Africa's Online Access: What Data Is Getting Accessed and Where It Is Hosted?

Babacar Mbaye[1], Assane Gueye[1,2(✉)], Desire Banse[3], and Alassane Diop[4]

[1] Universite Alioune Diop de Bambey, Bambey, Sénégal
assanel.gueye@uadb.edu.sn
[2] University of Maryland, College Park, USA
[3] Prometheus Computing, LLC, New Market, USA
[4] Universite Virtuelle du Sénégal, Dakar, Sénégal

Abstract. Recent studies have shown that most of the web traffic going from one African country to another has to transit through ISP's in other continents before coming back to Africa. This phenomenon is known as boomerang routing and proposals are being made on how to correct it. However, there is a more fundamental question that needs to be addressed: what web content is of interest to Africans and where is it hosted? Indeed, if most of the data needed by Africans is within the continent and yet boomerang is still prevalent, then correcting it is of paramount importance. If, on the other hand, most the data accessed by Africans is hosted outside the continent, then data repatriation might be more beneficial than boomerang correction.

By using publicly available data, this paper attempts to shed some light to that question. Our study suggests that locally producing content and locally hosting it should be given priority to correcting boomerang. The data used as well as the analytical process that have led to such a conclusion are presented in the sequel.

Keywords: Boomerang routing · Africa web access content · Data content · Website hosting

1 Introduction

ICTs have brought a lot of hope for socio-economic development in Africa. Many World Bank indicators have already confirmed that Africa is the continent that is witnessing the most of benefits from ICT development [1]. Well aware of this, the African Union (AU) and member countries are now engaged on several projects to build ICT infrastructures within the continent. For instance, the AU has adopted in 2012 the Program for Infrastructure Development In Africa (PIDA) [2]. Another project initiated by the African Union Commission is the African Internet Exchange System (AXIS) project that supports the establishment of National and Regional IXPs in Africa [3]. The main goal of these projects is to improve user experience by reducing cost and delay. Cost and delay are however closely dependent to where the data that most users access is located/hosted (locally or remotely). As a consequence, for an optimal improvement of African users' experience it is necessary to know the nature of the data they access as well as its location.

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The main goal of this project is to study Africa's online access. More precisely, we are interested in understanding the nature of the data that is accessed by users within the continent, as well as the physical location of the servers where the data is hosted. For that, we make use of publicly available data sets.

We gathered data provided by the site Alexa [4]. The free version of the provided data is a list of the 50 most visited sites by users of each country in the world. We wrote a python script that crawls the Alexa website and downloads, for each African country, the 50 mostly visited websites. We then use the Maxmind (IP) [5] geolocation database to find the geolocation of the servers that host those websites. We also analyze the content of the websites to determine whether it is mainly destined for an African audience or it is for any user around the world. Finally, the results of our findings are discussed, and conclusions and guidance are provided.

Our study has shown that despite the high Internet penetration rate claimed in Africa (mostly boosted by mobile data), most of the data that Africans attempt to access is located outside the continent. In other terms, very few Africans make use of the existing website hosting services that are available in the continent. Furthermore, only one (1) in five (5) of the most visited sites by Africans carries "purely" African content and only a fifth of those purely African sites are hosted within the continent. When it comes to Africans' interest to site designed by/for another African country, the data indicates a lack of cross-country interest. Finally, the study shows that African sites are dominated by news (information) category and categories of sites such as health, science, e-government, education and sport are not popular in Africa.

In conclusion, despite the high Internet penetration rate in Africa and despite the many projects to developing internetworking infrastructures in the continent, most of the traffic generated by African must transit through international network (even though the requested content is primarily destined to Africans). Consequently, end users will continue to experience additional cost and delay. However, according to our data, the main cause of this is not "boomerang routing". Rather, the additional delay and cost is mainly due to the fact that data accessed by most Africans is overwhelmingly located outside of the continent. Thus, in additional to developing network infrastructures within the continent, we believe that Africa should encourage the production of local content that is hosted locally.

This paper is organized as follows. We first describe the data used in our study in Sect. 2. We present the data, discuss some of its known (and sometimes addressed) limitations, and present some of the pre-processing work done for the analysis. The data analysis is presented in Sect. 3. We provide a summary of related work in Sect. 4. Concluding remarks as well as perspectives are given in Sect. 5.

2 Data Acquisition and Pre-processing

2.1 Alexa Traffic Data

Alexa Internet, Inc. is an American web traffic analysis company based in San Francisco. It is a subsidiary of Amazon. The Alexa Top Sites web service provides ranked lists of the top sites on the Internet. The ranking is based on the anonymous usage

patterns of a large and global sample of millions of Internet users using one of many different Alexa's browser extensions. In addition, Alexa gathers much of its traffic data from direct sources in the form of sites that have chosen to install the Alexa script on their site and certify their metrics [4].

The global traffic rank is a measure of how a website is doing relative to all other sites on the web over the past 3 months. The rank is calculated using a proprietary methodology that combines a site's estimated average of daily unique visitors and its estimated number of pageviews over the past 3 months. Alexa also provides a similar country-specific ranking, which is a measurement of how a website ranks in a particular country relative to other sites over the past month.

A site's ranking is based on a combined measure of reach and page views computed over a trailing 3-month period. Reach is determined by the number of unique Alexa users who visit a site on a given day. Page views are the total number of Alexa user page requests for a site. However, multiple requests for the same page (URL) on the same day by the same user are counted as a single page view. The site with the highest combination of users and page views is ranked #1.

Alexa provides a fraction of its ranking data for free (it also offers many other datasets and services with a subscription fee). This version includes a list of the 50 most visited sites by users of each country in the world. We gathered that data by writing a python script that crawls the Alexa website and downloads, for each African country, the 50 mostly visited websites. We then use the Maxmind (IP) geolocation database to find the geolocation of each of the websites and perform our data analysis presented in Sect. 3.

2.2 Alexa Data Limitations

Since its launch in 1998, there have been many concerns raised about the Alexa dataset. Originally, webpages were only ranked amongst users who had the Alexa Toolbar installed. Therefore, the data could be biased if a specific audience subgroup was reluctant to take part in the rankings. This caused some controversies over how representative Alexa's user base was of typical Internet behavior, especially for less-visited sites. In 2007, a study has provided examples of Alexa rankings known to contradict data from other web analytics services, including ranking YouTube ahead of Google [6].

This particular concern has however been addressed by Alexa in 2008, when they introduced [https://techcrunch.com/2008/04/16/alexa-overhauls-ranking-system/] new practices in which they would not only use data from their toolbar, but also from twenty five thousands of other widgets, plug-ins and services.

Alexa data has also been largely dubbed to be biased against sites with relatively low measured traffic, which tend to be inaccurately ranked by Alexa. For instance, it can be read from Alexa's website [4] that they "do not receive enough data from their sources to make rankings beyond 100,000 statistically meaningful. This means that, for example, the difference in traffic between a site ranked 1,000,000 and a site ranked 2,000,000 has low statistical significance." This limitation could have an impact in the study carried in this paper as many African sites are expected to, a priori, receive low traffic. However, our comparative studies have shown that Alexa rankings correlate

well with other raking systems such as SimilarWeb [7] and SEMrush [8]. Furthermore, this study confirms Alexa's claim that the closer a site gets to number 1, the more reliable its rank is. For the present study, we have compared Alexa and SimilarWeb rankings for three African countries for which SimilarWeb has available data. The comparison shows a 75% similarity. Furthermore, this paper is mainly concerned with sites that Africans mostly visit, and we expect these "top" sites to receive relatively high traffic. Hence, the omission of sites that receive low traffic data should not impact our analysis.

Bearing these limitations in mind (as well as the many critics that Alexa has addressed since 2008), we believe that Alexa and its cousin sites (SimilarWeb and SEMrush) are valuable tools that provide "good enough" traffic estimates for any site. Some of the limitations are inherent to the indirect method used to collect the data. Indeed, no indirect method for traffic determination will ever be as exact as the direct tools such as Google Analytics, or log file analyzers. However, the problem with Google Analytics is that you can't get that data for other people's sites and the data is mostly private. Overall, we believe that the results of our study can be used as first order guidance, given the lack of traffic data, especially with respect to Africa.

2.3 Data Pre-processing

As mentioned earlier, we have written a python script that crawls the Alexa website to collect the 50 most visited sites in every African country. The second step was to determine the physical location of the servers that host the sites. For that, we use the Maxmind geolocation database [5] that gives the geolocation of most Internet servers/routers. Maxmind is known to have some limitations with fine-grained localization such as city geolocation coordinates. However, its country level localization is accepted to be fairly accurate. In this paper, we are concerned only with country level localization.

After the localization of all the sites (whenever possible), we categorized them into:

- "**purely African**" (sites with mainly African content and mainly targeting African audience, such as www.seneweb.com) and
- "**others**" (all other sites, such as www.google.com).

This site categorization required a manual process in which we took several steps.

First, we look at the extension of the site's url. If it corresponds to the code of an African country (e.g., www.irembo.goc.rw), we classify the site as "purely African". Otherwise, (the extension does not correspond to an African country code), we load the page into a browser and analyze a set of metadata fields. The title of the site is a first indicator for classification. For instance, the title of the site www.seneweb.com is "Seneweb: le Senegal dans le Web", which clearly suggests that the site is Senegalese. If the title is not very informative, we inspect (and combine) a list of other fields such as: the language, the videos, the type of information, the title of the tabs, the other sites that are referenced, the site footer, the address and phone number in the contact section (if any) etc.

Some ambiguities might arise with this classification method, in which case we make some arbitrage. For example, sites such as www.google.country-code are classified as "others", because they are considered to belong to google and do not necessarily carry "African content". When we cannot geo-localize a site or classify it (after using all the methods above), we just ignore it. We also ignore sites that generate error codes such as "http error code 404: page not found".

Using this procedure, we were able to gather geo-localized site information is **47** African countries with an average of **48.7** sites per country. In the next section, we present our findings.

3 Data Analysis

Before proceeding to the analysis, we would like to put the African online access into a global perspective. For that, we collected Akamai's HTTP[1] hits per second data for a period of five day (during the period of November 1st to November 5th, 2018). The data can be classified by region, as show in Fig. 1.

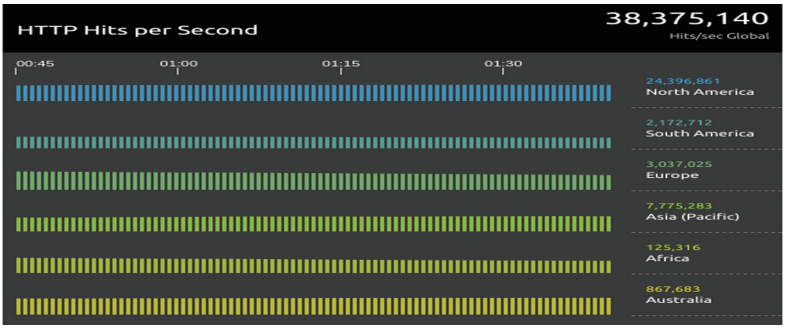

Fig. 1. HTTP Hits per Second (See footnote 1)

Considering the 5-day average, we found that the African traffic represents less than half percent of the global web traffic. Even though this is about requests received by Akamai servers, it can be fairly considered as proportionally representative. This means that our work is about a very small percentage of the global web traffic, despite the fact that African Internet users stands at 10.9%, as of December 2017 (according to InternetWorldStat [9]).

[1] Hits per Second Globally measures the number of raw requests received by Akamai servers from each major continental region. "Hits/sec. global", displayed at the top of the graph, is the cumulative number of hits, while the data points displayed vertically along the right are regional breakdowns. 24 h data patterns as well as 24 h peak data points are made available for each region. HTTP Hits per Second is measured in actual hits/sec [10].

After putting our working in a global perspective, we can proceed to the analysis. The analysis consisted in finding trends in website ranking, content consumption and finding probable explanation to the trends. We first consider the physical location of the servers that host the 50 mostly visited websites from any African country. To geo-locate a site, we query the Maxmind database by providing the site's url or IP address.

3.1 In-country Hosting

Figure 2 shows the percentage of sites that are hosted in each African country (among the 50 mostly visited sites in the country). Overall, we found that for any given African country, only less than 25% of the mostly visited sites are hosted in the country, with a continental average equal to 4.3% This indicates that overwhelming portion of the web traffic generated from the countries will transit internationally.

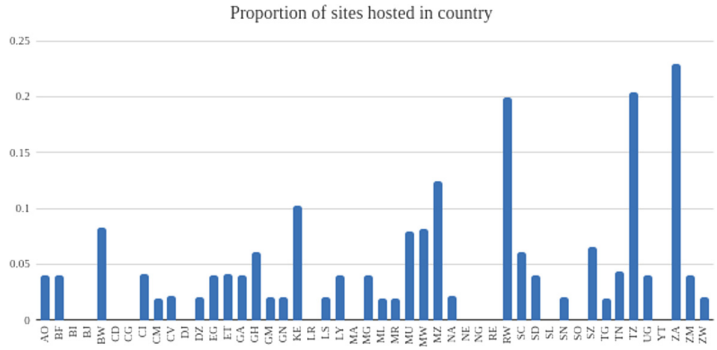

Fig. 2. Proportion of sites hosting in each African country

A closer look at the site hosting distribution shows that countries that have a solid number of sites hosted in country are those which have a good infrastructure. The top 5 of these countries are: South Africa, Tanzania, Rwanda, Mozambique and Kenya. Focusing on these five countries, we then look at the top 10 most visited websites per country (see Table 1).

We found that most of the top ten sites are foreign by content and hosting location (usually, they are Google, Facebook, Yahoo and Wikipedia). This is the trend that has been observed for almost all countries in the world (developed and developing). Indeed, it is well known that whose sites dominate the web. Our analysis is just a confirmation that the domination is occurs also in Africa.

We also found that each of these 5 countries has at least one site hosted in-country among the top 10, while none of the countries in the bottom half (with respect to number of in-country hosting) has a site hosted within the country among the 10 mostly visited sites. The world average of in-country hosted sites (US excluded) is equal 1.8.

Table 1. Ten (10) mostly visited site for the top 5 countries with in-country hosting

South Africa	Tanzania	Rwanda	Kenya	Botswana
0;google.com	0;google.com	0;google.com	0;google.com	0;google.com
1;google.co.za	1;youtube.com	1;youtube.com	1;youtube.com	1;youtube.com
2;youtube.com	2;yahoo.com_	2;igihe.com	2;standardmedia.co.ke	2;google.co.bw
3;facebook.com	3;facebook.com	3;google.rw	3;tuko.co.ke	3;yahoo.com_
4;yahoo.com_	4;jamiiforums.com	4;yahoo.com_	4;the-star.co.ke	4;facebook.com
5;wikipedia.org	5;ghafla.com	5;inyarwanda.com	5;facebook.com	5;wikipedia.org
6;dstv.com	6;instagram.com	6;facebook.com	6;yahoo.com_	6;gov.bw
7;gumtree.co.za	7;blogspot.com	7;umuryango.rw	7;sde.co.ke	7;ub.bw
8;fnb.co.za	8;wikipedia.org	8;umuseke.rw	8;sportpesa.co.ke	8;ask.com
9;instagram.com	9;meridianbet.co.tz	9;irembo.gov.rw	9;kenyans.co.ke	9;jobsbotswana.info

3.2 Continent-Wide Hosting

Having noticed that most of the sites viewed by users in a given country are not hosted in the country, we ask the question whether those sites are hosted in other African country. The answer to this question will inform about whether the African traffic will stay within the continent.

Figure 3 shows the proportion of sites viewed in each African country and hosted within the continent. We have mostly the same graph as for in-country hosted except for Soudan, Swaziland, Namibia, Mauritius and Lesotho. This suggests that hosting services that are available in some African countries (such as South Africa) are not used by other countries. The reasons behind this are not studied in the paper, however, understanding them could be key in developing Africa's internetworking infrastructures.

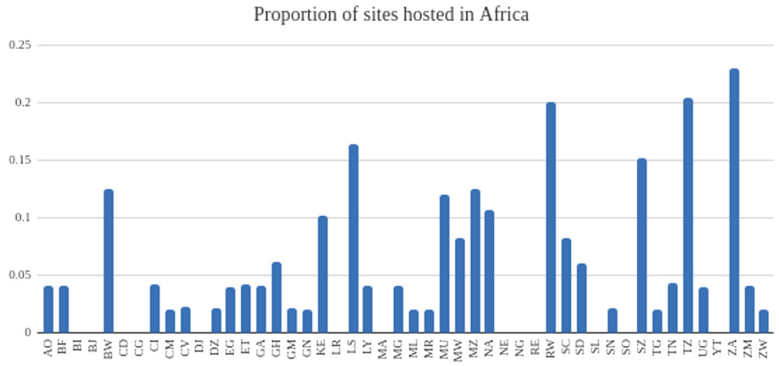

Fig. 3. Proportion of sites hosted within Africa

3.3 "Purely" African Sites

In this section, we are interested in figuring out which of the 50 mostly visited sites of each country carries a content that is mostly destined to an African audience. We use the procedure described in Sect. 2.3 to categorize the sites. Figure 4 shows the proportion of sites that were classified as "purely African".

The distribution of "purely" African sites is disproportionate and much lower compared to sites outside the continent. In average, only 20% of the mostly visited sites in the continent are considered as "purely" African. This indicates that even the traffic that is generated "by Africans and for Africans" has to transit through international link when accessed from within the continent.

It is to be noticed that the classification of a site as "purely African" is not correlated to the fact that the site is hosted within the continent or not. For instance, Mauritania is the country with the most sites classified as such (31 sites belonging to the country). However, only 1 of those sites is hosted within the country. This phenomenon is quite common across the continent, as shown in Fig. 4.

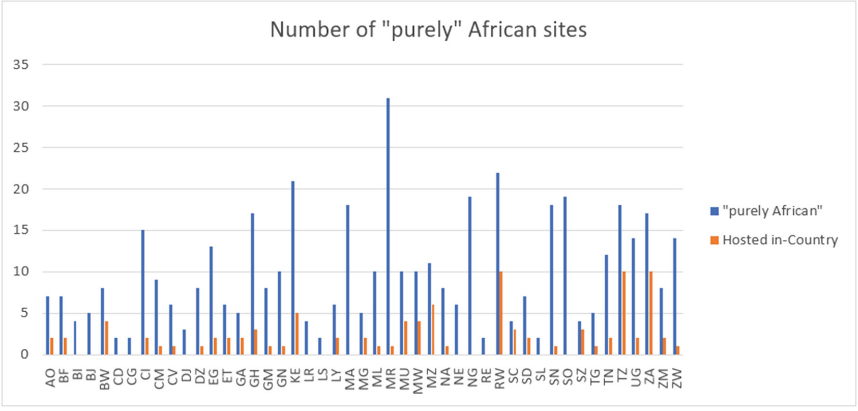

Fig. 4. Number of "purely" African sites

3.4 Content of the Sites

Having determined the most popular African sites as well as the "purely" African ones, we turn to the content in these sites.

We also found that each of these 5 countries has at least one site hosted in-country among the top 10, while none of the countries in the bottom half (with respect to number of in-country hosting) has a site hosted within the country among the 10 mostly visited sites. The world average of in-country hosted sites (US excluded) is equal 1.8.

Table 1 shows that social media sites are the most popular ones in the continent. As was mentioned earlier, this dominance is quite the same in other countries (developed and developing). Table 2 below summarizes the content of the top five African countries with the largest number of "purely" African sites. As can be seen, news

information sites are the most dominant ones and represent 64% of the sites. According to the data, government sites (e-gov) are not very popular in the continent, except for Rwanda which has 36% of e-gov sites among the most popular. This is not surprising as Rwanda has dematerialized 80% of its government services and is the leader with respect to that aspect. Education sites are also not very popular, which correlates well with the lack of popular universities in the continent. Also, some categories such as health, science and sport are missing among the most popular sites. The lack of health and science sites reflects well general observations in those sectors in the continent. However, despite the popularity of sport in Africa, there are still not many sites that propose "sport" content in the continent.

Table 2. Classification of "purely" African sites

Country	# "purely" African	Content
Mauritania	31	29 news, 1 gov, 1 business
Rwanda	22	9 news, 8 gov, 3 job, 2 edu
Kenya	22	11 news, 4 lottery, 2 gov, 2 business, 2 edu, 1 employ
Nigeria	19	12 news, 3 business, 2 lottery, 1 gov, 1 e-commerce
SN	19	11 news, 2 business, 1 edu, 1 adult, 1 money transfer, 1 cinema, 1 gov, 1 phone

3.5 Origins of the Visitors

In this section, we are interested in the country origin of the people who visit Africa website. In that, we would like to know if the content generated by Africans (one country) is of interest to other Africans. There are multiple ways to address the question. In this paper, we consider the most "purely" African sites in the top 4 countries (with respect to the number of in-country hosted sites: South Africa, Tanzania, Rwanda, and Kenya.

In South Africa, dstv.com comes out at 77.8% of visitors originating from South Africa. Nigeria and Angola follow at respectively 6.9% and 5.1%. South Africa has 80% of African total internet hosts as of 2013.

In Tanzania, 83.7% of visitors to jamiiforums.com come from within the country. The USA, UK and India are the next top origin of the requests. There is a large immigration population from Tanzania in the UK.

In Rwanda, we have about 2/3 of the visitors to igihe.com originating within the country. The following top countries with requests are in order the USA, Belgium, and Canada. Only 9% of those total requests come from a search engine, which means the website has mostly regulars, hence native or interested in business.

In Kenya, only 46.6% of visitors to standardmedia.co.ke originate from Kenya. Japan at 7.8%, the USA at 7.7% and China at 6.2% are the next largest visitors. Up to a quarter of visitors are coming from search engines. This website is also a news media website.

These observations suggest that data generated in a country does not (so far) interest other African. In other terms, the idea of "pan-Africanism" is not yet perceived online.

4 Related Work

Because of the high hope that ICT infrastructures is raising in Africa, network connectivity within the continent has recently attracted a lot of interest. The International Telecommunication Union (ITU) publishes yearly data on access to telecommunication services [11]. Several other reports are available documenting various aspects of access to the Internet such as regulation [12] and infrastructure assessment [13]. The studies in [14–16] were interested in the evolution of the African connectivity of the years. While these papers are mostly interested in the development of communication infrastructures in the continent, our paper is focused on the data that is accessed by African. Authors in [14–16] consider the intra-Africa communication an quantify the fraction of traffic that leaves the continent when a communication takes place between two African users. This phenomenon, call boomerang routing, is very important because it raises many issues: cost, delay, and privacy. Our paper is interested in the same issues, but asks a more fundamental question: where is the data that most African access and what is its nature? Understanding this later question is key to addressing the boomerang phenomenon. The study in [17] is similar to ours. It considers the content use and hosting in Africa. The authors address the question by making use of three datasets: (1) user surveys gathering from a campaign on https://researchictafrica.net/ that included seven African countries, (2) a list of African news websites compiled from ABYZ News Links, and (3) Traceroute data collected by the authors. Although the authors tackle the same questions as in our papers, their datasets present a number of limitations. The data from https://researchictafrica.net/ just covers 7 countries in the continent. Also, the news website data is most likely not representative (for a typical African user). For instance, among the sites listed by ABYZ News Links (for Senegal and Burkina Fasso), very few are among the 50 mostly visited sites according to Alexa. On the other hand, our paper is based on the most visited sites in the continent. In that, we believe that our dataset is more representative and gives better answers to the questions raised. However, despite the difference of the dataset used, the two studies come to the same conclusions and thus confirm each other.

5 Conclusion and Perspective

In this paper we consider the content and the hosting of the data that Africans are mostly accessing on the web. We make use of publicly available dataset provided by the site Alexa. Our study has shown that despite the high Internet penetration rate claimed in Africa (mostly boosted by mobile data), most of the data that African attempt to access is located outside the continent. Furthermore, only 1 in 5 of the most visited sites by African carries "purely" African sites and only a fifth of those purely African sites are hosted within the continent. When it comes to African's interest to site

design by/for another country, the data indicates a lack of cross interest. Finally, the study shows that African sites are dominated by news (information) category and categories of sites such as health, science, e-government, education and sport are not popular in Africa.

Our study suggests that despite the high Internet penetration rate in Africa and despite the many projects to developing internetworking infrastructures in the continent, most of the traffic generated by African must transit through international network (even though the requested content is primarily destined to Africans). Consequently, end users will continue to experience additional cost and delay. Thus, in additional to developing network infrastructures within the continent, we believe that Africa should encourage the production of local content that is hosted locally.

The main limitation of the paper is the lack of reliable data and this is very understandable: in fact, to date (and to the authors' knowledge) there is no good dataset on Internet communication in Africa. Alexa provides data on most visited websites but is largely criticized because of potential biases against small local websites. The measurement platforms such as CAIDA, RouteViews, RIPE Atlas, all focus on other parts of the world and lack representative data for Africa.

The authors would like to suggest to (and invite) the community to start thinking about a continent-wide data collection and measurement platform. Only this will enable the conclusive studies needed to understand the current African Internet communication ecosystem and provide guidance for building our future networks.

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