

# **PUSHING THE FRONTIER: Exploring the African Web Ecosystem**

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Pierre Francois<sup>3</sup>, and Arjuna Sathiaseelan<sup>4</sup>

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# The Paper

## Pushing the Frontier: Exploring the African Web Ecosystem

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### ABSTRACT

It is well known that Africa's mobile and fixed Internet infrastructure is progressing at a rapid pace. A flurry of recent research has quantified this, highlighting the expansion of its underlying connectivity network. However, improving the infrastructure is not useful without appropriately provisioned services to utilise it. This paper measures the availability of *web content infrastructure* in Africa. Whereas others have explored web infrastructure in developed regions, we shed light on practices in developing regions. To achieve this, we apply a comprehensive measurement methodology to collect data from a variety of sources. We focus on a large content delivery network to reveal that Africa's content infrastructure is, indeed, expanding. However, we find much web content is still served from the US and Europe. We discover that many of the problems faced are actually caused by significant inter-AS delays in Africa, which contribute to local ISPs not sharing their cache capacity. We discover that a related problem is the poor DNS configuration used by some ISPs, which confounds the attempts of providers to optimise their delivery. We then explore a number of other websites to show that large web infrastructure deployments are a rarity in Africa and that even regional websites host their services abroad. We conclude by making suggestions

project [2], as well as on underlying edge connectivity, with projects such as Liquid Telecom, Project Loon and Google Link deploying both wireless and wireline connectivity [22, 13, 1],

Despite these positive steps, challenges still remain. Most prominently, several studies have revealed content as the dominant component of network traffic [11]. Yet the lack of service infrastructure (*e.g.*, web servers) in Africa means that both mobile and wireline users must often fetch content from the other side of the world [20]. Hence, we argue that researchers and engineers should begin to place more focus on both underlying connectivity and content infrastructure (*e.g.*, web servers, caches) in the region. With this in mind, many large companies have begun to deploy content infrastructure in Africa. Google is perhaps the most famous in this regard [1]. As of yet, however, there is little evidence of how these companies approach the challenge.

Several recent efforts have shed light on web infrastructures worldwide [23, 27, 40, 18, 14, 17, 42, 20]. But, they have not (*i*) focussed on underdeveloped countries/regions; or (*ii*) explored if worldwide results apply to underdeveloped regions. This leaves critical questions unanswered, largely driven by the unusual make-up of African Internet and web infrastructures when compared to more developed regions.

R. Fanou, G. Tyson, P. Francois, and A. Sathiaselan (2016) *Pushing the Frontier: Exploring the African Web Ecosystem*. In: The 25th International World Wide Web Conference (WWW 2016), 11-15 April 2016, Montreal, Canada.

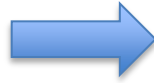
# Background: A brief intro to Web CDNs

Let's suppose that she wants to access a CDN ...

NOW



A user (in Africa) wants to access to [www.website.com](http://www.website.com)



- 1- She types [www.website.com](http://www.website.com) it in the browser
- 2- Her Computer sends a DNS lookup to the closest DNS server
- 3- The address [www.website.com](http://www.website.com) is translated into a set of IPs, those of her closest caches which are sent back to the computer
- 4- Depending on the content of the webpage, the computer may query one or more IP caches
- 5- They respond with parts of/all the webpage content
- 6- The user can open to the webpage

**Conclusion:** The closer (in terms of delay, i.e. geographically) are the caches the user are redirected to, the better is her QoS while accessing the website

# Related Work

- **IXPs deployments of particular interest in the African region [1, 2]**
- **Zaki et al. [3] investigated web performance in Ghana**
  - Key bottlenecks include slow DNS resolution
  - Lack of content caching
- **Calder et al. [4] studied Google infrastructure**
  - Enumerated caches IPs & found their locations
  - Studied its growth & matched users to clusters
- **Otto et al. [5] examined the role of DNS in the redirection process**
- **Su et al. [6] found Akamai redirects clients are based on active networks conditions**

# Background: Objective

**WHERE IS THAT CONTENT HOSTED?**

TYPE OF SITE	HOSTING LOCATION
Facebook / Twitter / Youtube	Mainly Europe/US with some content cached
Blogs	Mainly Europe / US
Iroking / Iroko TV	Amazon AWS (Europe / US)
Local news	Mostly France for french speaking news
	UK / Germany for english speaking news
Legal / regulatory informations	Sometimes in Europe / US

Jaguar Network

[7] Mathieu Paonessa (Jaguar Networks), Future of Content, [http://isoc-ny.org/afpif2014/AfPIF2014\\_Future\\_of\\_Content.pdf](http://isoc-ny.org/afpif2014/AfPIF2014_Future_of_Content.pdf), AFPIF2014

Top 20	Website	Server Location
1. IGIHE	<a href="http://www.igihe.com">www.igihe.com</a>	USA
2. Umuseke	<a href="http://www.umuseke.rw">www.umuseke.rw</a>	USA
3. Kigali Today	<a href="http://www.kigalitoday.com">www.kigalitoday.com</a>	USA
4. Umuryango	<a href="http://www.umuryango.com">www.umuryango.com</a>	USA
5. Inyarwanda	<a href="http://www.inyarwanda.com">www.inyarwanda.com</a>	USA
6. Tohoza	<a href="http://www.tohoza.com">www.tohoza.com</a>	Switzerland
7. The New Times	<a href="http://www.newtimes.co.rw">www.newtimes.co.rw</a>	USA
8. Imali	<a href="http://www.imali.biz">www.imali.biz</a>	USA
9. Rwanda Directorate General of Immigration and Emigration	<a href="http://www.migration.gov.rw">www.migration.gov.rw</a>	Rwanda
10. University of Rwanda	<a href="http://www.nur.ac.rw">www.nur.ac.rw</a>	Rwanda
11. College of Science and Technology, University of Rwanda	<a href="http://www.kist.ac.rw">www.kist.ac.rw</a>	Rwanda
12. Rwanda Broadcasting Agency	<a href="http://www.orinfor.gov.rw">www.orinfor.gov.rw</a>	Rwanda
13. Living in Kigali	<a href="http://www.livinginkigali.com">www.livinginkigali.com</a>	USA
14. Ubugingo	<a href="http://www.ubugingo.com">www.ubugingo.com</a>	USA
15. Rumalex	<a href="http://www.rumalex.net">www.rumalex.net</a>	Germany
16. Zion Temple	<a href="http://www.ziontemple.rbm.tv">www.ziontemple.rbm.tv</a>	USA

[8] M. Kende and K. Rose, Promoting Local Content Hosting to Develop the Internet Ecosystem. ISOC Report, 2015

Investigate the way users in Africa access the web (African Web Ecosystem), since the outcome has serious impacts on both mobile and wireline performance.

# Possible Methodology Approaches

- **Straightforward method:** record in a public repository, data from all (mobile and wireline) users in Africa for websites they access (**quite difficult to achieve as of today**)
- **Alternative:** Ask all local ASes to randomly launched from their servers, scripts that locally collect this data (**quite difficult to achieve as of today – Some reasons: Networks' trust, frequent current cuts**)
- **Another one:** Use an existing measurement infrastructure
  - Planet Lab (in 2015, 8 monitors)
  - Archipelago (in 2015, 5 monitors)
  - RIPE Atlas (in 2015, 379 probes in 170 ASes across 45 countries /58) : **the best option**

# Our choice for the measurements infrastructure: RIPE Atlas

- **RIPE Atlas probes:**
  - The largest measurement platform in Africa
  - DNS measurements, traceroutes, pings, HTTP requests, etc
  - Make our measurements publicly available



RIPE Atlas probes



RIPE Atlas probes in African networks

# 4 Main Tasks

- **Task1:** Mapping a large Content Provider from African ASes
- **Task2:** Compare DNS queries results to EDNS0 results
- **Task3:** Investigate DNS in African ASes
- **Task4:** Comparing top Global Providers Infrastructures serving Africa to those of top Regional ones



# Methodology Overview: Summary (1)

- **Collect all IP prefixes allocated by AFRINIC (African prefixes)**
  - 3,082 prefixes of various length allocated by AFRINIC
- **Discover all content servers/caches that serve them**
  - EDNS0 Client-Subnet Probes for a week
  - 28,387,226 RIPE Atlas DNS Probes
  - Targets: top regional, top global Alexa websites
- **Geolocate caches** (Improved version of geoloc method in [1])
  - Cross-checking 10 data sources: OIM, MM, TC, RDNS, WHOIS & RP, AR, AF, LAC, AP assignments databases
  - 5 sets of pings measurements to tie break between multiple CCs
  - Checking Speed of light violation (Extended version - Ongoing): 100 random RIPE Atlas probes worldwide per cache IP

# Methodology Overview: Summary (2)

- **IP Geoloc Summary**

DB	3,105 GGCs IPs		144 DNS resolvers	
	Coverage	Trust	Coverage	Trust
<i>OIM</i>	0.45%	100%	0%	N/A
<i>RDNS</i>	8.27%	93.77%	0%	N/A
<i>MM</i>	98.29%	89.54%	100%	98.61%
<i>RP</i>	10.04%	75.32%	12.5%	88.89%
<i>AF</i>	35.81%	93.07%	81.25%	94.02%
<i>AP</i>	2.58%	100%	0.69%	100%
<i>AR</i>	10.66%	98.49%	22.91%	87.88%
<i>LAC</i>	0%	N/A	0%	N/A
<i>TC</i>	98.97%	90.34%	100%	95.13%
<i>WHOIS</i>	97.93%	47.41%	94.44%	8.82%

Table 1: Comparison of Geolocation DBs for both GGCs' and DNS resolvers' IPs. N/A stands for Not Applicable.

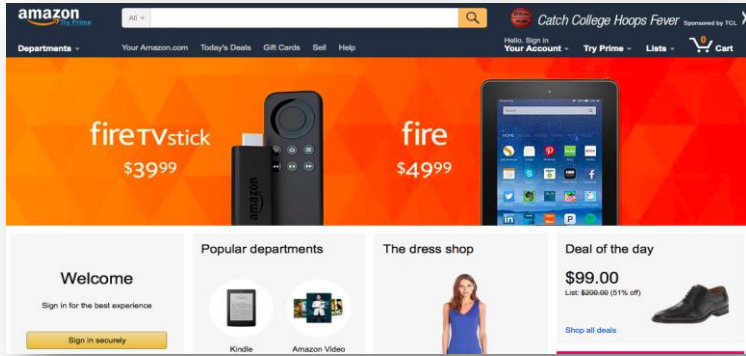
- **Measure paths characteristics**

- 1,309,151 UDP Paris-traceroutes (February 18 to May, 22 2015)
- randomly launched from RIPE Atlas probes to GGCs IPs

- **Measure Web performance**

- HTTP queries (from 242 probes in Europe) with RIPE Atlas probes towards [www.google.com](http://www.google.com) & HTTP queries (from 225 RIPE Atlas probes in Africa) towards top global and regional Alexa websites

amazon.com (E-commerce)



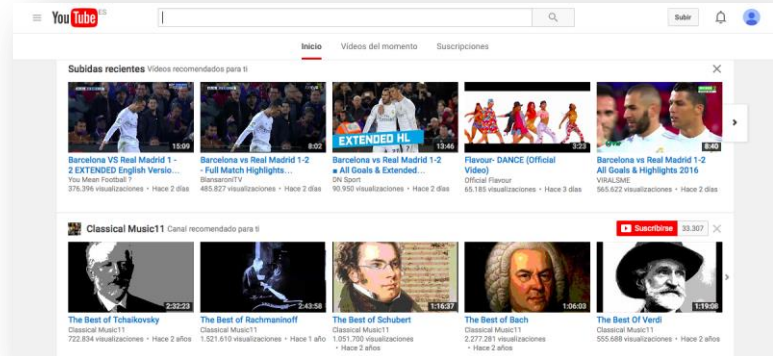
taobao.com (E-commerce)



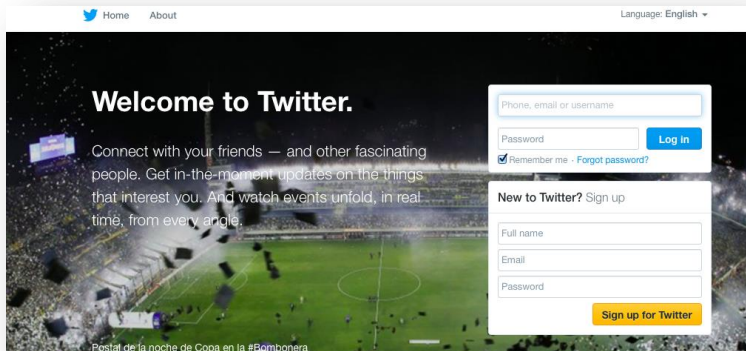
wikipedia.com (Encyclopedia)



youtube.com (Videos)



twitter.com (Social network)



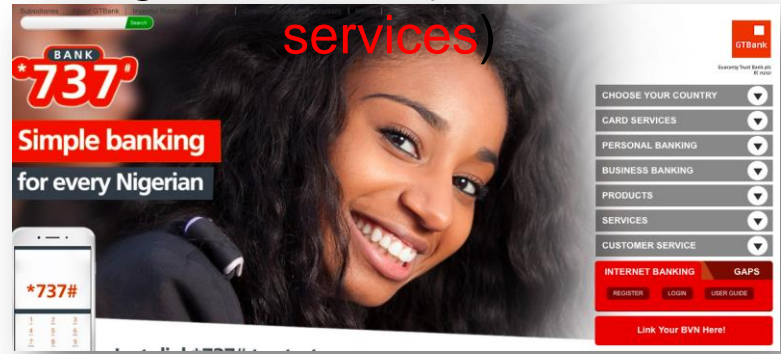
facebook.com (Social network)



jumia.com (E-commerce)



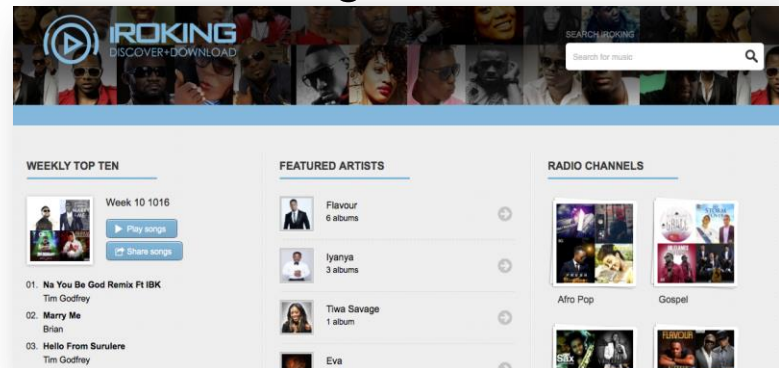
gtbank.com (Financial services)



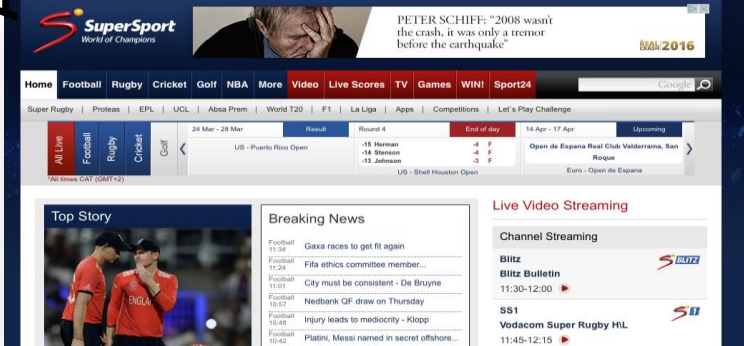
news24.com (News/media)



iroking.com



supersport.com (Sports)



nairaland.com (Online Community)



# Data publicly available

R. Fanou, G. Tyson, P. Francois, A. Sathiaseelan, **Technical report: African Content Measurement Campaign**, [https://techrep\\_cdma:PDQ7Rjkj@fourier.networks.imdea.org/external/techrep\\_cdma/index](https://techrep_cdma:PDQ7Rjkj@fourier.networks.imdea.org/external/techrep_cdma/index)

## CONTENT DELIVERY MEASUREMENT IN AFRICA: TECHNICAL REPORT

Note: This technical report contains details about data used to produce the paper entitled "Pushing the Frontier: Exploring the African web Ecosystem under submission. Our EDNSO Probes — [Back to Menu](#)

Menu: CCs to count EDNSO queries through Google name server ns1.google.com

DNS resolvers located in Africa • [DNS queries to top global Alexa websites roughly every hour from May 23 to May 26, 2015 — Back to Menu](#)

EDNSO queries through (DNS queries from all probes (207 probes online) in Africa with www.facebook.com as argument

EDNSO queries through (DNS queries from all probes) • [Traceroutes from all the RIPE Atlas probes in Africa to each GGC IP: data collected from February 18 to May 22, 2015 — Back to Menu](#)

EDNSO queries again through (DNS queries from all probes) Paris-traceroute on 2015-02-18 19:04:14 from all probes (213 probes online) in Africa towards GGC IP 105.187.242.15

We made our measurements

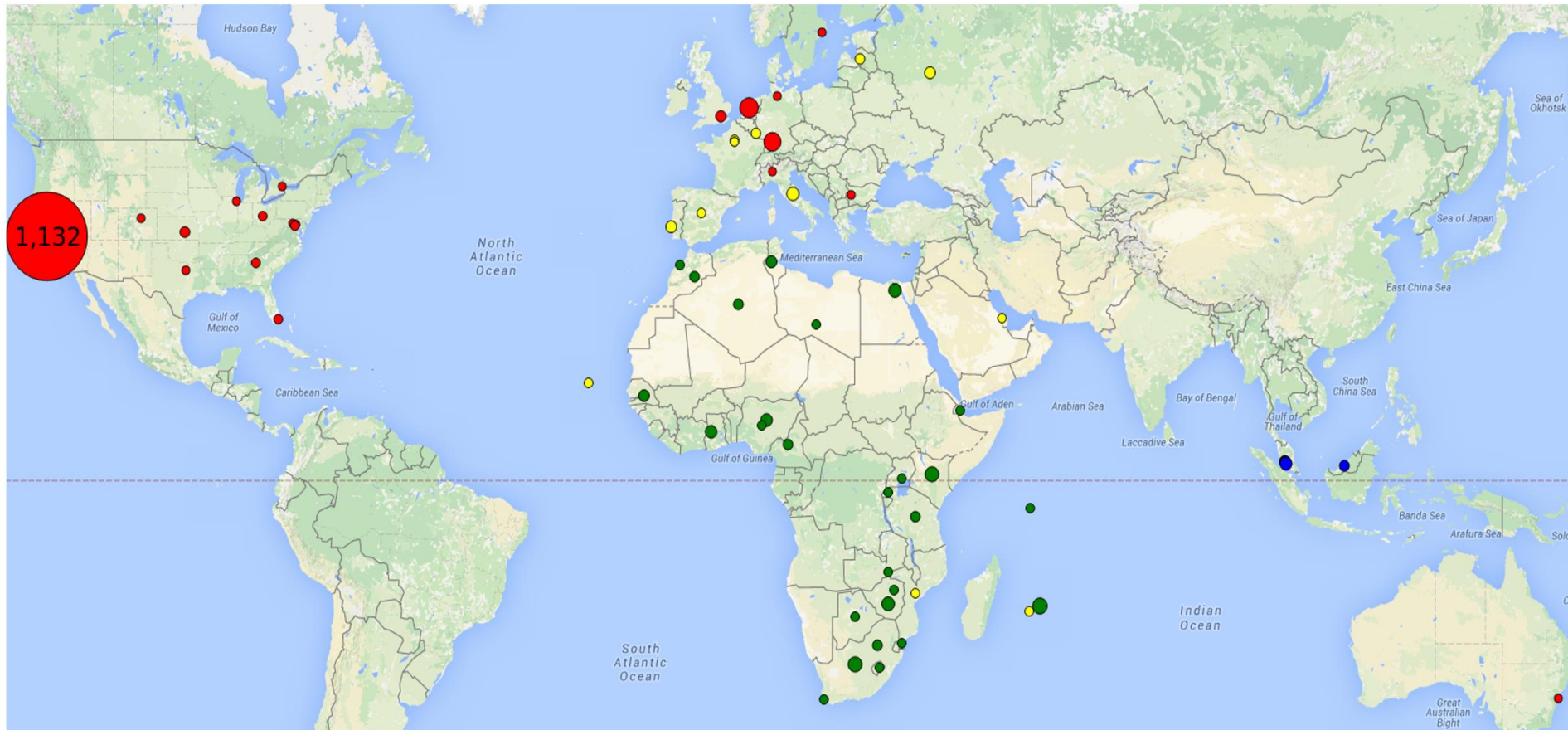
DNS queries from all probes Paris-traceroute on 2015 • [HTTP queries to top global Alexa and local Alexa and Afrodigit websites roughly every 12h from June 2 to June 5, 2015 — Back to Menu](#)

- The 3 EDNSO crawler datasets (Here is the [dataset](#))
- The RIPE Atlas DNS March 30, 2015 (Here is the [dataset](#))
- The pings measurement inconsistent. The identifiers are:
  - o 1913370 and 1957754 and 1960733 and 1961338 and 2015508 and 2017664 and 2017664 and 2017664
- Our measurements for:
  - DNS queries to top global Alexa websites roughly every hour from May 23 to May 26, 2015
  - Traceroutes from all the RIPE Atlas probes in Africa to each GGC IP: data collected from February 18 to May 22, 2015
  - DNS queries from all probes in Africa with www.facebook.com as argument
  - DNS queries from all probes in Africa towards GGC IP 105.187.242.15
  - HTTP queries to top global Alexa and local Alexa and Afrodigit websites roughly every 12h from June 2 to June 5, 2015
  - HTTP GET from all the RIPE Atlas probes in Africa to jumia.com.ng
  - HTTP GET from all the RIPE Atlas probes in Africa to konga.com
  - HTTP GET from all the RIPE Atlas probes in Africa to bidorbuy.co.za
  - HTTP GET from all the RIPE Atlas probes in Africa to fnb.co.za
  - HTTP GET from all the RIPE Atlas probes in Africa to gtbank.com
  - HTTP GET from all the RIPE Atlas probes in Africa to absa.co.za
  - HTTP GET from all the RIPE Atlas probes in Africa to standardbank.co.za
  - HTTP GET from all the RIPE Atlas probes in Africa to almasryalyoum.com
  - HTTP GET from all the RIPE Atlas probes in Africa to elkhobar.com
  - HTTP GET from all the RIPE Atlas probes in Africa to vanguardngr.com
  - HTTP GET from all the RIPE Atlas probes in Africa to news24.com
  - HTTP GET from all the RIPE Atlas probes in Africa to punchng.com
  - HTTP GET from all the RIPE Atlas probes in Africa to iol.co.za
  - HTTP GET from all the RIPE Atlas probes in Africa to ghanaweb.com
  - HTTP GET from all the RIPE Atlas probes in Africa to nairaland.com
  - HTTP GET from all the RIPE Atlas probes in Africa to supersport.com
  - HTTP GET from all the RIPE Atlas probes in Africa to alwafd.org
  - HTTP GET from all the RIPE Atlas probes in Africa to iroking.com
  - HTTP GET from all the RIPE Atlas probes in Africa to iol.co.za
  - HTTP GET from all the RIPE Atlas probes in Africa to ghanaweb.com
  - HTTP GET from all the RIPE Atlas probes in Africa to nairaland.com
  - HTTP GET from all the RIPE Atlas probes in Africa to supersport.com
  - HTTP GET from all the RIPE Atlas probes in Africa to alwafd.org

Note that each RIPE Atlas probe is located in Africa. For more details, see the <https://atlas.ripe.net/api/> endpoint.

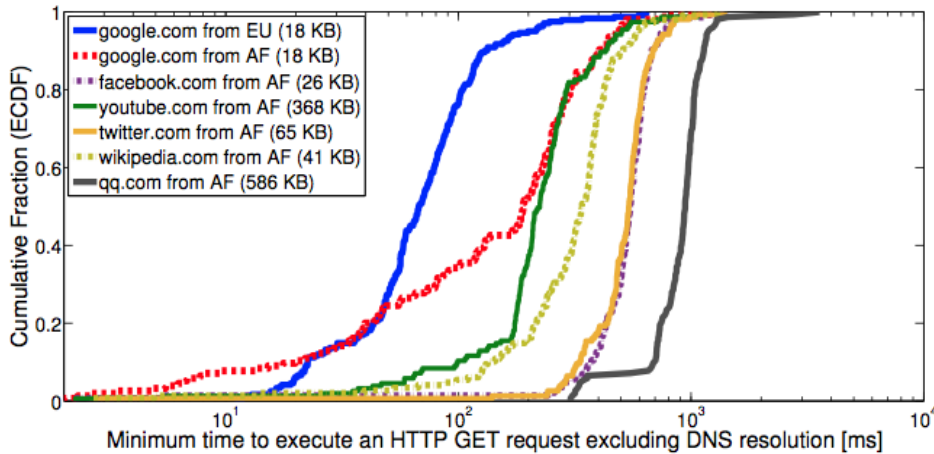
Moreover, the metadata files are available on the [GitHub](#) repository.

# How are African prefixes served by Google?

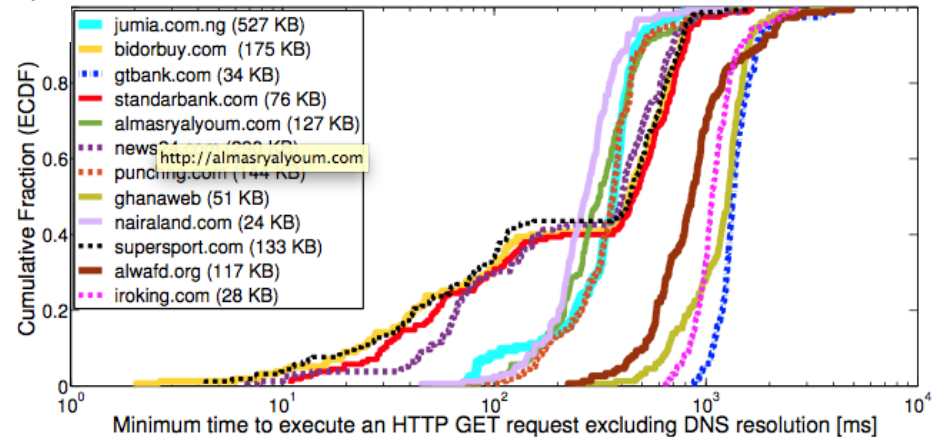


Spread of the 3,120 Caches IPs discovered. Each dot represents a set of IP caches. Its size is proportional to the number IP caches at its location

# Websites performance



(a) *Distribution of minimum time to execute an HTTP GET request per probe (ms) from Europe (EU) and Africa (AF) to top global Alexa websites.*



(b) *Distribution of minimum time to execute an HTTP GET request per probe from Africa to selected top local Alexa & Afrodigit websites.*

# Any Feedbacks on the Methodology?

- **Any comments on the methodology?**
  - Any idea on how we can agree on where were located 3,120 IP caches and the 157 DNS resolvers?
  - May be Groundtruth on discovered IPs geoloc from CDNs for comparison?
- **Possible Improvements? => frequent assessment of the web African ecosystem**
- **Any idea to improve African measurements infrastruc-ture for enabling deeper studies**
- **Possible to obtain from local operators similar/related datasets to better the analysis?**



# References

- [1] R. Fanou, P. Francois, E. Aben, On the Diversity of Interdomain in Africa, In PAM 2015
- [2] A. Gupta, M. Calder, N. Feamster, M. Chetty, E. Calandro ,and E. Katz- Bassett. Peering at the Internet's Frontier: A First Look at ISP interconnectivity in Africa. In *PAM*, 2014
- [3] C. Matt, F. Xun, H. Zi, E. Katz-Basset, H. John, and G. Ramesh. Mapping the Expansion of Google's Serving Infrastructure. In *IMC*, 2013
- [4] J. S. Otto, M. A. Sanchez, J. P. Rula, and F. E. Bustamante. Content Delivery and The Natural Evolution of DNS: Remote DNS Trends, Performance Issues and Alternative Solutions. In *ACM*, 2012
- [5] A.-J. Su, D. R. Choffnes, A. Kuzmanovic, and F. E. Bustamante. Draft-ing Behind Akamai (Travelocity-Based Detouring). In *ACM SIGCOMM '06*, 2006.
- [6] Y. Zaki, J. Chen, T. Pötsch, and T. A. Lakshminarayanan Subramanian. Dissecting Web Latency in Ghana. In *IMC*, 2014.



**Thank you!**  
**Questions or Comments?**



# BACKUP SLIDES

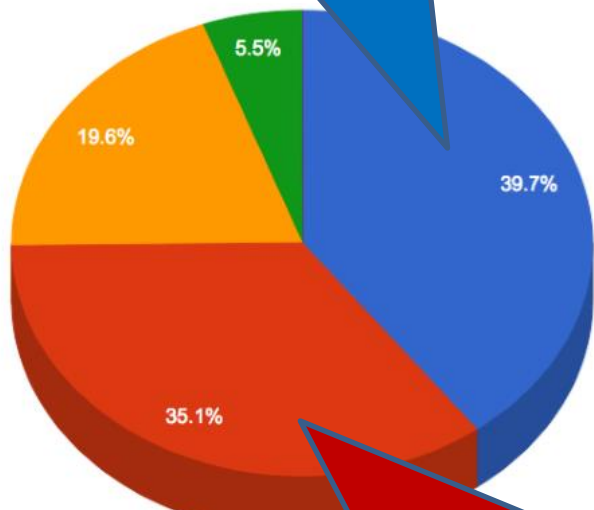
# Extended Version: Geolocation results Rechecks (Ongoing)

- 100 RIPE atlas probes randomly selected in the world
- Around 18,751 pings measurements towards 1,870 IPs among
- Computation of the delay
  - XXX of IPs whose geoloc are expected to be wrong

# Striking Results

# Who's serving whom (DNS+EDNS0 results)?

But US still wins

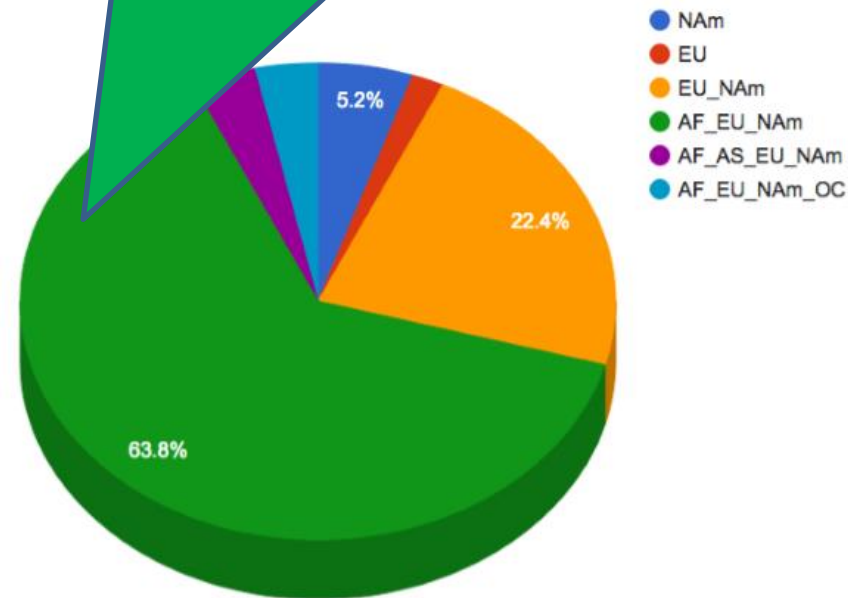


Africa does pretty well!

Location of caches

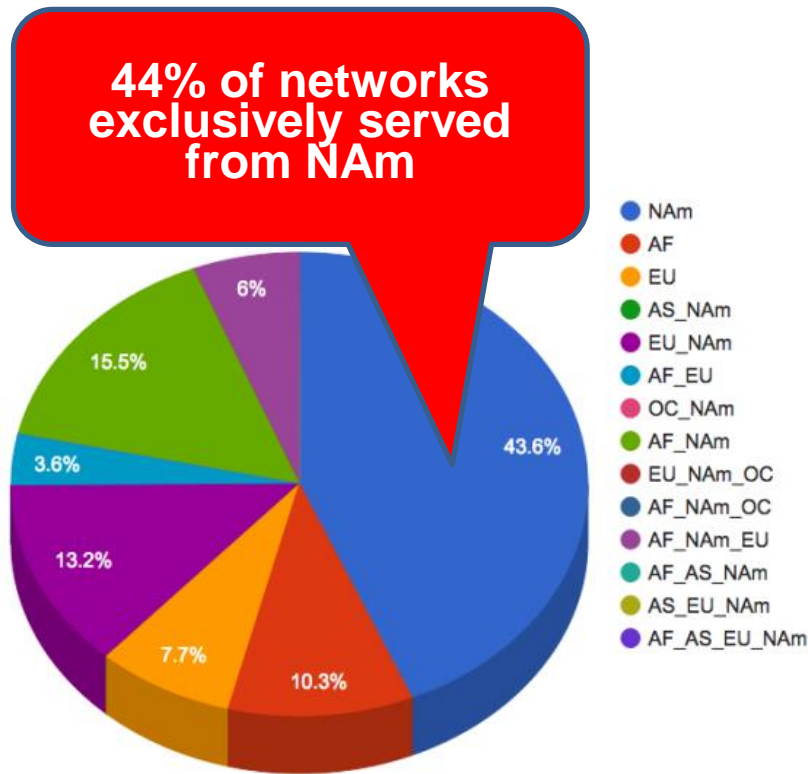
Most countries are a combo

- NORTH AMERICA (NA)
- AFRICA (AF)
- EUROPE (EU)
- ASIA (AS)
- OCEANIA (OC)



Percentage of countries served by each continent

# But it's not just about the countries

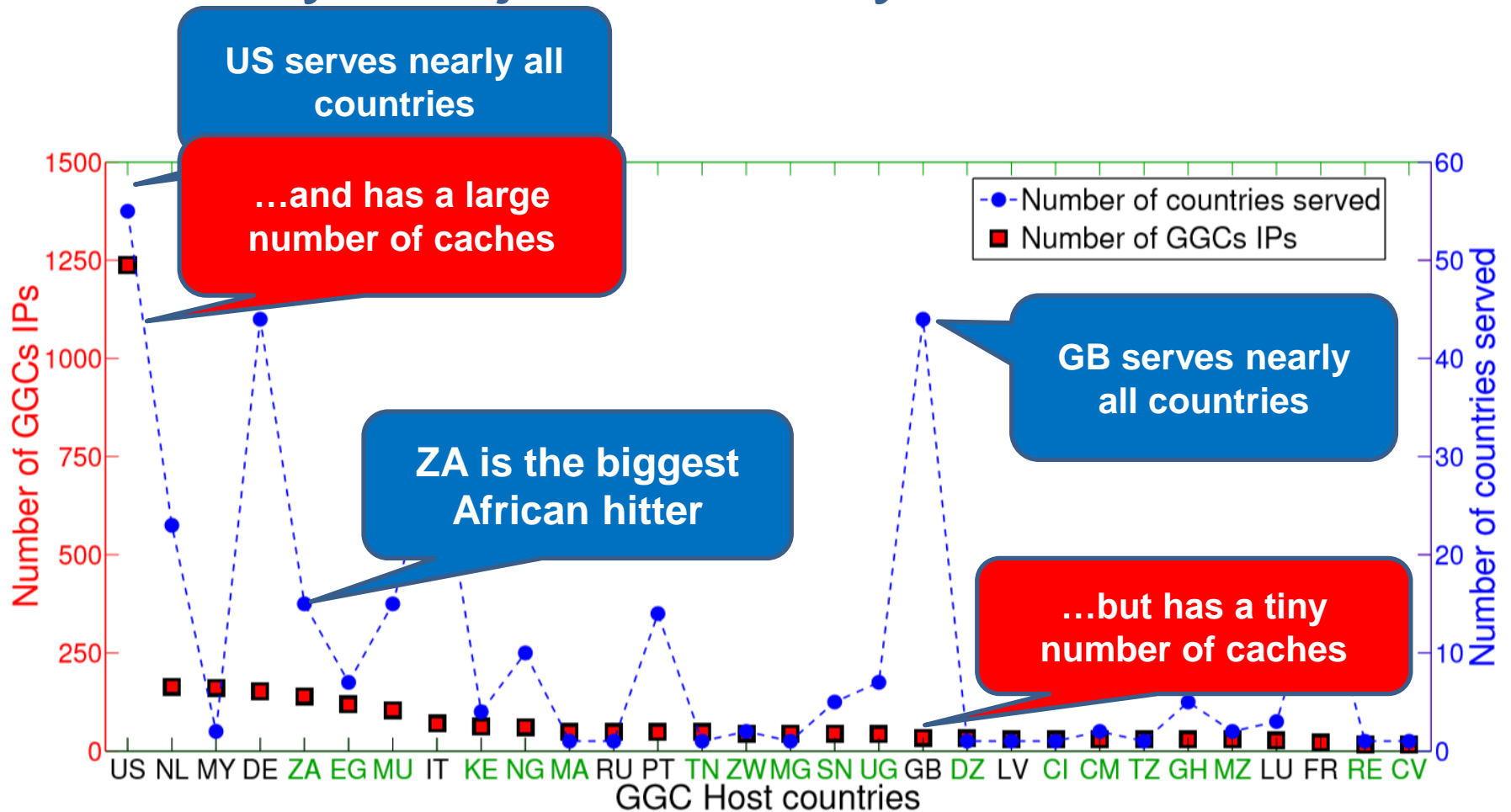


## Percentage of prefixes served by each continent

- Only 5% of **countries** exclusively served by US
- But 44% of **networks!**
- No **country** is exclusively served by Africa
- But 10% of **networks** are

AS	
1	GOOGLE, US (37.21%)
2	TMNET-AS-AP, MY (5.13%)
3	YOUTUBE GOOGLE, US (4.74%)
4	LEVEL3, US (2.56%)
5	MEO-INTERNACIONAL, PT (2.05%)
6	RETN-AS, UA (1.98%)
7	ROSTELECOM-AS, RU (1.53%)
8	ETISALAT-MISR, EG (1.51%)
9	TELECOM ITALIA, IT (1.5%)
10	MTNNS-AS, ZA (1.47%)

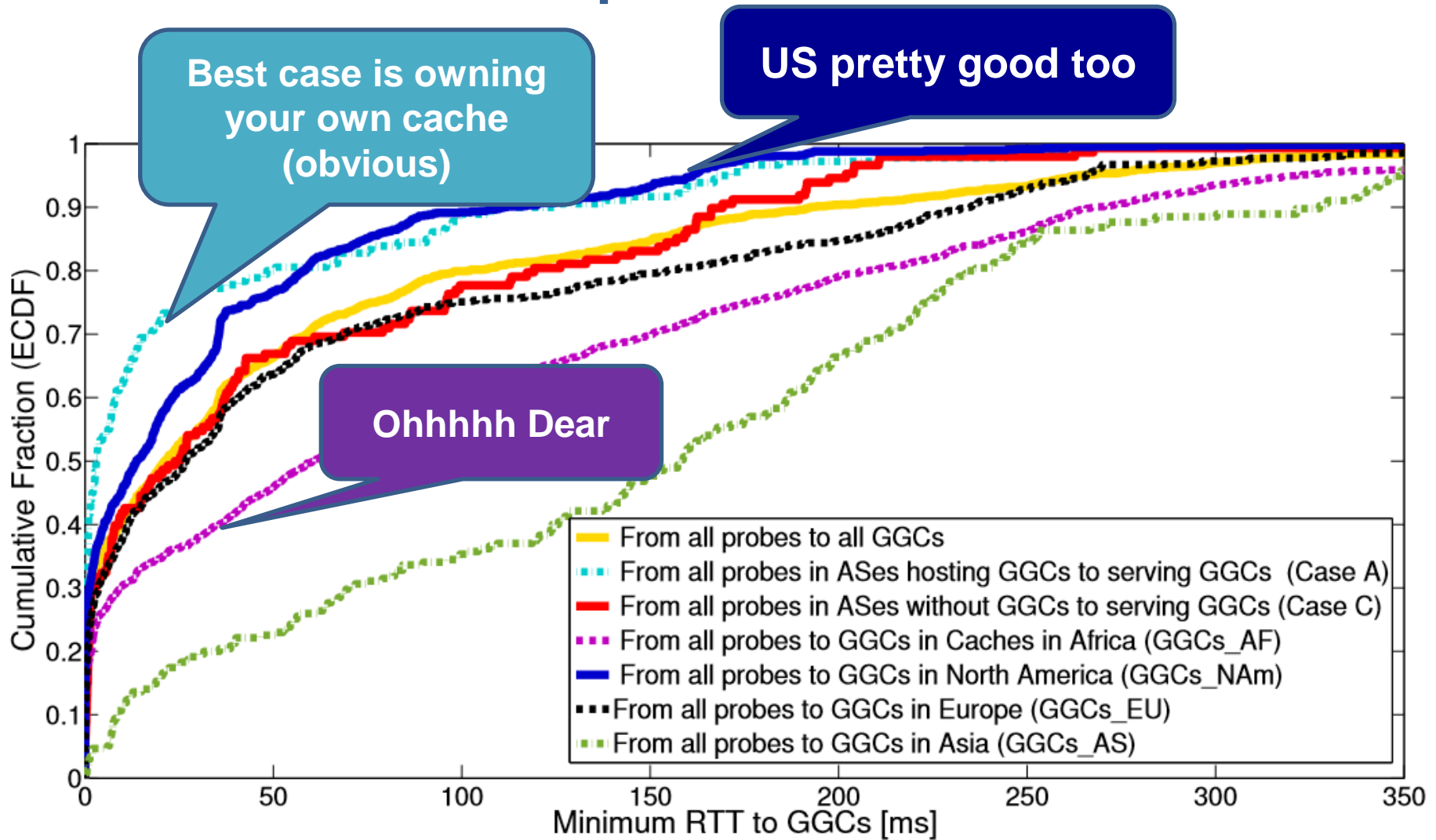
# Why not just share your cache?!



**Distribution of GCCs serving African prefixes across countries**



# What's the performance hit?



**CDF of the minimum RTT distribution**

# Peering is the key to low delays

BFIX IXP launched ([www.bfix.bf](http://www.bfix.bf))

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Internet Availability Center

Home » First Internet Exchange Point Launched in Nouakchott, Mauritania

## First Internet Exchange Point Launched in Nouakchott, Mauritania

02 December 2015

Internet Society supports launch with IXP training workshops

[Nouakchott, Mauritania – December 2, 2015] The Internet Society announced that Mauritania's first Internet Exchange Point (IXP) was successfully launched on 27 November 2015, in Nouakchott,

Liberia-IXP launched in LR

African Union  
a United and Strong Africa

Search

## African Internet Exchange System Project

Supporting Establishment of Internet Exchange Points in Africa

AXIS

AXIS Resources

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- AXIS Project Map
- Support of establishing National IXP
  - Best practice Workshop
  - Technical Training
- Regional IXP and Internet Carriers
- Documents
- News & Events

Aug.02.2015 - Aug.06.2015

### Setting up and launching of Internet Exchange Point in Liberia

August.02.2015 – August.06.2015 Setting up and launching of Internet Exchange Point in Liberia

Following the capacity building support provided by the African Union Commission (AUC) through the African Internet Exchange System (AXIS) Project, additional support from the AUC is being extended by providing the necessary equipment to set up the Internet Exchange Point (IXP) in readiness for the Commissioning of the IXP on 06 August 2015.

Upcoming Events

Sorry, there are currently no upcoming Events

AXIS

Windhoek-IXP launch in NA

TeleGeography  
AUTHORITATIVE TELECOM DATA

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## Namibia launches its IXP

13 Mar 2014

Namibia

Namibia officially launched the Windhoek Internet Exchange Point (WIXP) on 7 March 2014, reports InternetSociety.org. The domestic IXP eliminates dependence on international connectivity for local internet services and internet-based communications, and is expected to serve as a catalyst for innovation and

RIMIX IXP launched in MR

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## Mauritania Internet Exchange Point to be launched on 27 November 2015

25 November 2015 Africa Bureau

MS. BETEL HAILU  
Communications Coordinator for the African Regional Bureau

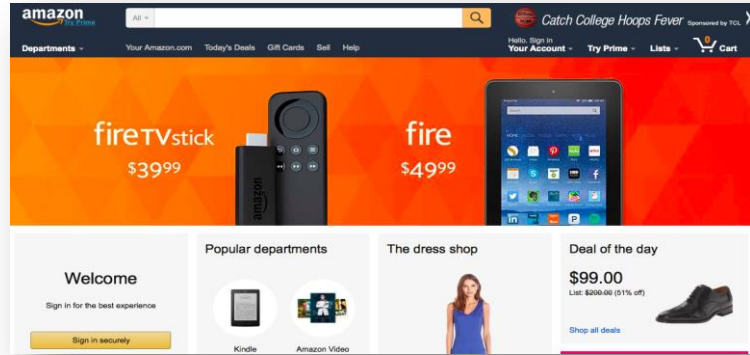
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# Peering is the key to low delays

- Launch of some of them proved [2]
  - RTTs among peers decrease
  - Financial costs decrease
- But many networks still remain **disconnected from IXPs**
  - Currently, on average 16 members at an African IXP

[2] Fanou et al. On the Inderdomain Routing in Africa, in PAM 2015

# amazon.com (E-commerce)



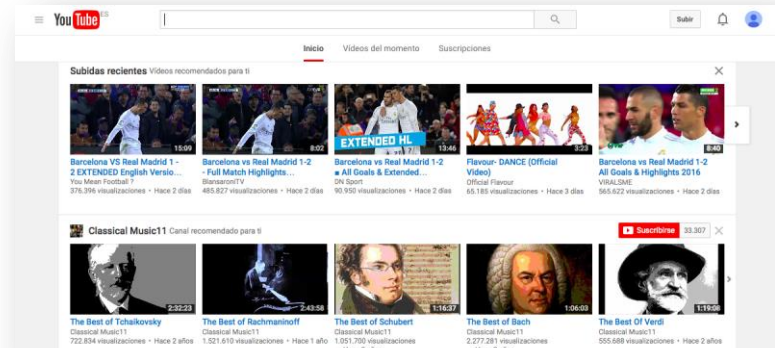
# taobao.com (E-commerce)



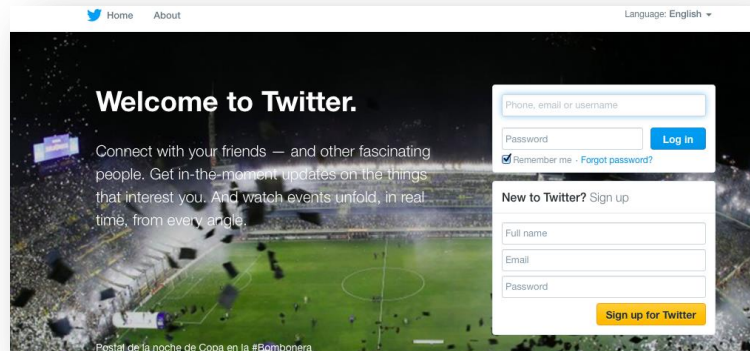
# wikipedia.com (Encyclopedia)



# youtube.com (Videos)



# twitter.com (Social network)



# facebook.com (Social network)

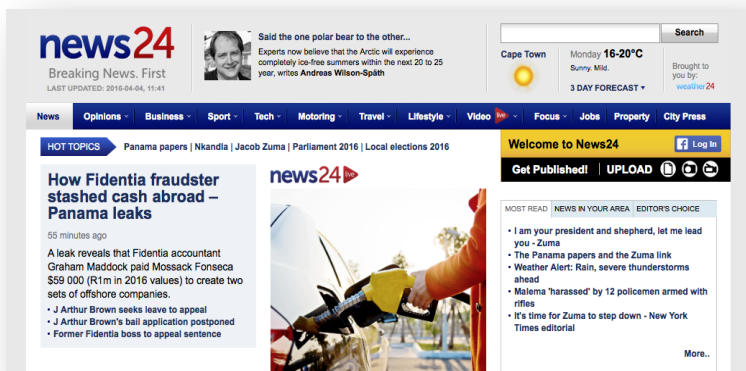


SOME TOP GLOBAL WEBSITES (ALEXA RANKING)

jumia.com (E-commerce)



news24.com (News/media)



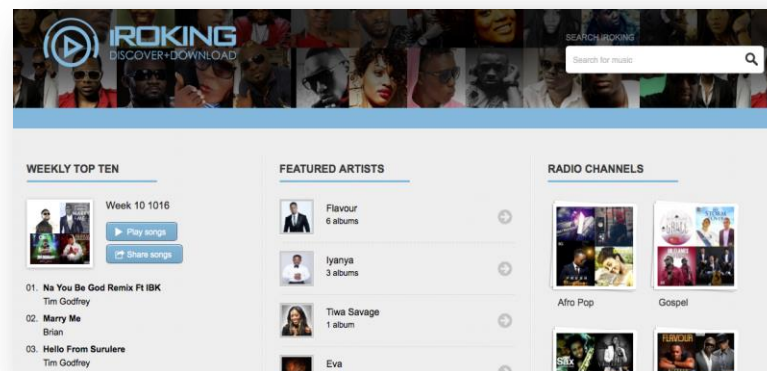
supersport.com (Sports)



gtbank.com (Financial services)



iroking.com (Videos)



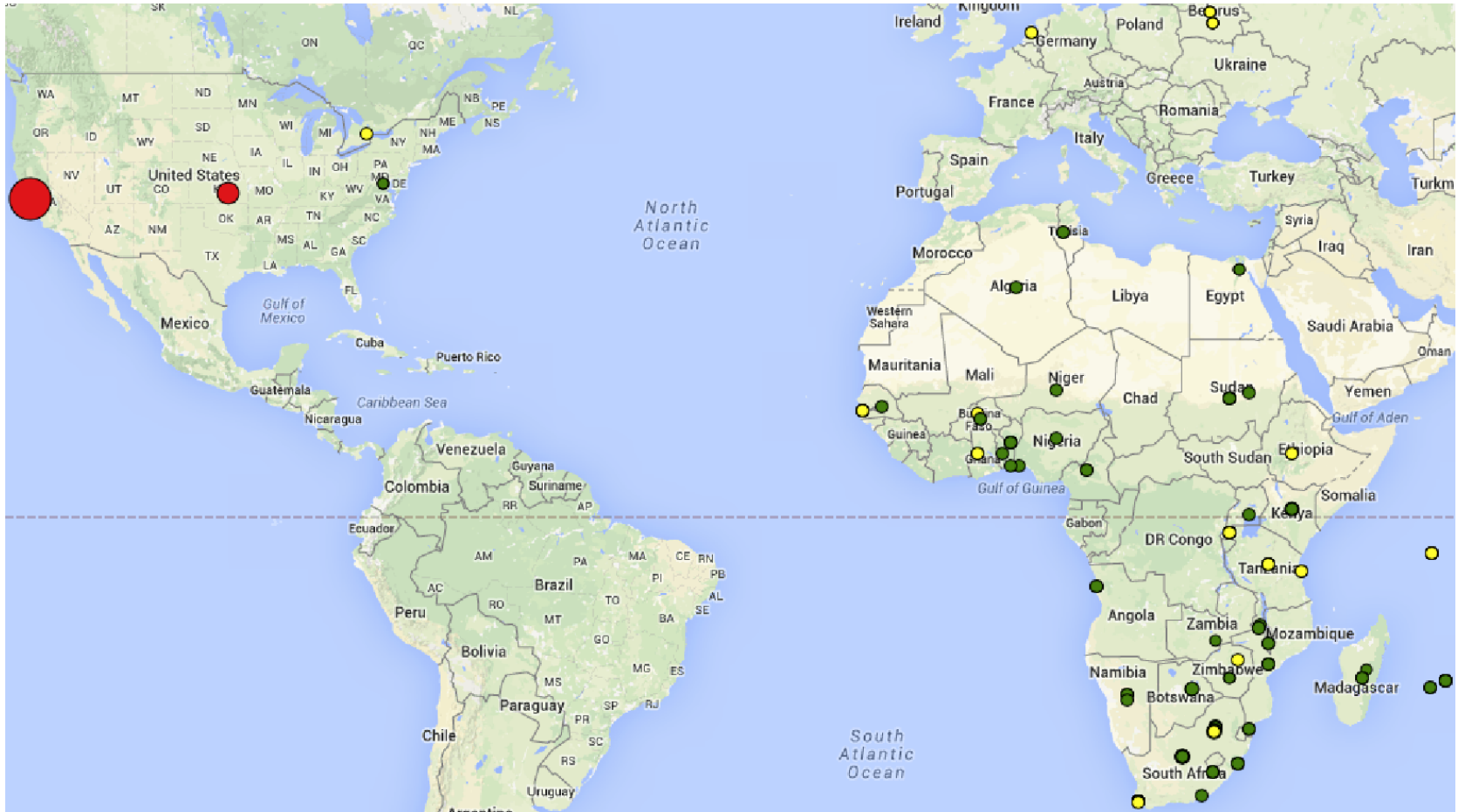
nairaland.com (Online Community)



# Expanding to other providers

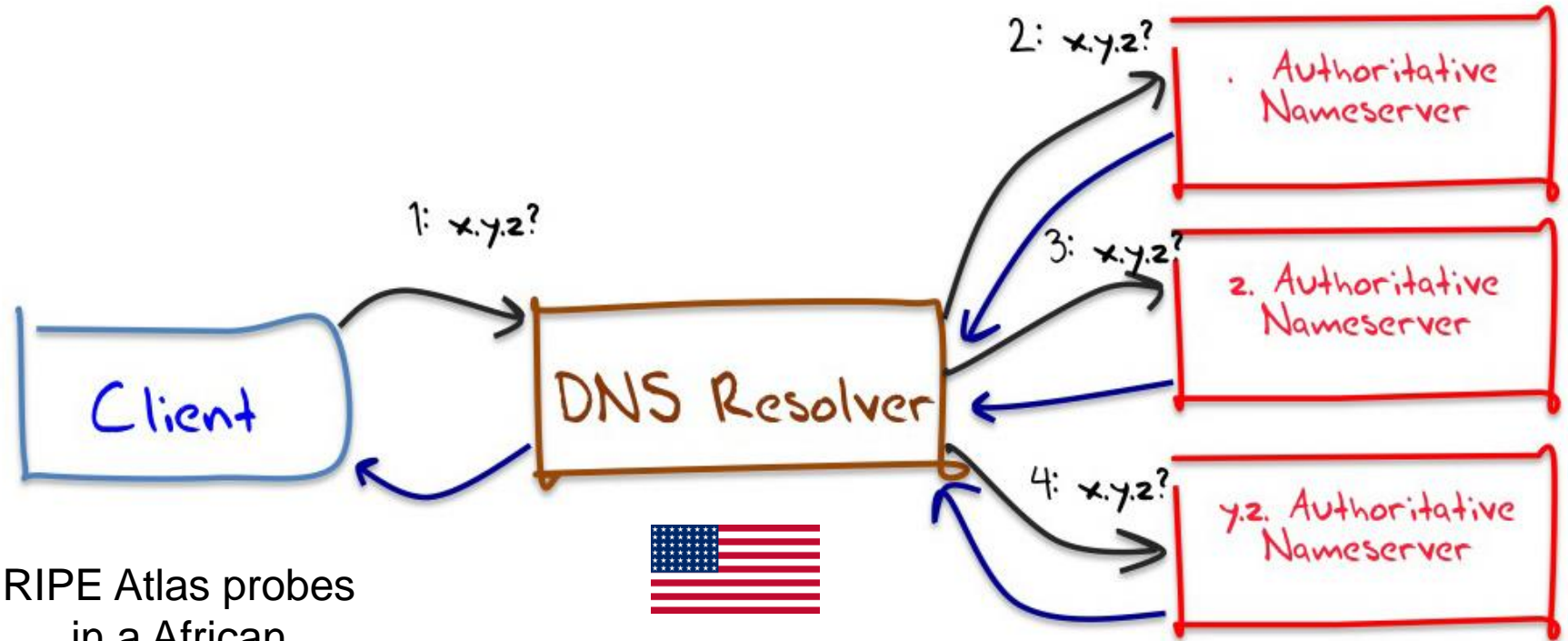
Top 15 sites in Africa (by Alexa & Afrodigit)	Type	#IPs caches	CCs host caches	ASes	Top 10 global web- sites (by Alexa)	Type	#IPs caches	CCs host caches	#ASes
jumia.com.ng	E-commerce	1	DE	20546	amazon.com	E-commerce	4	US	2
konga.com	E-commerce	1	US	15169	taboola.com	E-commerce			
bidorbuy.co.za	E-commerce	1	ZA	3741	Qq.com	Internet services	2	CN	2
fnb.co.za	Financial services	1	ZA	17148					
gtbank.com	Financial services	1	US	26496					
absa.co.za	Financial services	1	ZA	3741					
standardbank.co.za	Financial services	1	ZA	10798					
almasryalyoum.com	News/media	5	NL, CR	13335	google.com	Search engine	924	18 (§ 4.1)	26
elkhabar.com	News/media	2	US	13335	yahoo.com	Search engine	4	US, UK	2
vanguardngr.com	News/media	1	US	14618	baidu.com	Search engine	1	HK	1
news24.com	News/media	1	ZA	10474	wikipedia.com	encyclopedia	2	NL, US	2
punchng.com	News/media	1	IE	16509	facebook.com	Social network	5	US, DE, NL	1
iol.co.za	News/media	2	IE	16509	twitter.com	Social network	7	US	2
ghanaweb.com	News/media	1	US	7859	youtube.com	Videos	41	SN, MU, US	3
nairaland.com	Online community	5	US	13335					
supersport.com	Sports	1	ZA	10474					
alwafd.org	Politics	2	NL	13335					
iroking.com	Videos	2	IE	16509					

# DNS resolvers used by Atlas probes



Each dot represents a set of DNS resolvers. Its size is proportional to the number ASes that used them for the resolution

# Outsourcing the operation of DNS



RIPE Atlas probes  
in a African  
Networks



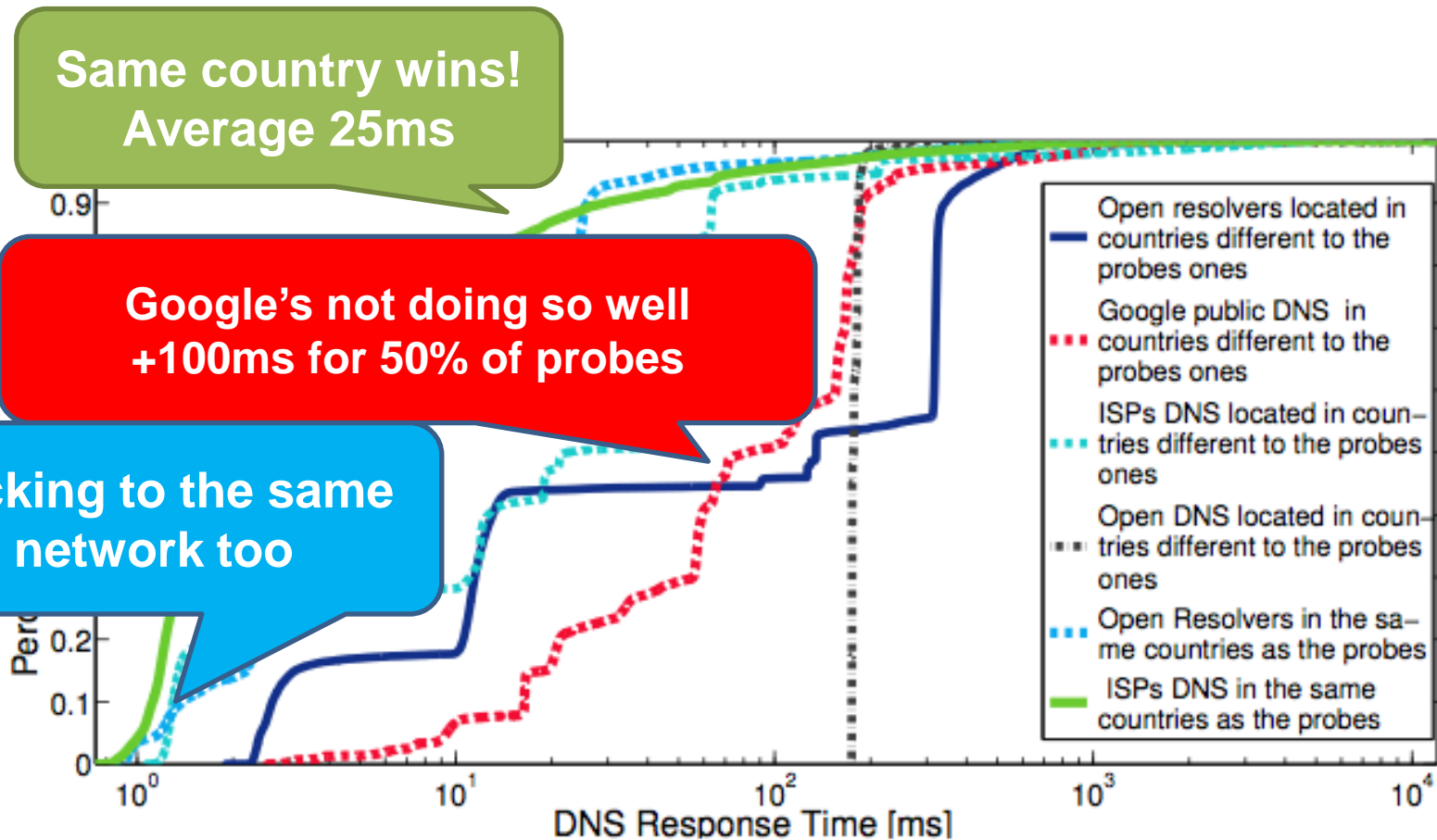
13.6% of DNS resolvers  
outside Africa & 4.7% in US





# Analyzing DNS in Africa

This translates into big delays !



**Cumulative Distribution of DNS resolution delays**

# Conclusions

- Superior **connectivity is only part of the equation**
- Africa is **not self sufficient in hosting infrastructures**
  - Most probed networks reliant on US infrastructure
  - Few third party networks share their GGC caches
- Google **is more developed in Africa** than other Content providers
- Even **local and regional websites hosted outside**
  - Higher HTTP load times from non-Google websites hosted outside
- **Poor DNS configuration** by African operators
  - High reliance on Open resolvers and Open DNS vs. ISPs DNS

# Our suggestions

- CDNs should begin to improve their presence in Africa
    - Popular regional providers as front-runners
  - Operators should improve peering
  - CDNs must concurrently host caches at existing African IXPs (37 functional/ 39 on PCH website - <https://prefix.pch.net/applications/ixpdir/summary/growth-region/>)
  - Network operators should correct their DNS settings
  - More public DNS resolvers should be placed in Africa
  - [Technical report available:](#)
- R. Fanou, G. Tyson, P. Francois, A. Sathiaselan, **Technical report: African Content Measurement Campaign**, [https://techrep\\_cdma:PDQ7Rjkj@fourier.networks.imdea.org/external/techrep\\_cdma/index](https://techrep_cdma:PDQ7Rjkj@fourier.networks.imdea.org/external/techrep_cdma/index)

# A few ideas to finish on ...

- **Deploying CDN caches/replication points is**
  - Let's do more of it!
- Network operators should **improve peering**
  - ... and stop using **third party DNS** (or place resolvers in Africa)
- **Need better hosting infrastructure in Africa** to bring in smaller players
  - E.g. cheaper, more reliable etc.
- Pick the **right ISP!**
- **Users can adopt smarter protocols**
  - E.g. SPDY/HTTP 2.0

# Acknowledgements

- We are grateful to all RIPE Atlas probes hosts and the RIPE Atlas team
- Arjuna Sathiaseelan is funded by H2020 RIFE Project

# References

[1] A. Gupta

[2] R. Fanou, P. Francois, E. Aben, On the Diversity of Interdomain in Africa, PAM2015, USA, April 2015

[3]

[4]

[5]

[6]



Thank you! Any questions?

