



Cloud Latency in Africa

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About Me

- Academic at University of Cape Town
 - Internet measurements
 - Focus on QoS/QoE in low-resource networks
 - Measuring properties of the Internet in Africa

Introduction: Cloud in Africa

- Most of the Cloud infrastructure are North America, Europe and South-East Asia
- Africa clients largely **redirected to CDN nodes in North America and Europe**
- Cloud consumers within Africa **experience high latencies to the Cloud destinations** at high costs.



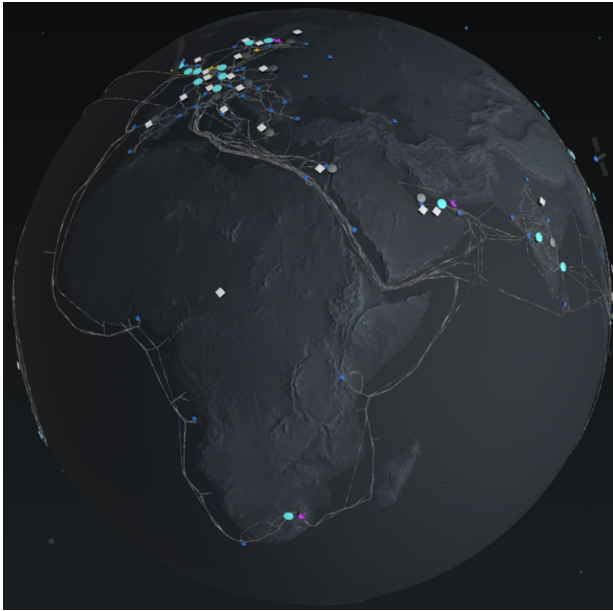
AWS Regions -

<https://aws.amazon.com/about-aws/global-infrastructure/>

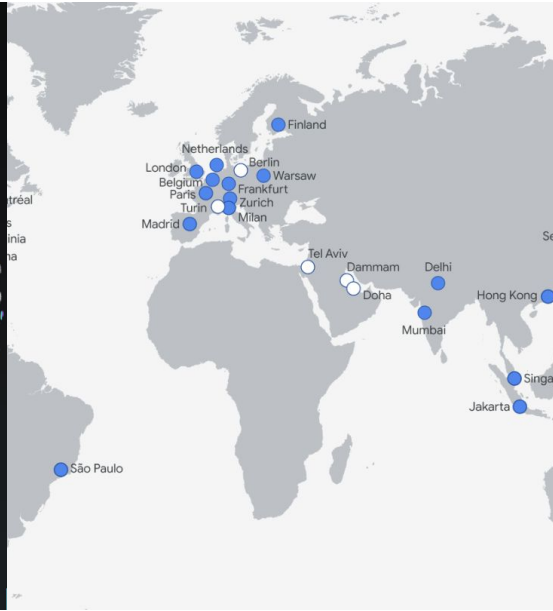
Introduction: Cloud Presence in Africa - AWS, Azure, and Google

★ Data Centers for Major Public Cloud Providers

- Cape Town, Johannesburg
- Amazon Web Services (AWS) and Microsoft Azure



Azure Regions



Google Regions

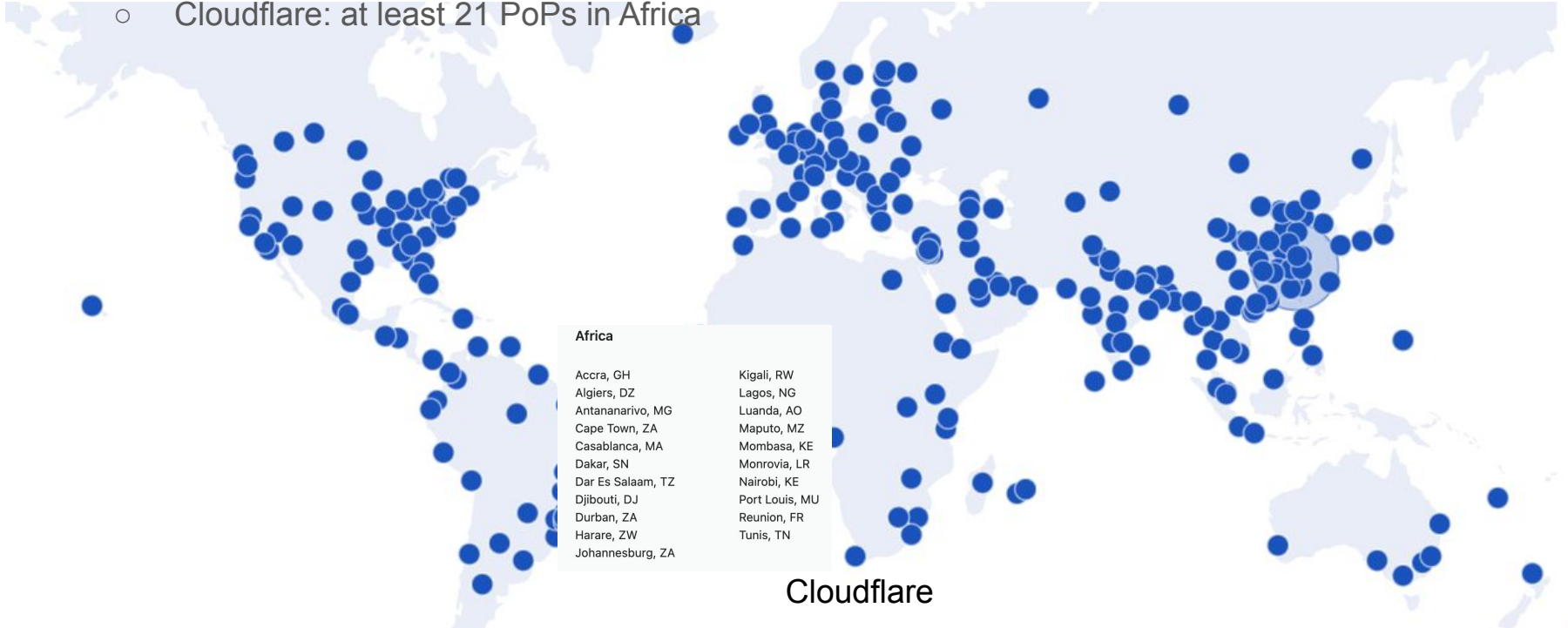


AWS Regions

CDNs in Africa - AWS, Azure, Google and **Cloudflare**

★ The Points of Presence (PoPs) serve as locations where the Cloud providers host Content Delivery Network (CDN) servers.

- CDN PoPs: Cape Town, Johannesburg, Nairobi, Lagos, Mombasa
- Cloudflare: at least 21 PoPs in Africa



Cloud Providers approach to improve performance

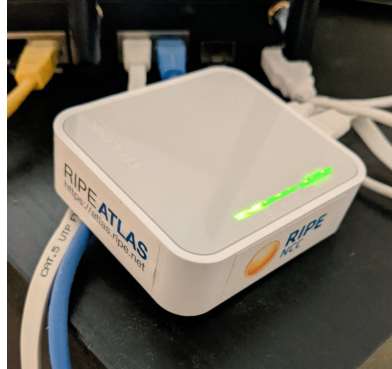
- ★ Utilizing DNS to direct users to the **closest CDN PoP**
 - **Geographic redirection** - use locations of clients (e.g Azure)
 - But: external DNS resolver (e.g. outside of Africa), or if geolocation inaccurate
 - Geographically close server may have high latency
 - **Latency-based DNS redirection**: latency between the DNS resolver and the available CDN servers is used to determine the closest server
- ★ Anycast based redirection (e.g Google, Cloudflare): prefixes are announced and advertised from multiple locations:
 - ISPs with limited peering and routing policies may direct a user to a distant CDN server

Questions

1. Which CDN PoPs are Users in Africa directed to?
2. What are the delays from African countries to DataCenters and CDN PoPs for major Cloud Providers?
3. How do these characteristics differ for Cloud users in Europe?

Experiment: Measuring Latency from Ripe Atlas Probes to CDN Nodes

- **RIPE Atlas Probes to CDN endpoints and Virtual Servers**
 - Cloud Web application
 - **71 Atlas Probes in 17 African** Countries: Rwanda, Burundi, Kenya, Tanzania, South Africa, Botswana, Namibia, Zambia, Tunisia, Morocco, Algeria, Ghana, Senegal, Togo, Cameroon, Mauritius, and Madagascar.
 - **58 Atlas Probes in 6 European** Countries: France, Germany, Ireland, UK, Italy, Russia
 - Ping and Traceroute measurements **every 8 hours for 30 days** (September 1 and September 31, 2021)



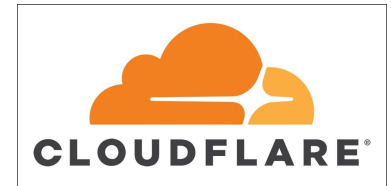
<http://dbp4ix4vge93x.cloudfront.net/>



<http://uctmit.azureedge.net/>




<http://google.victorbabs.com>



<http://afreenigeria.com>

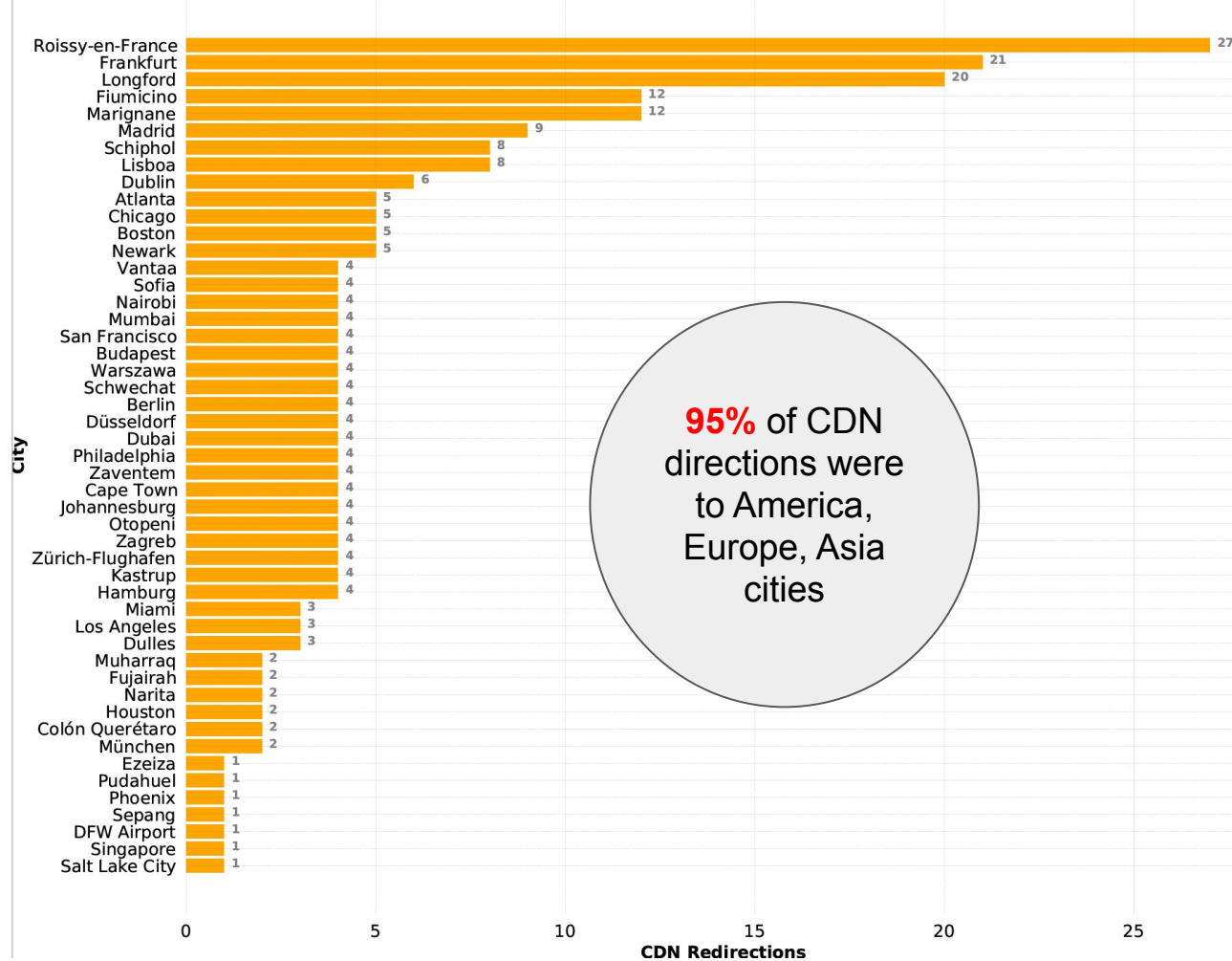
CDN Node Geolocation via Reverse DNS Lookup

CDN Destination IP address (~300 IPs)	Reverse DNS lookup	DNS results
52.222.128.153 52.222.128.147 18.66.92.96 18.66.92.61 18.66.92.161 18.66.92.159 18.66.121.179 13.249.12.106 99.84.221.220 54.230.252.101 52.222.161.147 52.84.40.3	 <p>https://www.infobyip.com/ipbulklookup.php</p>	<p>↓ IATA codes</p> <p>server-52-222-128-153.fco50.r.cloudfront.net server-52-222-128-147.fco50.r.cloudfront.net server-18-66-92-96.fra56.r.cloudfront.net server-18-66-92-61.fra56.r.cloudfront.net server-18-66-92-161.fra56.r.cloudfront.net server-18-66-92-159.fra56.r.cloudfront.net server-18-66-121-179.fra60.r.cloudfront.net server-13-249-12-106.cdg53.r.cloudfront.net server-99-84-221-220.iad79.r.cloudfront.net server-54-230-252-101.atl56.r.cloudfront.net server-52-222-161-147.cdg52.r.cloudfront.net server-52-84-40-3.mrs52.r.cloudfront.net</p>

AWS Redirections

- ~300 Unique IP address
- Observed Africa clients to AWS mostly redirected to nodes in North America and Europe

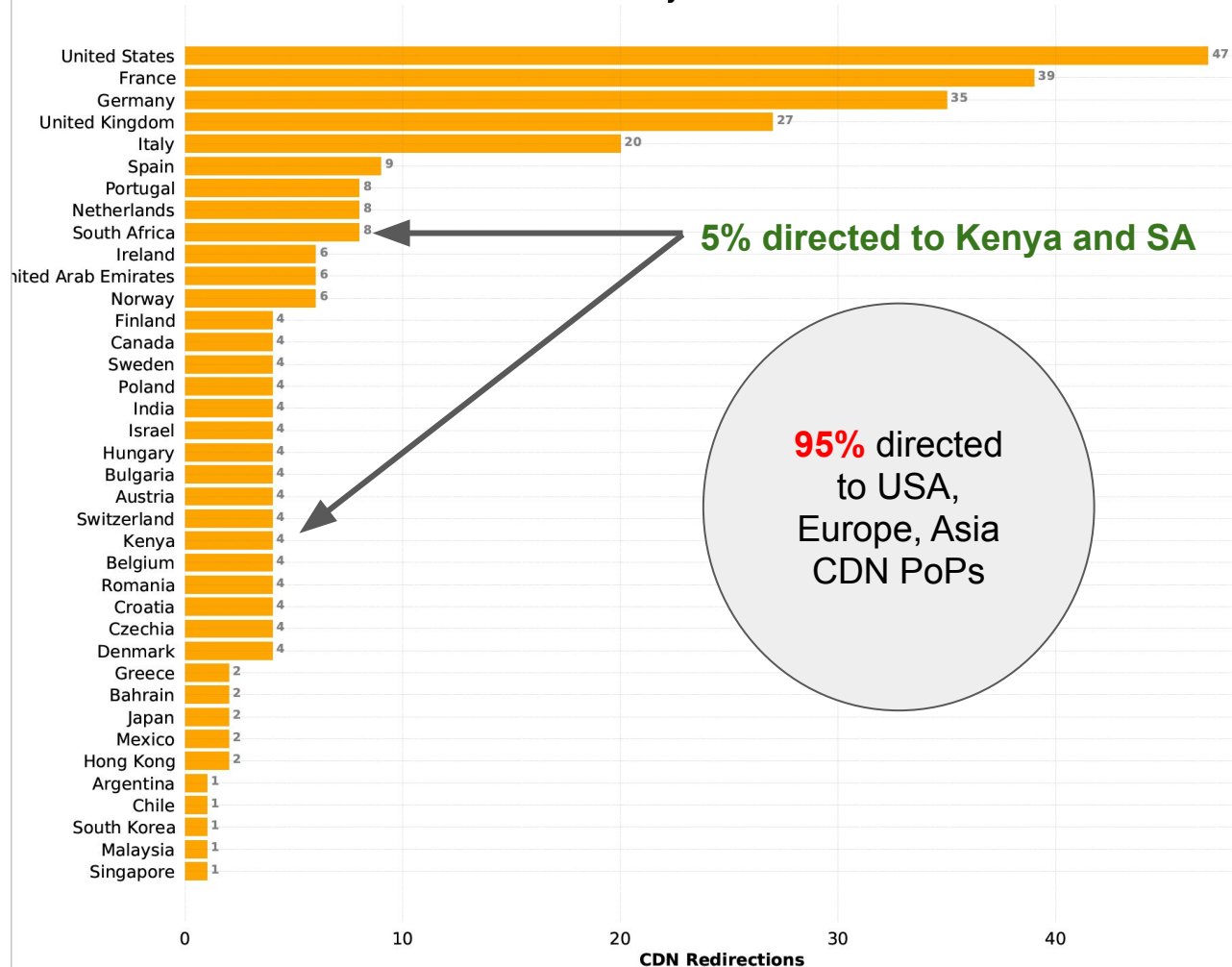
AWS CDN City Redirections from Africa



AWS Redirections

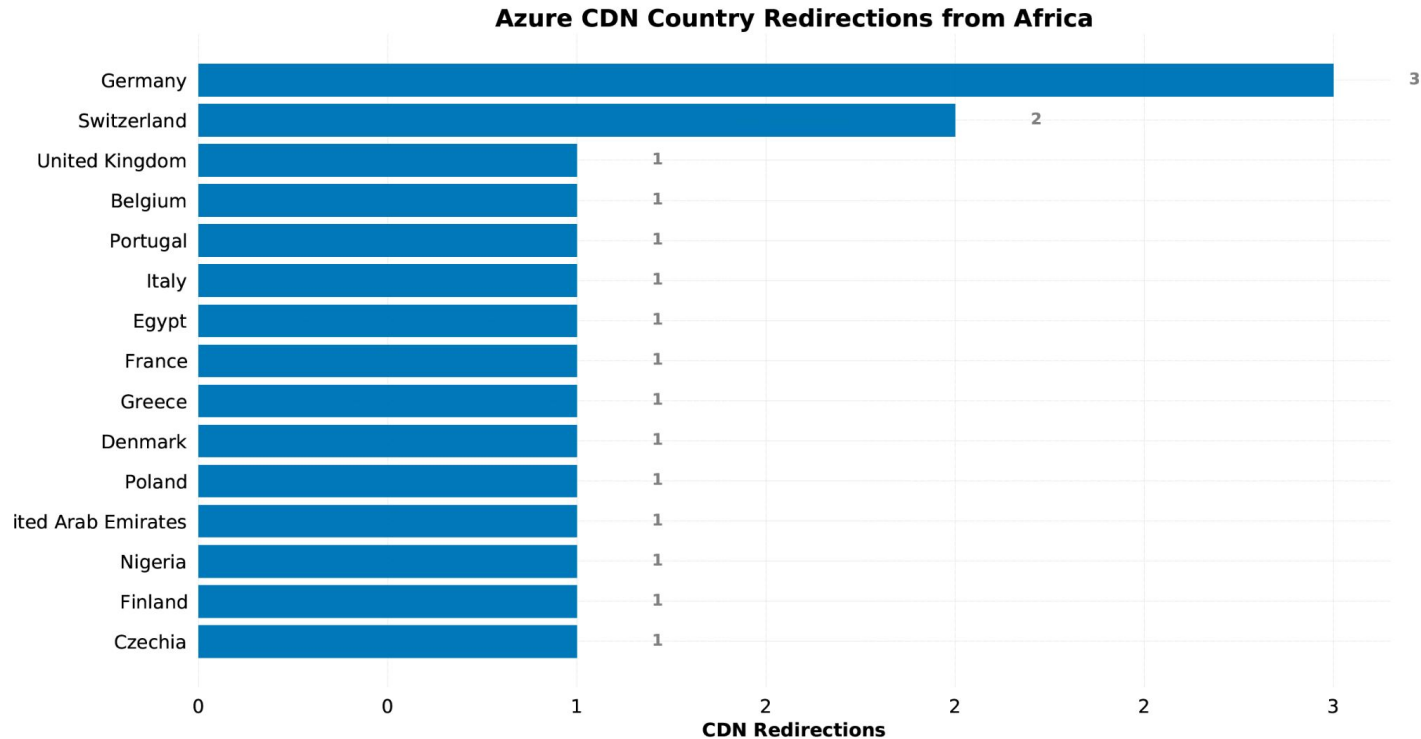
- ~300 Unique IP address
- Observed Africa clients to AWS mostly redirected to nodes in North America and Europe

AWS CDN Country Redirections from Africa



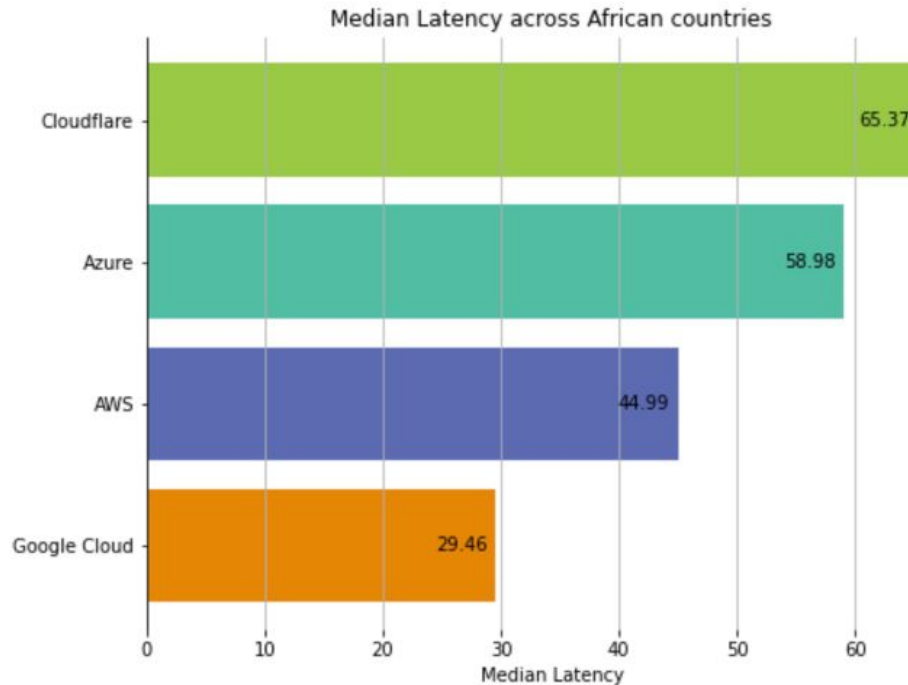
Azure Redirections

- Africa clients to MS Azure mostly redirected to nodes in North America and Europe



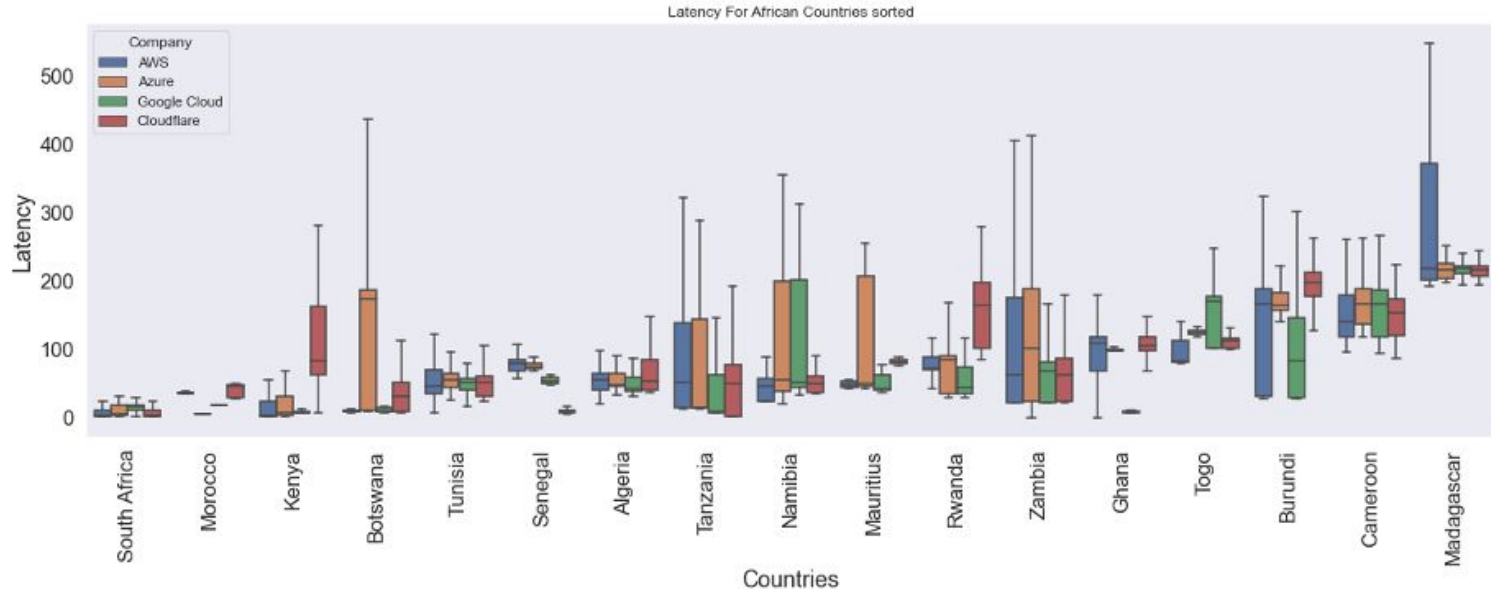
Results: Latency from RIPE Probes to CDN nodes

→ Median Latency - ranged from **29ms to 65ms**



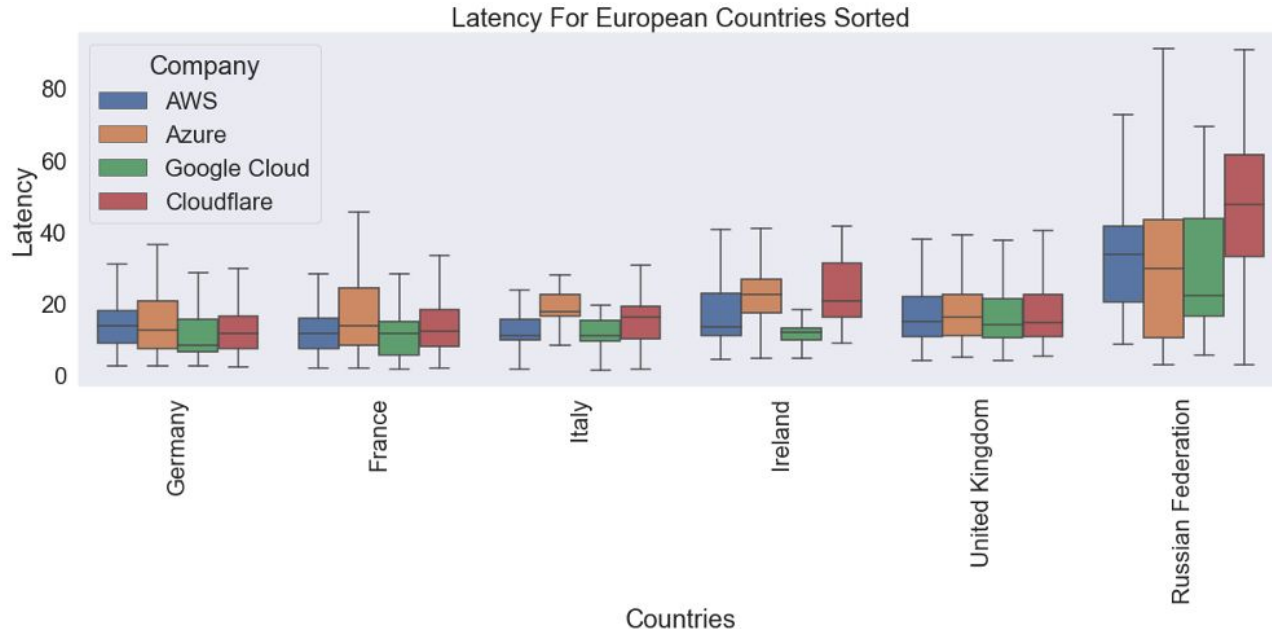
Results: Latency from RIPE Probes to CDN nodes

- South Africa, Morocco and Kenya had lowest median latencies: **5ms to 10ms**
- Burundi, Cameroon and Madagascar had the highest median latencies: **153ms to 216ms**



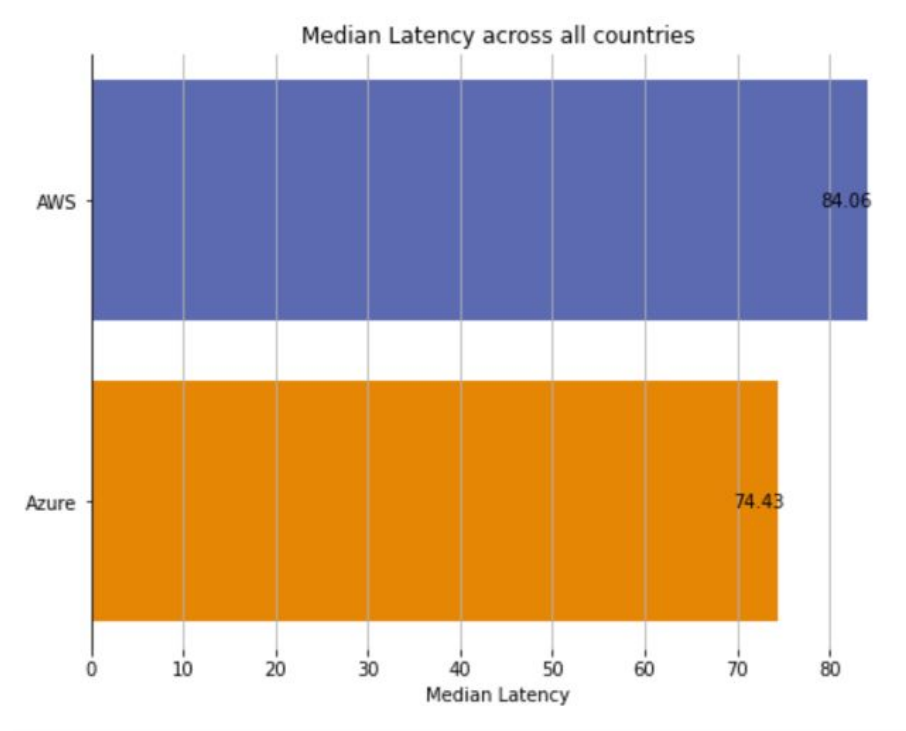
Latency from European RIPE Probes to CDN nodes

- Lowest median latencies to CDNs range from **12ms to 15ms** (France, Germany and UK)
- Highest CDN latencies in Europe was around **33ms** (Russia)



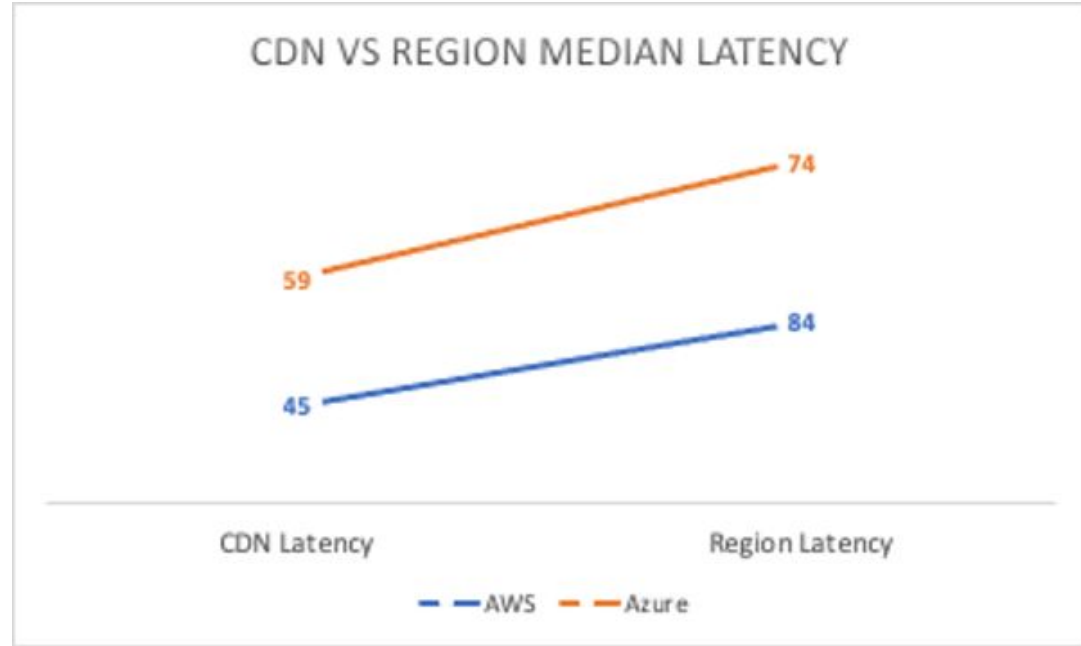
Latency from Africa's Atlas Probes to Data Centers

- Median latency to AWS Africa Region was **84ms** (vs **45ms for CDN nodes**).
- For Azure, latency to Africa Region was **74ms** (vs **59ms for CDN**).



Africa Latency to CDN vs Data Centers (Regions)

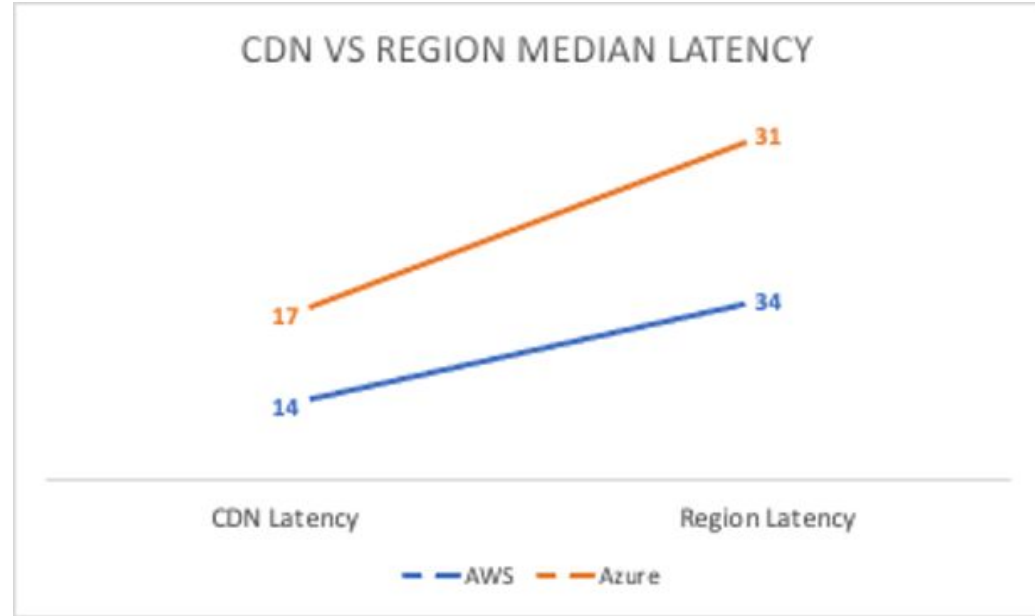
- African countries with CDN presence experienced lower latency between **5ms and 10ms**:
 - ◆ SA and Kenya
- Latencies to CDN endpoints were lower than to the Data Centers in South Africa
 - ◆ **87 percent** improvement with AWS
 - ◆ **25 percent** improvement with Azure
 - ◆



Europe Latency to CDN vs Data Centers (Regions)

→ Performance advantage in Europe was higher than observed in Africa:

- ◆ AWS CDN showed **142%** **performance advantage** over Data Center
- ◆ Azure CDN **showed 82%** **advantage** over Data Center



Observations

- Large majority of CDN endpoints used in Africa were outside the continent
 - ◆ AWS has **CDN locations in South Africa and Kenya**, but **returned caches outside of Africa** for probes in Africa (**latency-based redirection**)
- Google Cloud showed the least latency (uses Anycast)
 - ◆ Cloudflare also uses Anycast but had higher median latency
- Google and Cloudflare also directed users outside the continent (Anycast)

Conclusions

- ★ Better performance using CDNs PoPs of presence in Africa
- ★ **Peering Issue?** Cloud Providers have limited control in delivering quality performance to users
 - Little control over how Internet providers route traffic towards their infrastructure.
 - Ingress routing is at the discretion of ISPs / BGP routing.

Thank You!

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