended, but positive impact on local Internet content. Many channels are creating their own content at local digital centers, and this content may be streamed or broadcast, some by a local streaming service provider (e.g., Viusasa). While all the new video content developed is not yet hosted locally—streaming may go through YouTube or another international provider - it is locally accessible via the international platforms.

Nigeria is not yet at this level of localized content. The government of Nigeria does not have the same availability of e-government services and those that are available may be hosted outside the country. Nonetheless, there is a data localization requirement that requires e-government services to be hosted locally, which when fulfilled can provide further local content for the ecosystem. Further, while Nigeria boasts a significant entertainment industry in movies, as well as in music, local content is still hosted abroad, including Nigerian entertainment content.

Expanded markets

Governments can create larger markets as part of regional integration. For example, the East Africa Community and the East African Communications Organisation are conducting work on regional data connectivity and increasing awareness of its benefits, which would include Kenya. Regional coordination has increased the number of cross-border terrestrial cables. While this activity is not yet taking place around Nigeria, the country does benefit from a significantly larger domestic market than exists in Kenya.

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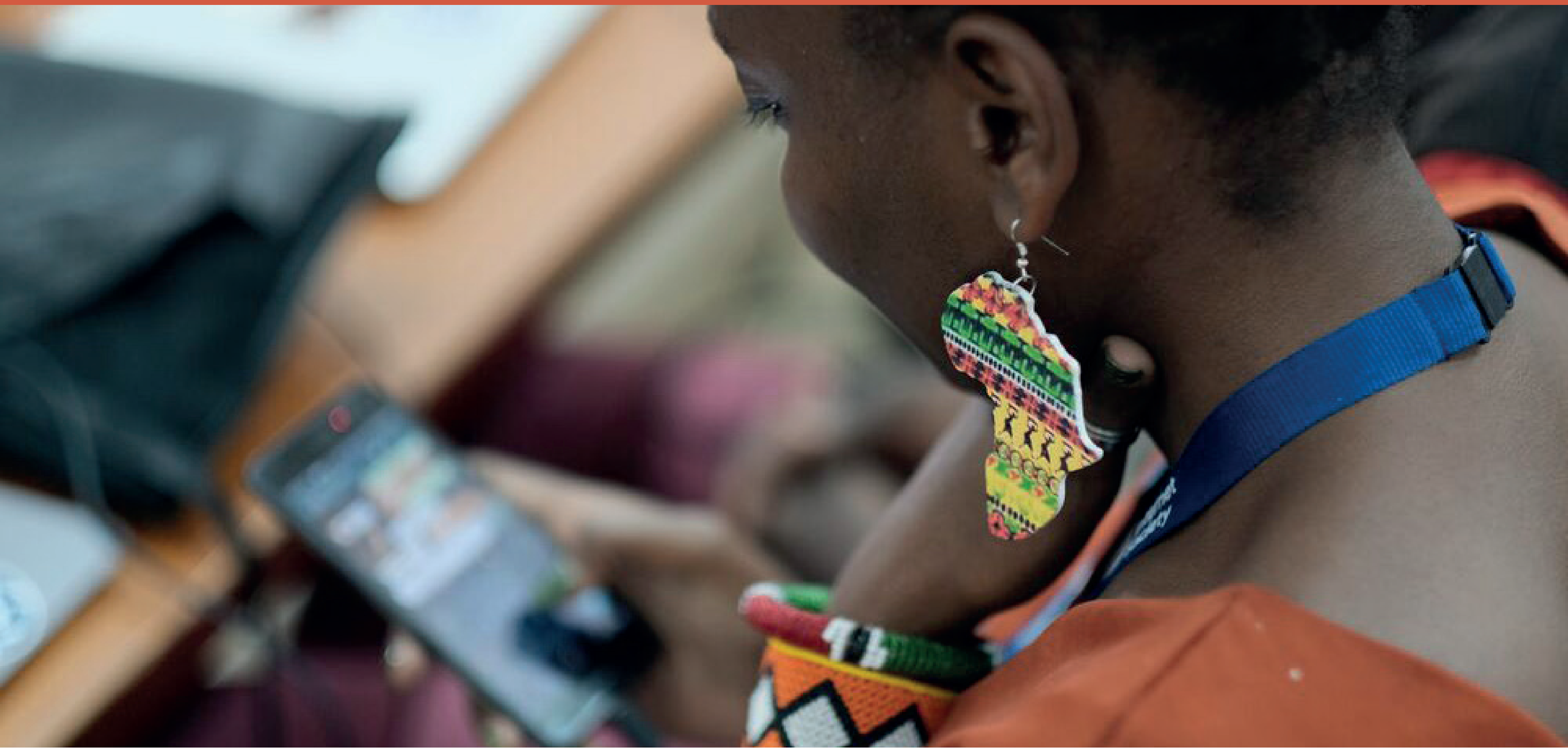

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The role of the user

In both countries, users have helped to drive change and have benefitted from those changes. First, increased adoption and usage of the Internet is creating an increased amount of demand for access to online content and services. Users are taking advantage of inexpensive smartphones to access the Internet via mobile broadband, and are using inexpensive devices to stream online video at home. In addition, online services enable businesses and employers to make innovative use of social media, such as using Instagram and WhatsApp for marketing, community building, and communication.

In turn, users are rewarded by a broader and deeper online ecosystem. The increased content availability enriches the online experience, and local hosting lowers latency and improves the resilience of the services. In addition, the cost savings from the IXP can be passed on to the users in the form of lower prices for mobile data and/or larger data packages. For example, special pricing for online services in Kenya, such as WhatsApp, lowers online costs for subscribers because usage does not count against their data packages.

Market gaps

The ecosystems in both Kenya and Nigeria have evolved significantly since 2012, and in positive ways that would have been difficult to predict eight years ago.

Specifically, the build out of every large international CDN has included both countries. There are, of course, still steps that some may take, such as installing a PoP to complement a cache or building out to other cities in the country, but these are matters of degree. They are likely to be driven by demand, but would benefit from lower intercity transport costs. This is significant progress that provides benefits for connected ISPs and their users.

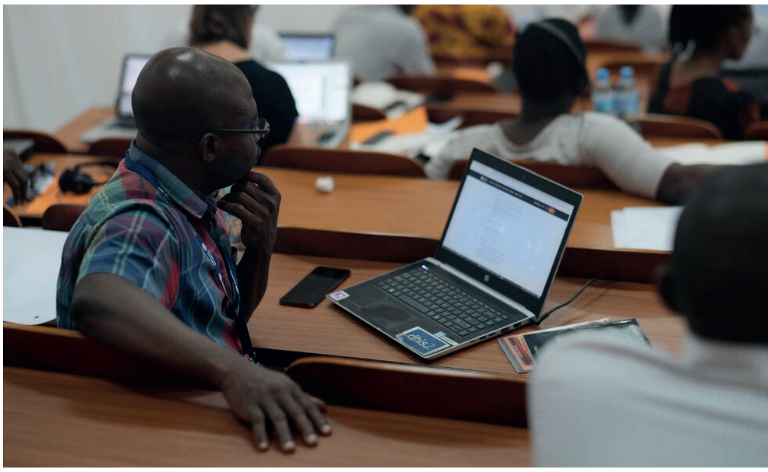
There are, however, two groups who are not participating fully in the local ecosystems of their countries: local content providers and small ISPs. Their increased participation would not only provide them with benefits in terms of increased users and usage, but would most certainly push both countries into Stage 3 of development and help fulfill the 80/20 goal of the Internet Society, a true milestone in the development of the Internet in Africa.

Local content providers

Local content providers are still hosting their content abroad with large companies. For instance, they might purchase a domain name (e.g., .com) from a big registrar, such as GoDaddy, and take an attractive offer for hosting with unlimited capacity at prices that could not be matched at home. Or a content provider might work with a local developer, who aggregates the websites they are developing and hosts them outside the country, again, where it costs less. By one estimate in Nigeria, it is three times more expensive to host locally than abroad.

To be fair, some websites, such as local newspapers, have a significant expatriate audience outside the home country that may be better served by foreign content hosting, even if it is at the expense of quality at home. However, others have begun to use CDN services to distribute the content and ensure both local availability and availability for expatriates.

In Nigeria, one of the main mobile ISPs has a free television offering, but it is hosted in the United Kingdom, without even a local cache. Even real-time television would go abroad before streaming back into the country. The provider noted that as demand grows, they will explore hosting locally. On the other hand, there are already television channels streaming local content locally.



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The issue is that local data centers tend to be more expensive to operate than ones in Europe or North America. This is not just because of scale, but because of the cost of electrical power from the grid; and in Nigeria, because of the cost of continuously operating the backup power given the poor reliability of the grid. Local hosting providers, in turn, do not have the scale of the large international ones, and thus local content providers may turn to free international platforms such as YouTube for hosting, which reduces the addressable market for local providers.

However, there are exceptions. A sports-betting company in Kenya is locally hosted, and connected to KIXP as a result of assistance and support from the IXP. The reason is that online betting is latency sensitive. Local hosting, therefore, is a business imperative, the benefits of which can help pay for the hosting. At least one betting company is hosted in Nigeria at present, but it connects through an ISP rather than directly to IXPN; we understand that additional betting companies are investigating local hosting.

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In addition, local enterprises are using cloud services that are hosted abroad. While they save on the capital costs of building their own services, they are increasingly less willing to accept the latency that goes with hosting abroad. Hybrid services do exist, in which data is hosted locally, but service is provided from abroad. However, an increased amount of local hosting is likely to develop over time to benefit from the lower latency. In turn, local enterprises may also use IXPs to gain access to content hosted by other providers, and should be targeted alongside government and education services when promoting the value of the IXP.

Small ISPs

Small ISPs would benefit significantly from directly connecting to an IXP: by peering as widely as possible to access content and traffic, thereby reducing the transit they would need to purchase in order to access the broader Internet. Unfortunately, small ISPs may not have the capacity or the resources to take advantage of an IXP. To start, they may not understand the benefits of peering and the opportunity to do so. As a result, most small ISPs still purchase their upstream access from a large ISP, despite the fact that they indirectly benefit from peering in the likely case that large, upstream ISP uses the IXP to peer.

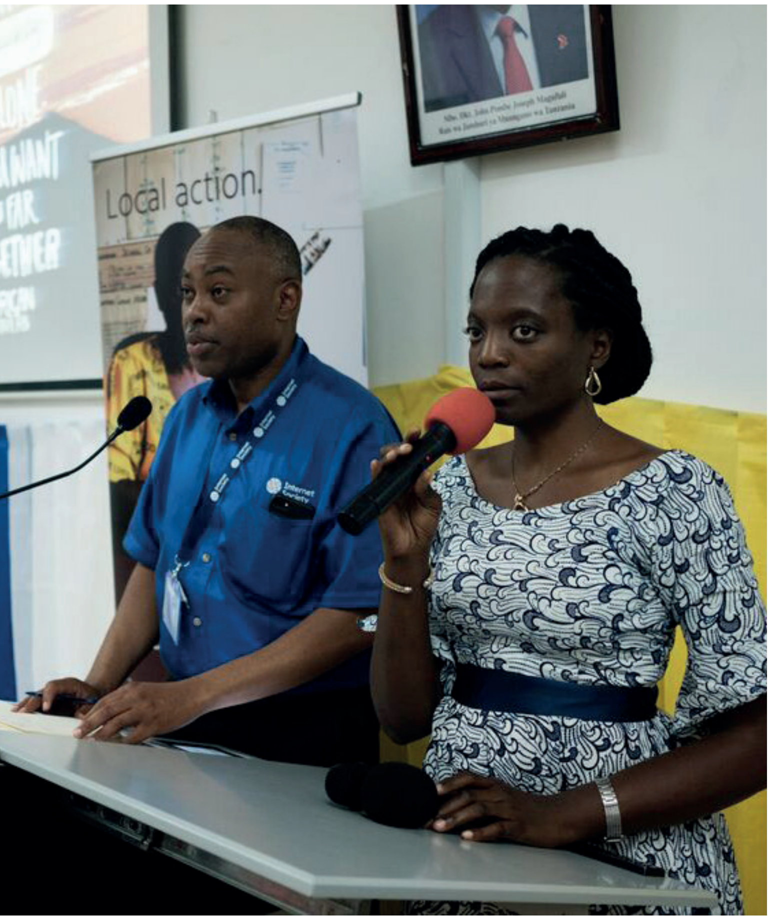
In Kenya, some small ISPs have indirectly discovered the presence of the large international content providers and have translated it into a demand for so-called CDN links. These links allow access to the CDNs' content through a larger ISP, content that can amount to more than 50% of the traffic demanded. This is a form of paid peering or partial transit. And while this is a useful service for small ISPs, it also is one that they could arrange for themselves at the IXP with settlement-free peering.

Even if small ISPs fully understood the possibilities of peering at an IXP, some ISPs may not be in a position to benefit from it. The cost of accessing the data center and the IXP within it may be out of reach, leading to a reliance on transit. This would be compounded if the ISPs were not in the main city of the country, and needed to arrange for transport to the IXP node and related content.

Recommendations

Stakeholders in other African countries have an unparalleled opportunity to learn from the experiences in Kenya and Nigeria—both countries have made tremendous strides since 2012 toward strong, healthy, Internet ecosystems, and are reaping the rewards.

Yet, more is possible. In order to reach Stage 3 of IXP development, both countries must increase their localized content past 70%. Following are the Internet Society's recommendations for Kenya and Nigeria, and developmental best practices for all countries seeking to increase their localized traffic exchange between Internet service providers and to attract content providers for more efficient content delivery through their IXPs.



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1. Leverage the relationship between IXPs and carrier-neutral data centers.

IXPs tend to come before data centers, and can help facilitate their development. From there, a data center may host the IXP along with the network PoPs, including ISPs, CDNs, and enterprises. This, in turn, enables the networks to peer publicly using the IXP and privately using PNIs within the data center. As the IXP expands to comprise multiple nodes in data centers in the same and other cities, its nodes may grow in importance such that they enable networks in one data center to peer with networks in other data centers.

2. Ensure sound governance of the IXP.

This is crucial to effectively manage the IXP's future membership, traffic, and node growth. Prioritize keeping costs affordable, upgrading equipment when necessary, innovating and improving on existing services, and keeping the IXP running smoothly. It is also important to provide capacity building, so peers, prospective networks, and the local technical community are aware of the benefits of peering at the IXP and apprised of changes and upgrades.

3. Create economies of scale to lower costs.

Large international content providers have the scale to extend their networks into multiple countries, a significant benefit for the ISPs and their subscribers in those countries. IXPs are important enablers for these transitions. Similarly, the largest ISPs in the country may build or buy capacity at submarine-cable landing stations and between cities in order to more efficiently receive and deliver content through the country.

4. Increase awareness among small ISPs and local content providers.

Local content providers and smaller ISPs frequently lack the awareness to take advantage of the benefits of an IXP and the scale to do so efficiently. Smaller ISPs lack both the traffic for volume discounts in buying capacity and the means to build their own. Likewise, small content providers have insufficient scale to lower the cost of local hosting. Awareness drives demand. The following steps toward increased awareness pave the way toward aggregating demand in order to apply scale economies.

- Promote to smaller ISPs the benefits of peering at the IXP (lower upstream transit costs), and promote to local content providers the benefits of local hosting (lower latency and increased usage). It is particularly important to engage the local content providers, their developers, and data centers, to ensure that they understand the tradeoffs involved in hosting abroad and the opportunities for doing so at home. Capacity building may take place at the IXP, and it also may take place at Internet Network Operator Group (NOG) meetings, which attract smaller ISPs.
- These efforts may also focus on enterprises, government, educational, and other nontraditional services and applications. Local enterprises should understand the benefits of locally hosted content and cloud services, including decreased latency, resilience in case of submarine cable cuts, and a lower cost of support using local services. This awareness is best developed via capacity building for the industry, and by demonstrating the benefits with existing and new clients.
- Create partnerships between IXPs and key stakeholders, including government and research and education networks. These partnerships can help build awareness by hosting forums on peering and interconnection, or by convening content providers and providing a location for meetings. IXPs also can encourage local organizations, government services, and businesses, to join the IXP and benefit from its connectivity.

In Nigeria, IXPN is an active participant in NG NOG, the Nigerian Network Operators Group. And the Nigeria Internet Registration Association (NIRA), the registry of the country code top-level domain .ng, educates local content providers on using .ng for local content (instead of .com) and hosting that content locally. Similarly, data centers and local hosting providers help raise awareness of IXPN. Commercial data centers in Nigeria play an important role in localizing Internet traffic. For example, Rack Centre promotes local interconnection by granting free cross connects into the IXPN node hosted in its facility.

- For example, in Kenya, KIXP successfully encouraged the Kenya Revenue Authority to join in 2009, and more recently supported the membership of a local betting company; Technology Service Providers of Kenya (TESPOK), the parent organization of KIXP, provided support for a local CDN, Angani.
- Conduct government-sponsored trials. For example, the government of Rwanda conducted a trial in conjunction with the Internet Society to demonstrate the benefits of local content hosting.[18] The results should then be broadly conveyed to the industry via the awareness-building exercises.

18. Michael Kende and Bastiaan Quast, "The Benefits of Local Content Hosting: A Case Study" (Internet Society, May 2017), https://www.internetsociety.org/wp-content/uploads/2017/08/ISOC_LocalContentRwanda_report_20170505.pdf

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5. Enable aggregation.

Once awareness is built, a number of possible avenues for aggregation emerge.

- **Capacity in and between cities.** On the supply side, encourage wholesale providers to build or buy capacity at scale, and make it available to smaller players at advantageous rates. On the demand side, have smaller ISPs pool their demands in order to buy capacity at bulk and enjoy volume discounts, or coordinate with a third-party to aggregate the demand and arrange for the supply.
- **Content hosting.** Focus on ways to aggregate smaller local content providers and acquire hosting services for them. For example, to build on increased awareness, website developers could help their customers aggregate and negotiate better rates in their country. For those websites abroad, a shared cache in one or more local data centers that is connected to the IXP could help lower the costs of localizing content.

6. Government action to broaden the market.

The government can make the local ecosystem more attractive to smaller ISPs and content providers by lowering costs and increasing demand. These efforts will also help the broader ecosystem already present and operating in the country.

- **Fiber deployment costs.** Metro and intercity rights of way are often expensive and time consuming to access. The government can provide access to its own rights of way—whether along roads or highways, railroads, electricity transmission infrastructure, or other networks—and require providers to share the cost of deploying passive infrastructure, such as ducts for fiber, that they can all use. In Nigeria, work is being done on harmonizing rights-of-way in an effort to lower both access costs and administrative time.
- **Data centers.** Reliable and affordable power is a key cost constraint—one estimate provided to us claimed that hosting costs three times more in Lagos than in Europe. Governments can help address these challenges. In addition, encouraging government services and large enterprises to host locally will help to create economies of scale for data centers and increase the amount of local content. Governments can also develop data protection policies that will help to create trust for hosting content and services locally.
- **Internet adoption and usage.** Efforts to increase Internet adoption and usage should increase. In addition to the obvious benefits, greater adoption and usage help to create demand and scale for ISPs and local content providers. Increased local content, in turn, helps to create demand. Actions could include lowering taxes on handsets and data services, and enabling community networks.[19]

19. For more actions, see "A Policy Framework for Enabling Internet Access" (Internet Society, April 2017), https://www.internetsociety.org/wp-content/uploads/2017/08/bp-EnablingEnvironment-20170411-en.pdf Stephen Song, Carlos Rey-Moreno, and Michael Jensen, "Innovations in Spectrum Management" (Internet Society, 3 April 2019), https://www.internetsociety.org/resources/doc/2019/innovations-in-spectrum-management Kende and Rose, "Promoting Local Content Hosting to Develop the Internet Ecosystem." "Unleashing Community Networks: Innovative Licensing Approaches" (Internet Society, May 2018), https://www.internetsociety.org/wp-content/uploads/2018/05/Unleashing-Community-Networks_Innovative_Licensing_Approaches-2.pdf

Conclusions

The progress in Kenya and Nigeria since 2012 has been significant. It highlights how an IXP can play a key role in developing the Internet infrastructure, along with the role that all stakeholders can play in growing their country's Internet ecosystem.

This paper demonstrates the general day-to-day value of the IXP in the Internet ecosystem of each country, and the present COVID-19 crisis magnifies the benefit in enabling increases of traffic to accommodate the changes brought about by social distancing and lockdowns.

In 2012, both countries were in Stage 1 of development, with about 30% of traffic localized, and were poised to move into Stage 2. Each country already had a strong base for growth, including an existing IXP that was well-managed and trusted by the local stakeholders. Each country also had its first international content available, namely a Google Global Cache. And finally, each had the necessary infrastructure to grow as a hub, including notably diverse submarine cables landing in the country.

In 2020, both countries have reached Stage 2 of development—approximately 70% of traffic is localized, and they are poised to move to Stage 3. Their IXPs have transformed into multisite and multicity IXPs with at least one node in a carrier-neutral data center. All of the large international content providers have at least an edge cache in the country, and many have a PoP. While the respective IXPs sat at the center of this expansion by enabling traffic exchange, a significant amount of traffic was exchanged privately within the data centers that host the IXP nodes. Finally, government actions further promoted the ecosystems.

To move forward into Stage 3 of development, in which more than 70% of traffic is localized, will require several further developments.

- Local content developers, including the government in some cases, who are hosting their content outside the country, will need to bring it 'home' to increase local traffic.
- Smaller ISPs in the countries will need to connect to the IXPs to increase the efficiency of their interconnections.
- Domestic infrastructure will have to be extended beyond the main landing point for submarine cables and into the other major population centers.

These developments will require awareness of the benefits of local content hosting and traffic exchange at the IXP, which can be achieved via targeted capacity building and information exchange. Then, to lower the cost of access, aggregation of demand will help to lower the cost of local content hosting, and also help access backbone capacity at lower costs.

This history of positive steps in Kenya and Nigeria and set of future actions should act as a blueprint for other countries to develop their Internet ecosystems and move through the stages of development. Together, as countries began to localize increasing amounts of content, the 80/20 goal of the Internet Society and African Internet community can be realized.

Annex A: Kenya Internet Exchange Point

Figures 5–8 show both the autonomous system numbers (ASNs) reachable via each IXP in the system and the IP prefixes announced at the IXP. As such, they offer an overview of the geographical distribution of the networks available at KIXP from local, regional, and international perspectives. More than 62% of all ASNs and more than 68% of IP prefixes assigned to Kenya are potentially reachable via KIXP. This means that most of the Kenyan Internet networks are accessible locally via the KIXP. On a regional level, as of November 2019, 30% of African networks outside of Kenya are potentially reachable via KIXP. From an international perspective, more than 90% of the total prefixes and 80% of the total ASNs potentially reachable via the IXP are from outside of Africa, highlighting the value of connecting to the KIXP to access large parts of the Internet.

Figure 5. Local ASNs Visible at KIXP (Source: ARDA, November 2019)

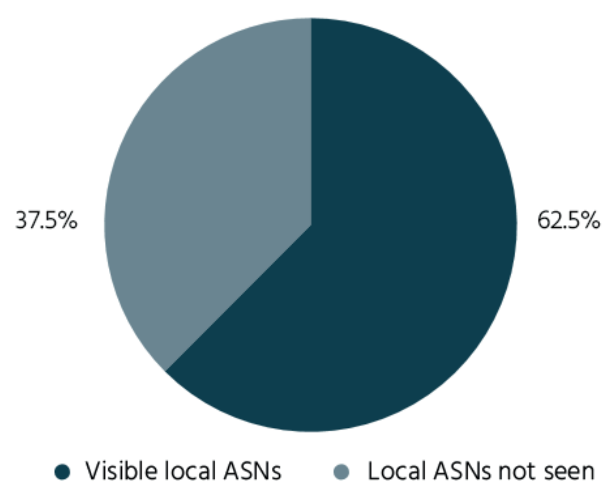


Figure 7. Local Prefixes Visible at KIXP (Source: ARDA, November 2019)

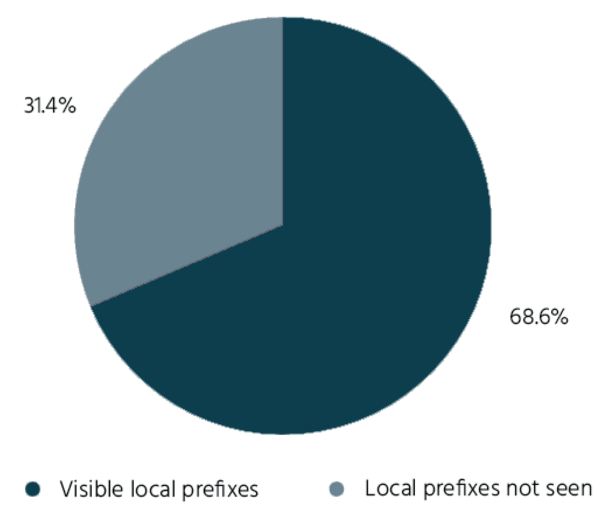


Figure 6. ASNs Visible at KIXP per Regional Internet Registry (Source: ARDA, November 2019)

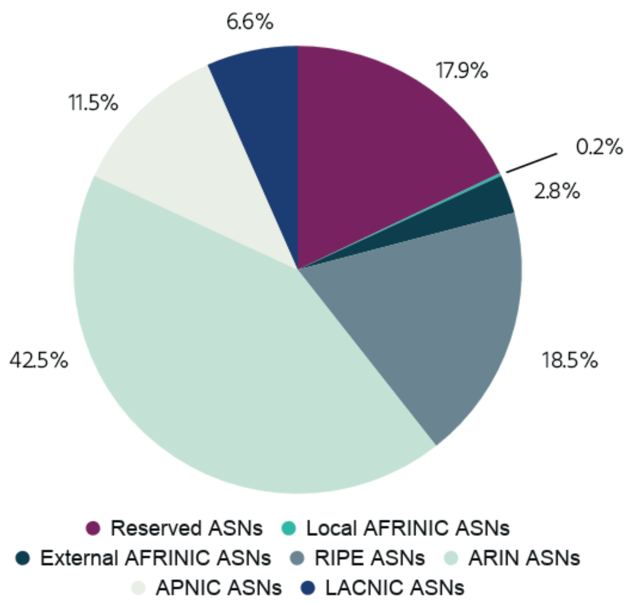
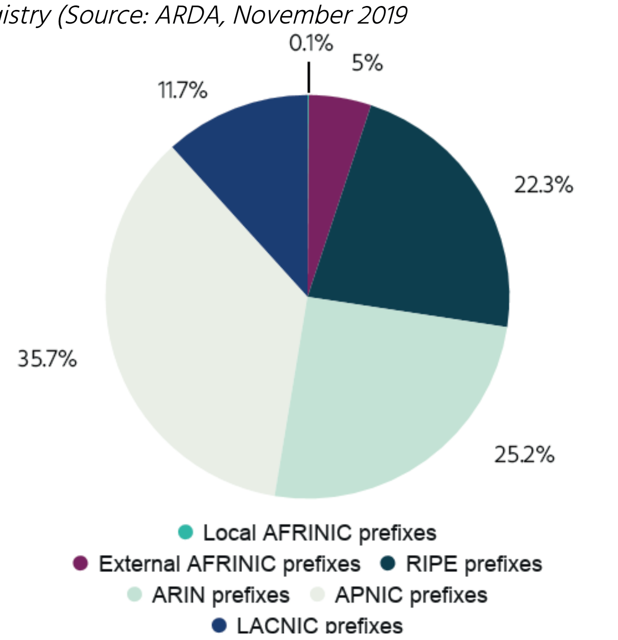


Figure 8. Prefixes Visible at KIXP per Regional Internet Registry (Source: ARDA, November 2019



Annex B: Internet Exchange Point of Nigeria

Figures 9–12 show both the ASNs reachable via NIXP and the IP prefixes announced at the IXP. As such, they offer an overview of the geographical distribution of the networks available at IXPN from local, regional, and international perspectives. More than 53% of all ASNs and more than 46% of the IP prefixes assigned to Nigeria are potentially reachable via IXPN. On a regional level, as of November 2019, less than 1% of African Network outside of Nigeria were potentially reachable via the IXP, suggesting a further regionalization of the networks would be beneficial. Somewhat similar to Kenya, more than 80% of the network prefixes potentially reachable via IXPN are international, but only 25% of the total ASNs are international.

Figure 9. Local ASNs Visible at IXPN (Source: ARDA, November 2019)

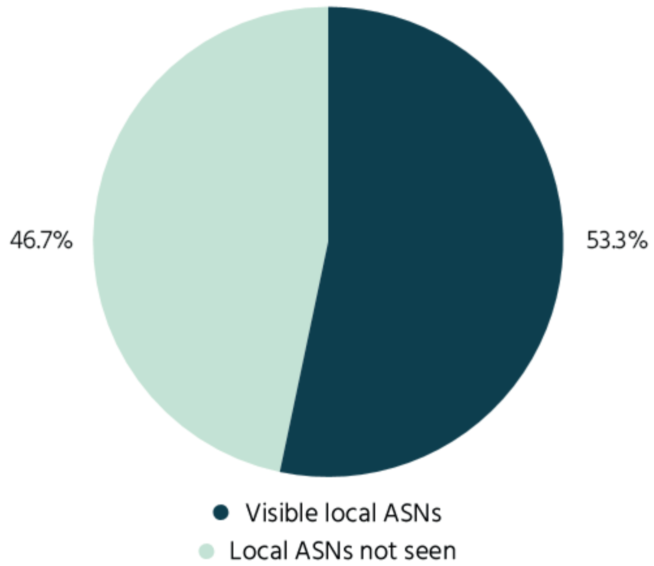


Figure 11. Local Prefixes Visible at IXPN (Source: ARDA, November 2019)

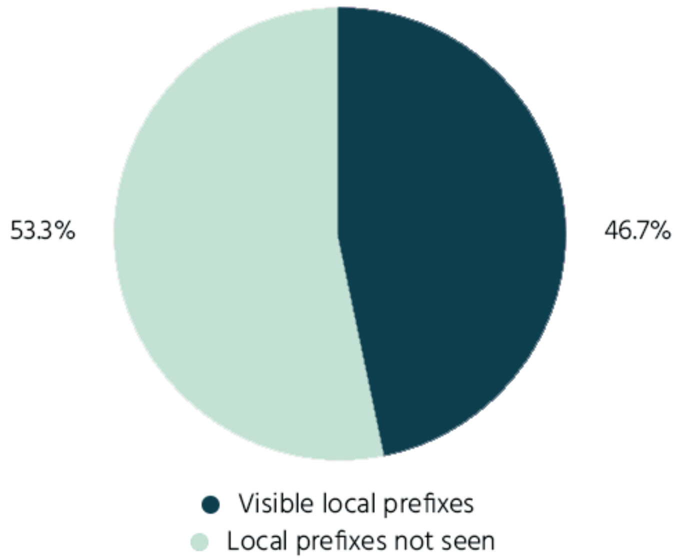


Figure 10. ASNs Visible at IXPN per Regional Internet Registry (Source: ARDA, November 2019)

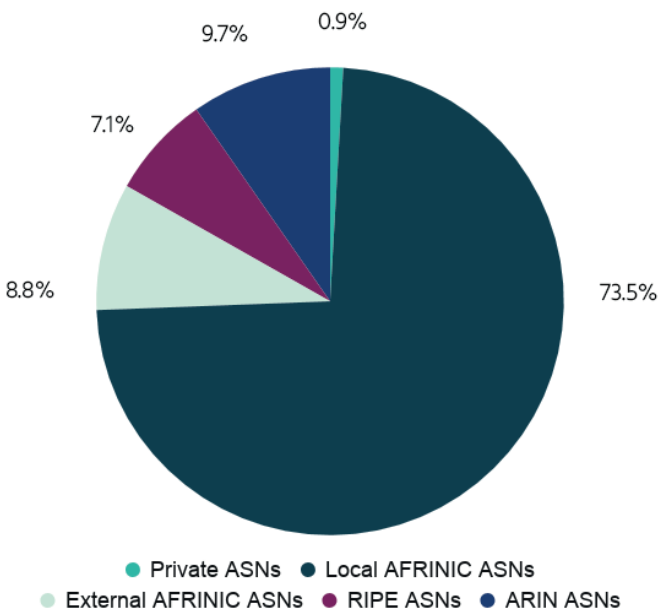
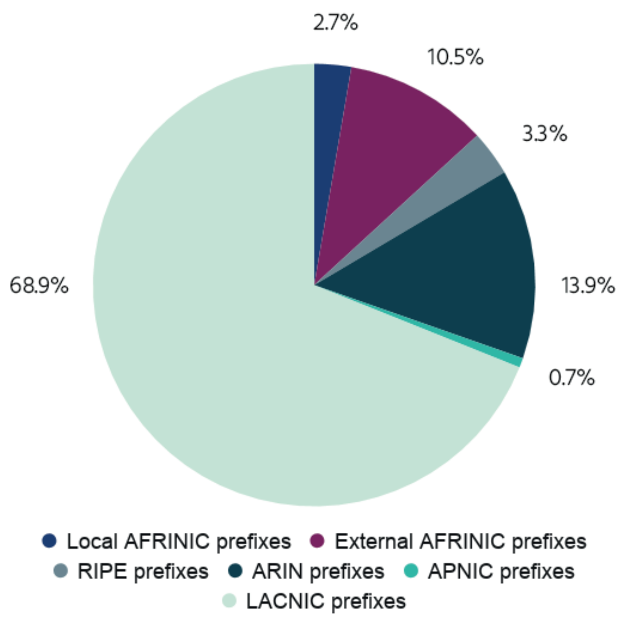


Figure 12. Prefixes Visible at IXPN per Regional Internet Registry (Source: ARDA, November 2019)



Annex C: Acknowledgments

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SawaSawa

Telkom Kenya

Wananchi

Nigeria

Airtel

IXPN

Layer3

MainOne

MTN

ntel

Rack Centre

International

Euro-IX

Facebook

Google

Annex D: Glossary of terms

ADC – Africa Data Centres

Af-IX – The African IXP Association

AfPIF – African Peering and Interconnection Forum

AFRINIC – African Network Information Centre

ARDA – African Route-collectors data Analyzer

ASN – Autonomous System Number

CDN – Content Delivery Network

Gbps – Gigabits per second

GGC – Google Global Cache

IP – Internet Protocol

ISP – Internet Service Provider

ITE – Interconnection and Traffic Exchange

IXP – Internet Exchange Point

IXPN – Internet Exchange Point of Nigeria

KIXP – Kenya Internet Exchange Point

MMLPA – Mandatory Multilateral Peering Agreement

NDPR – Nigeria Data Protection Regulation

NIRA – Nigeria Internet Registration Association

NITDA – National Information Technology Development Agency [of Nigeria]

NOG – Network Operator Group

PNI – Private Network Interconnection

PoP – Point of Presence

TESPOK – Technology Service Providers of Kenya

VLAN – Virtual Local Area Network

WAF-IX – West African Internet Exchange

Annex E: List of figures and tables

The author thanks Jane Coffin and Michuki Mwangi for their leadership and insights, and the Internet Exchange Point of Nigeria for its support in arranging member meetings and providing insights and reviews. All content about KIXP is based on publicly available information.

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By Michael Kende