Peering at the Internet's Frontier:
A First Look at ISP Interconnectivity in Africa

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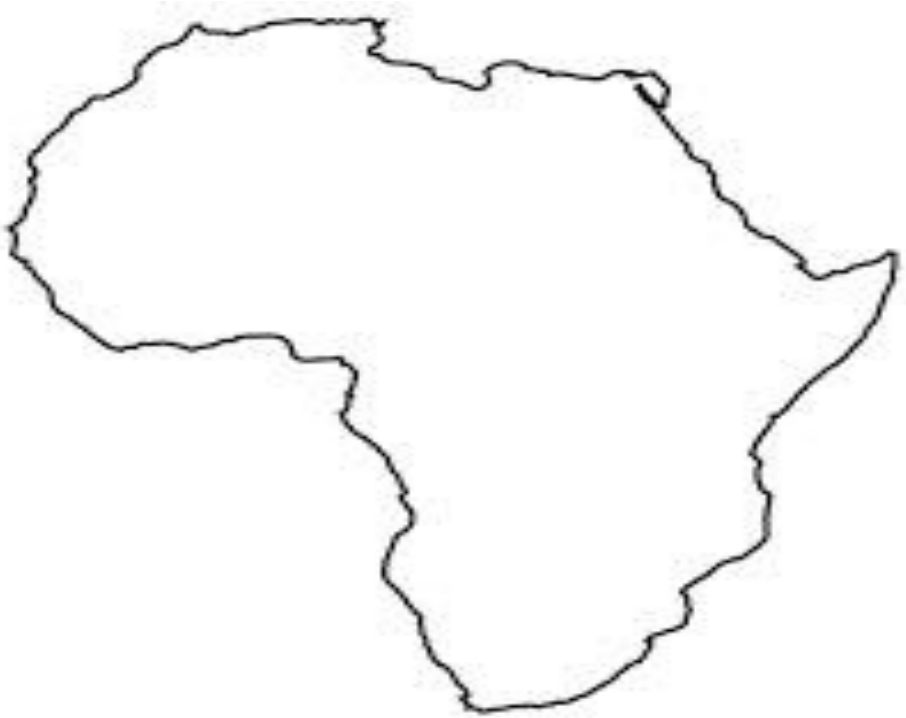
Broadband Connectivity in Africa



According to ITU in 2013

- 93 million broadband subscriptions
- 27% growth in past 4 years (**Highest**)
- Broadband associated with economic growth + development

Yet, very little is known about performance in Africa and what causes poor performance when it does arise.

How Well Does Broadband Perform?

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SA pigeon 'faster than broadband'

Winston the pigeon carries a 4GB memory stick across country

Broadband promised to unite the world with super-fast data delivery - but in South Africa it seems the web is still no faster than a humble pigeon.

A Durban IT company pitted an 11-month-old bird armed with a 4GB memory stick against the ADSL service from the country's biggest web firm, Telkom.

Winston the pigeon took two hours to carry the data 60 miles - in the same time the ADSL had sent 4% of the data.

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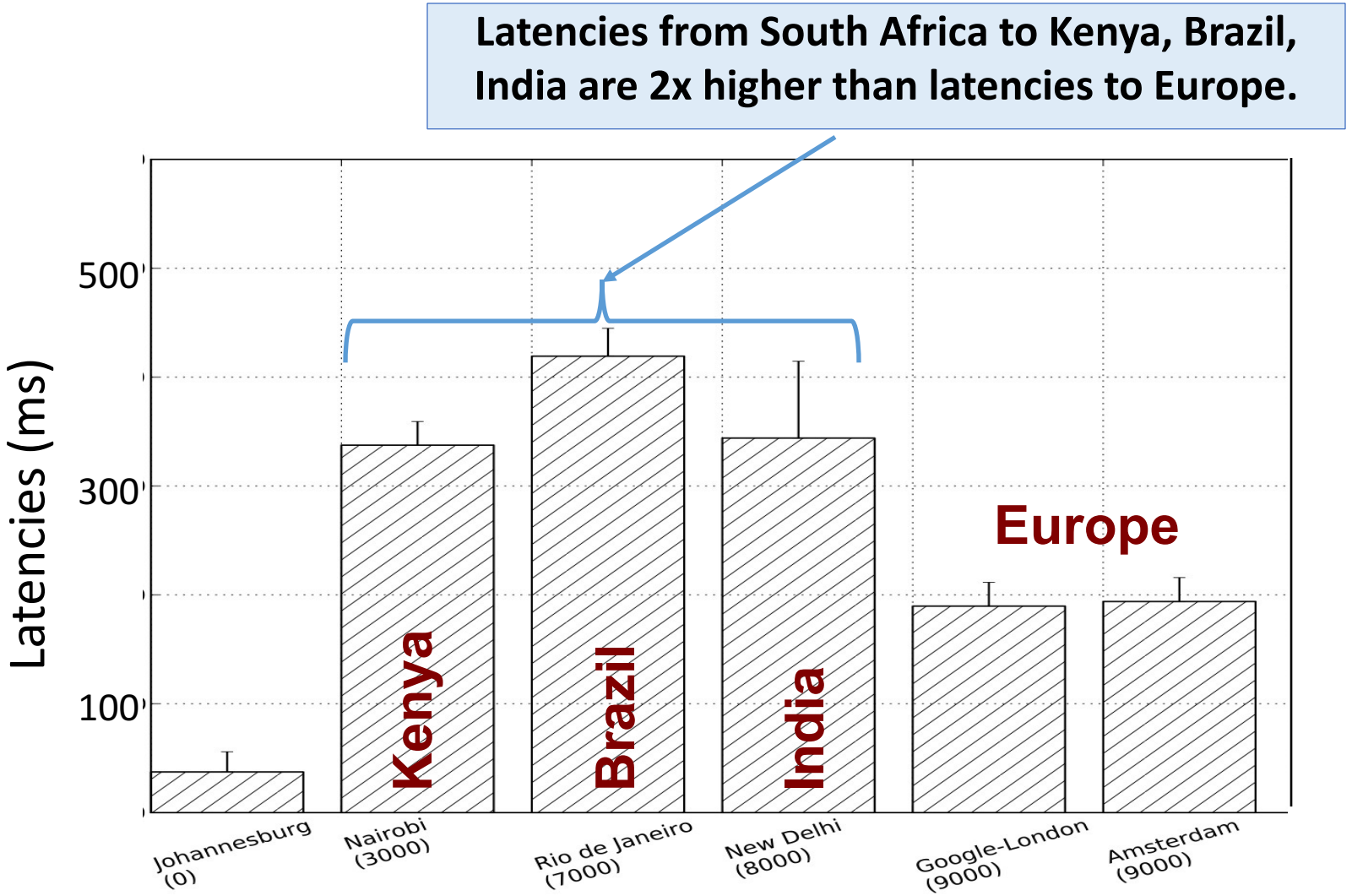
"Winston is over the moon"

Kevin Rolfe

- East Africa gets high-speed web
- Africa - are you connected?

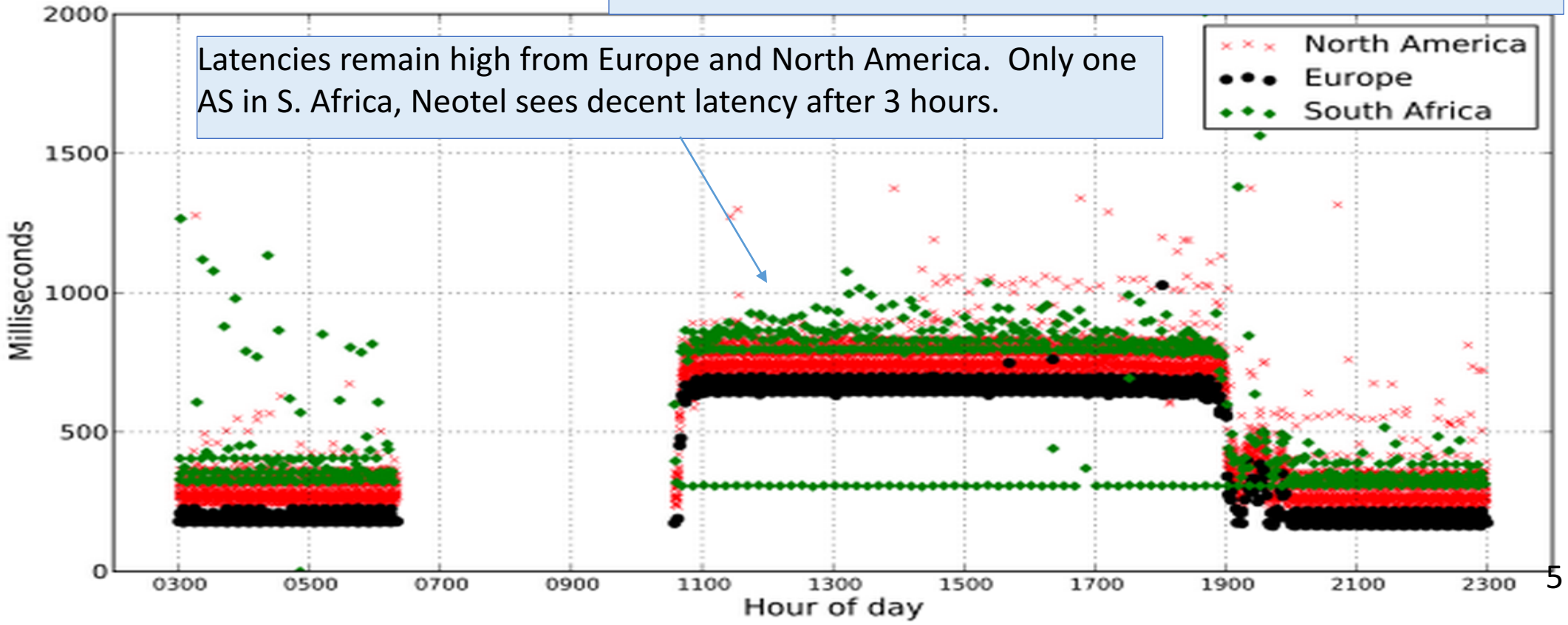
Latencies to Nearby Locations are High



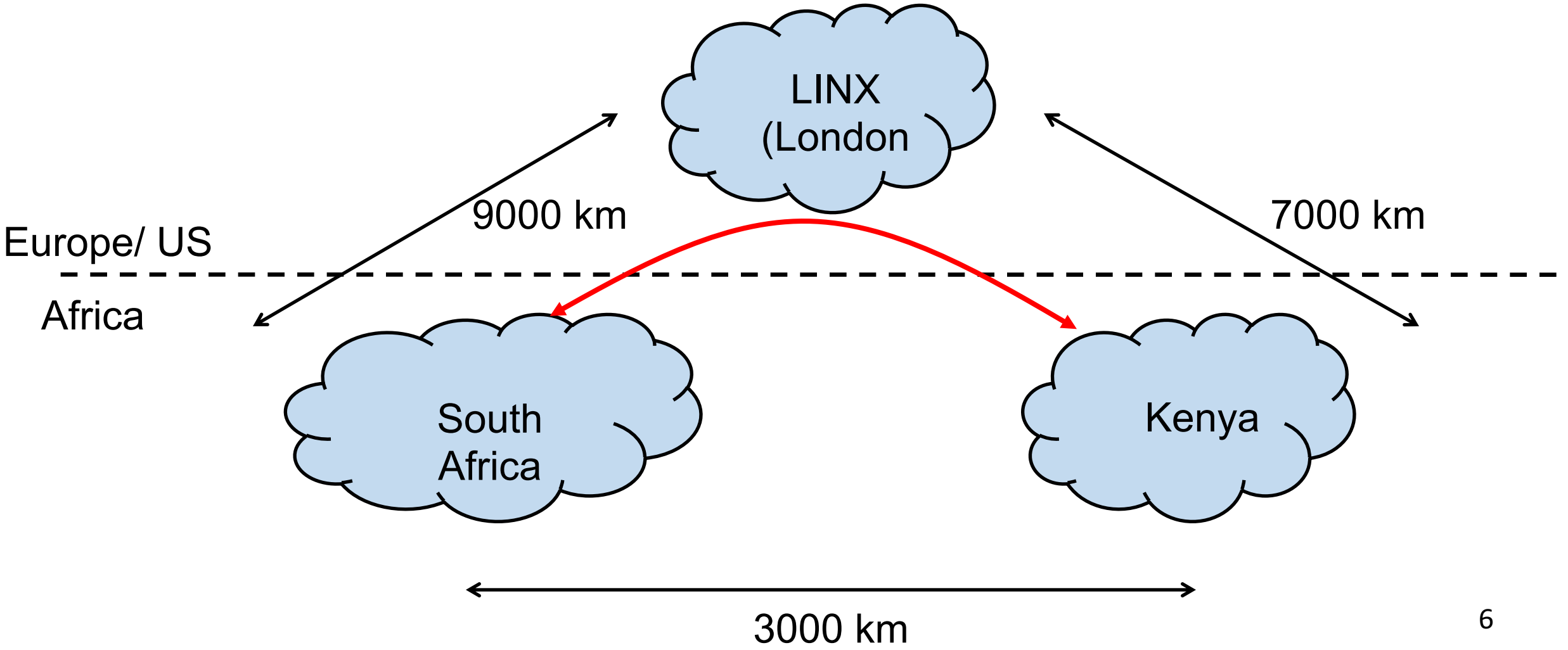
Latencies are Even Higher During Failures

- March 27, 2013 0620 UTC: SWM4 Fiber Cut
- All BISmark hosts could not reach KENet for 3+ hours
- Latencies remain high for another 8+ hours (except for Neotel, in South Africa)

More details: http://connectionmanagement.org



Causes of High Latency: Circuitous Routing Paths



Two Questions

- What is the nature of Internet interconnectivity (between ISPs) in Africa?

- What can be done to reduce latency to common Internet services?

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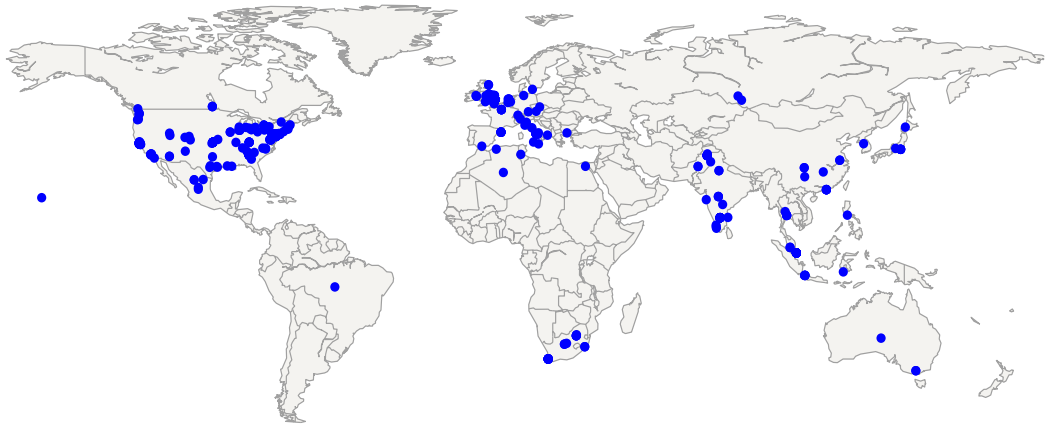
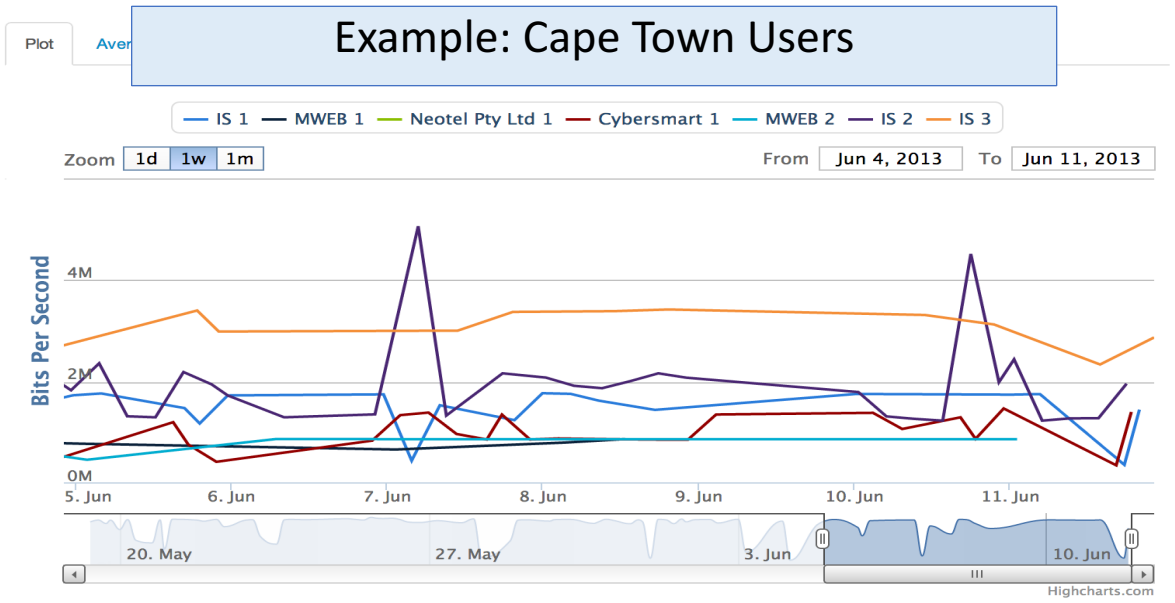
BISmark: Measurements from Fixed Locations



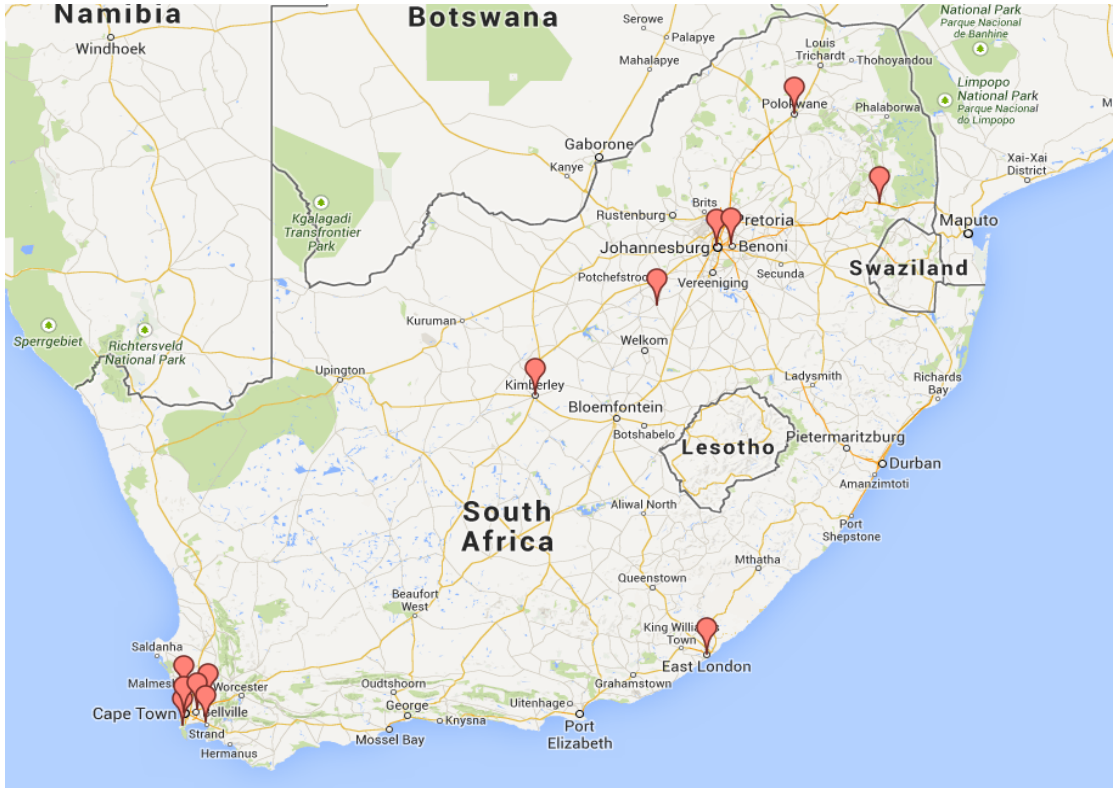
175+ Active Routers, 20+ countries



- Users install routers in home networks
- Custom firmware performs periodic measurements
- Can aggregate by country, city, ISP

BISmark Deployment in South Africa

- Periodic latency and throughput measurements
- Traceroutes to explain the cause of path performance
- Router-based deployment
  - 17 home networks, 7 ISPs, all 9 provinces



Destinations for Traceroute Probes

Global M-Lab Servers

Google Caches in Africa

High Latencies to Nearby Locations…

Cape Town (SA) to M-Lab Johannesburg (SA)

…
7, 196.44.0.74, 7.793, South Africa, AS16637
8, 196.223.22.24, 8.338, South Africa, Cape Town IXP
9, 41.164.0.243, 34.679, South Africa, AS36937
…
14, 196.24.45.146, **92.511**, South Africa, AS2018

Cape Town (SA) to M-Lab Nairobi (KE)

…
8, 209.212.111.201, 199.446, South Africa, AS16637
9, 195.66.225.31, 217.301, United Kingdom, London IXP (LINX)
10, 196.32.209.77, 201.569, South Africa, AS36944
…
14, 197.136.0.108, **368.107**, Kenya, AS36914

High Latency

… Circuitous Routing Paths

Cape Town (SA) to M-Lab Johannesburg (SA)

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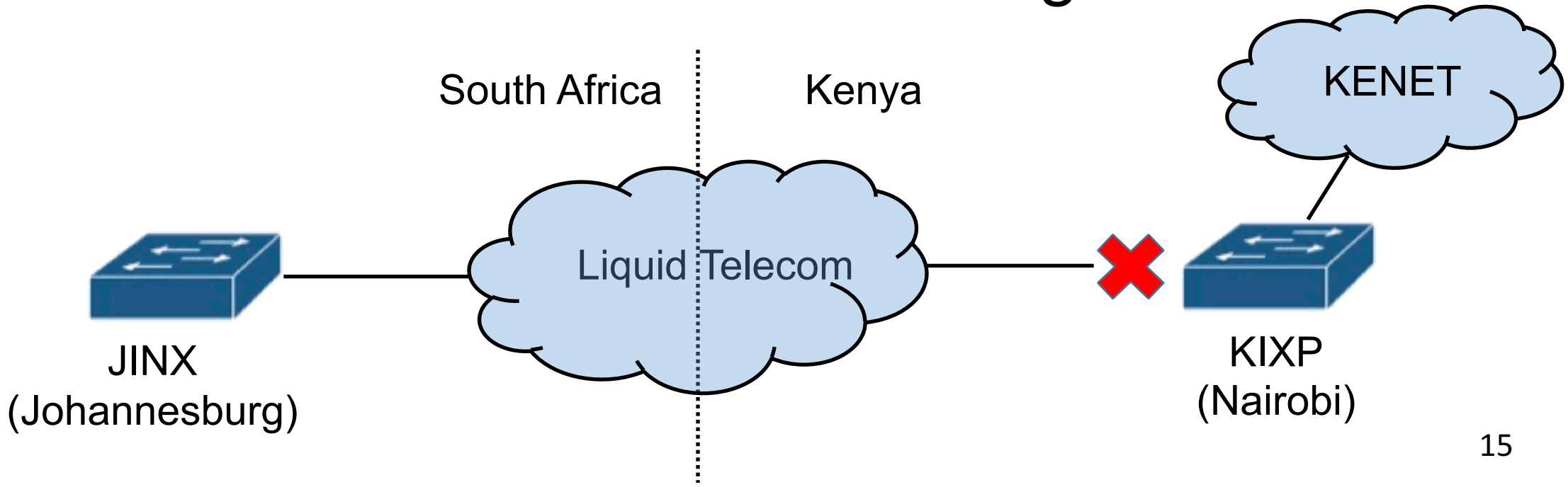
Packets leaving Africa

Poor ISP Interconnectivity in Africa

- Reasons
  - Local ISPs not present at regional IXPs
  - IXP participants don’t peer with each other
- Consequences
  - Local traffic does not stay local
  - Paths leave continent

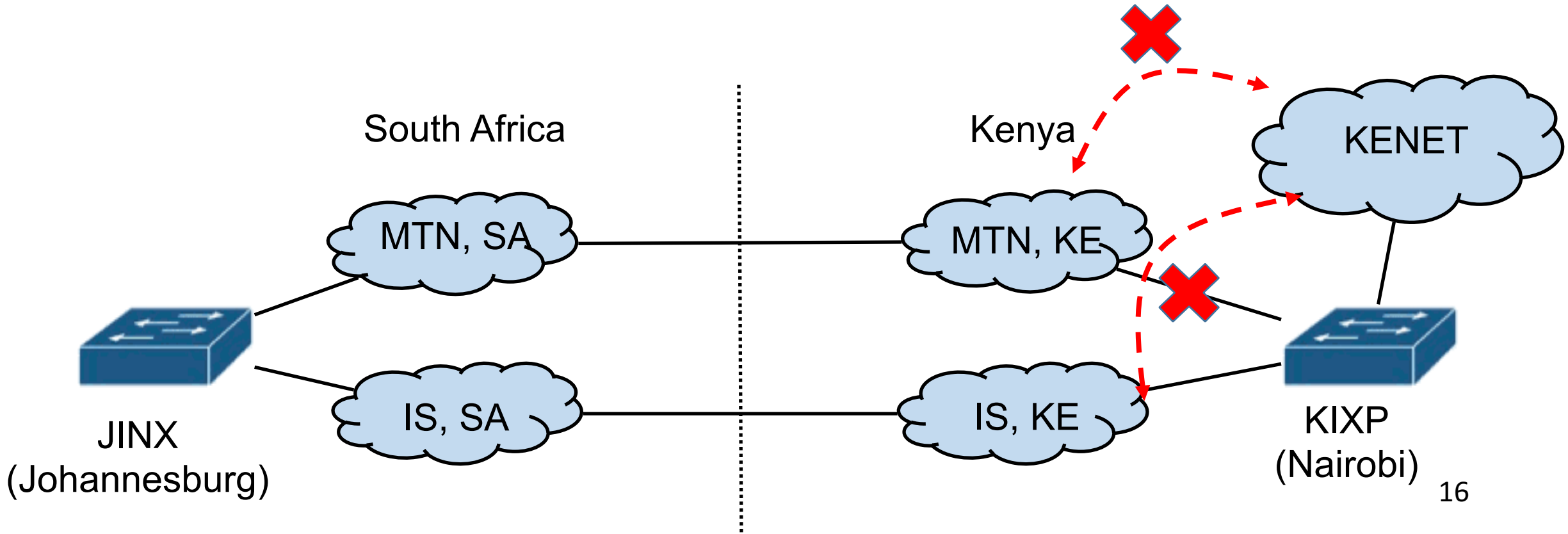
Local ISPs not Present at Regional IXPs

- ISPs prioritize connecting to European IXPs
- Lesser incentives to connect at regional ones



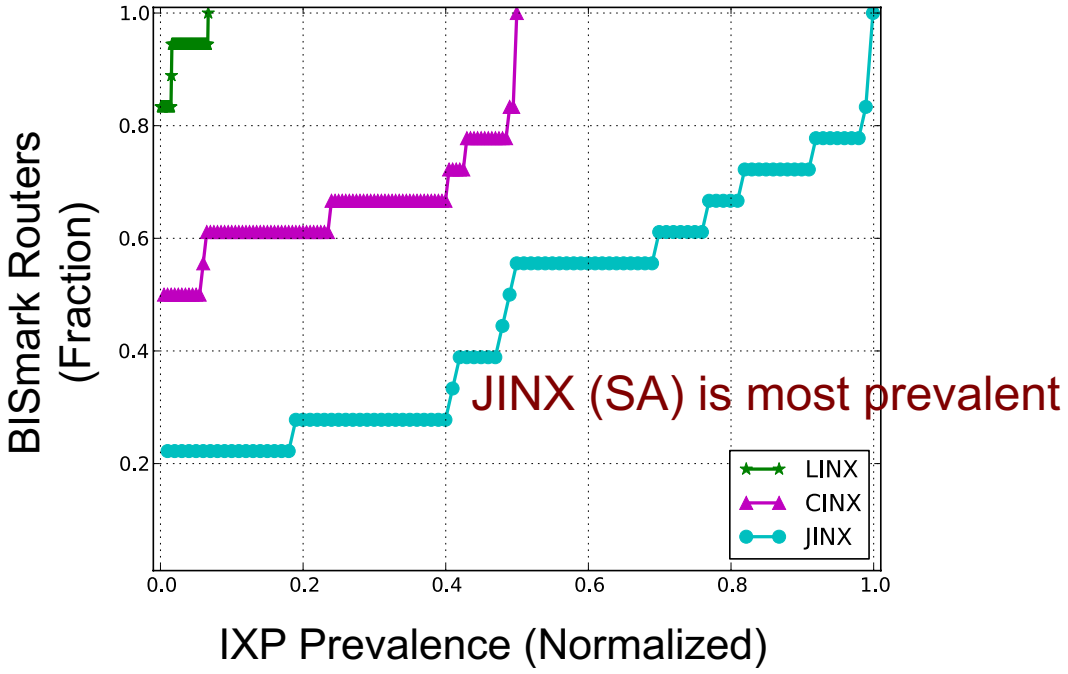
Missing Peering Links at Regional IXPs

- Most content not available locally
- Less incentive to peer with local ISPs



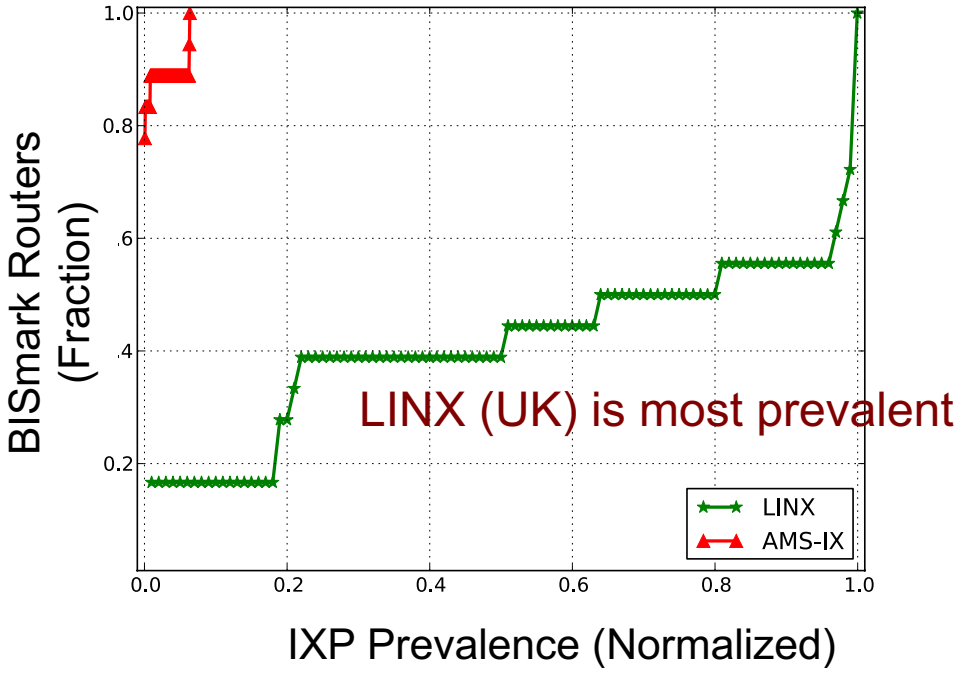
Regional IXPs Only Prevalent on Intra-Country Paths

Within South Africa:
High Fraction of Paths Have at Least one Major Regional IXP



M-Lab Johannesburg

Between South Africa and Kenya:
Few Paths have Regional IXPs



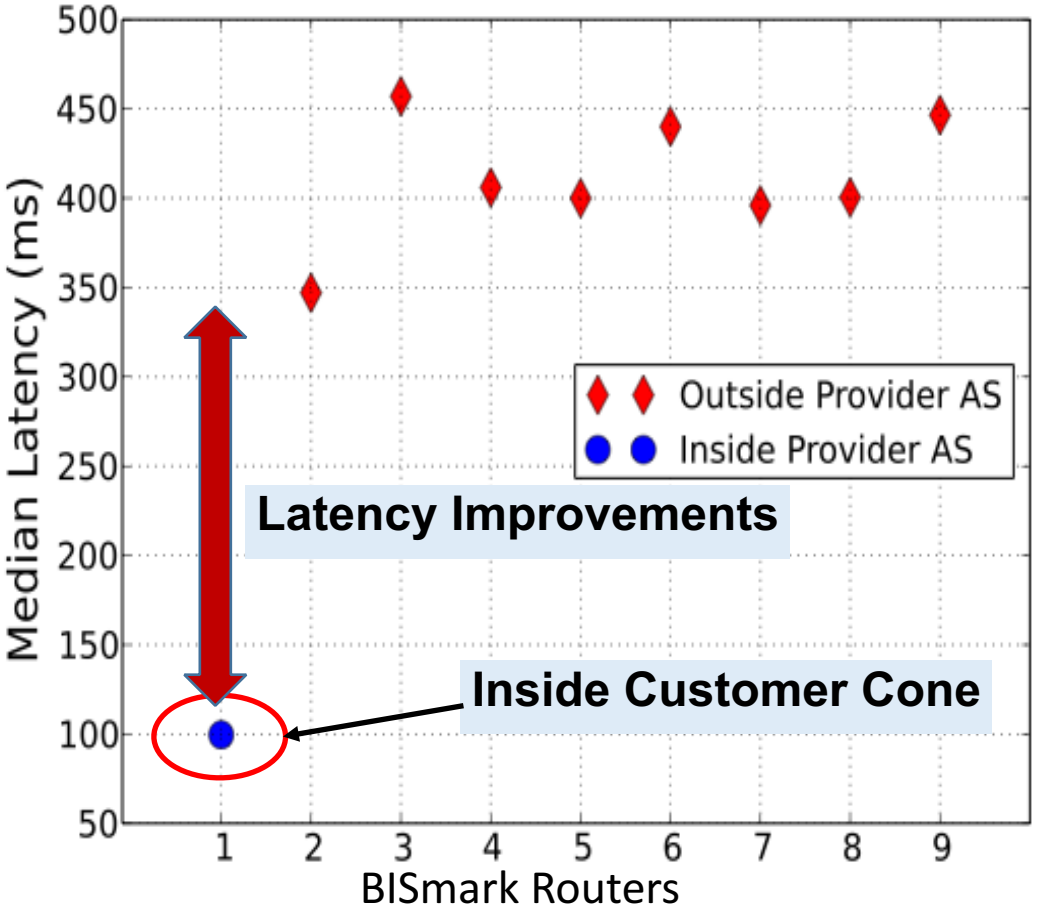
M-Lab Nairobi

Two Questions

- What is the nature of Internet interconnectivity (between ISPs) in Africa?

- **What can be done to reduce latency to common Internet services?**

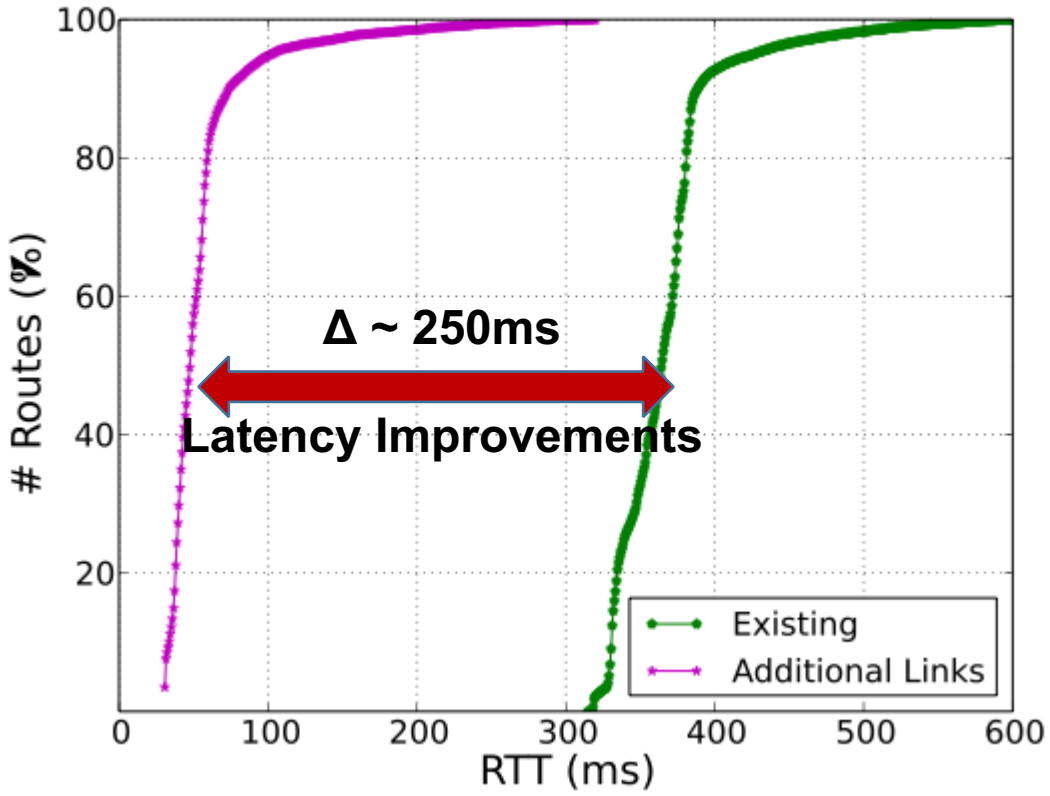
Solution #1: Add More Caches



- Traceroute Probes between BISmark routers (eyeball) and Google Cache Node in Uganda (content)
- Google cache hosted by MTN
- Emulates scenario where content is in nearby country

Latency improvements are limited when peering to the cache is not adequate.

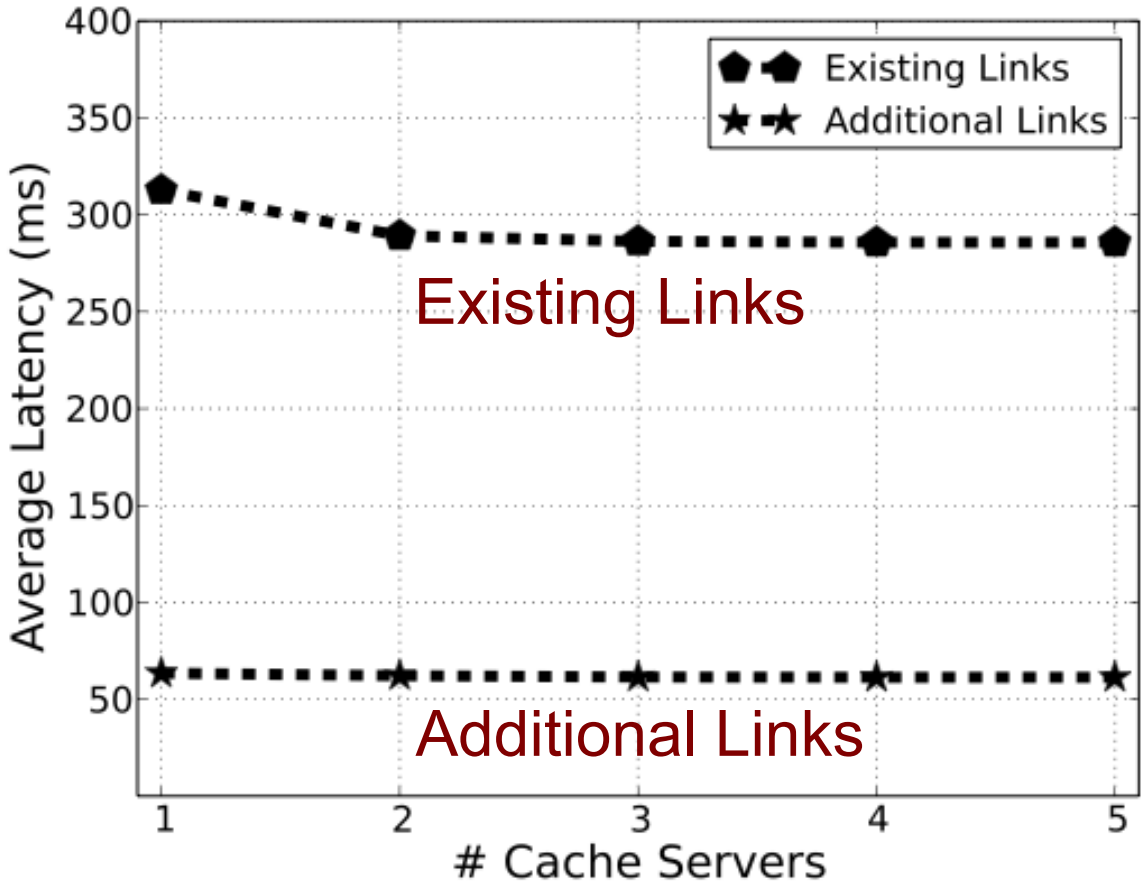
Solution #2: Add More Peering Links



- **Simulation**: Add peering links between all the participants at
  - JINX (Johannesburg)
  - KIXP (Nairobi)
- Emulates scenario where more ISPs connect and peer at regional IXPs

Additional peering links → Significant latency improvements

Better Peering is a Substitute for Additional Caches



- Experiment:
  - add caches in Kenya
  - traceroute Probe from SA
- Two scenarios
  - Use existing peering links
  - Add more peering links

Additional caches have little effect on average latency (compared to adding more peering links).

Summary

- What is the nature of Internet interconnectivity (between ISPs) in Africa?
  - Many ISPs are not present in regional IXPs
  - Many ISPs do not interconnect at regional IXPs
- What can be done to reduce latency to common Internet services?
  - Peering at regional IXPs can reduce median intra-continent latencies by 250ms
- Next steps: Better incentives for interconnectivity

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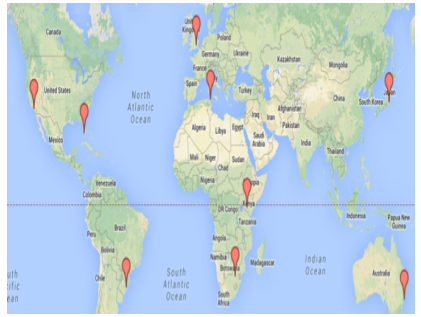
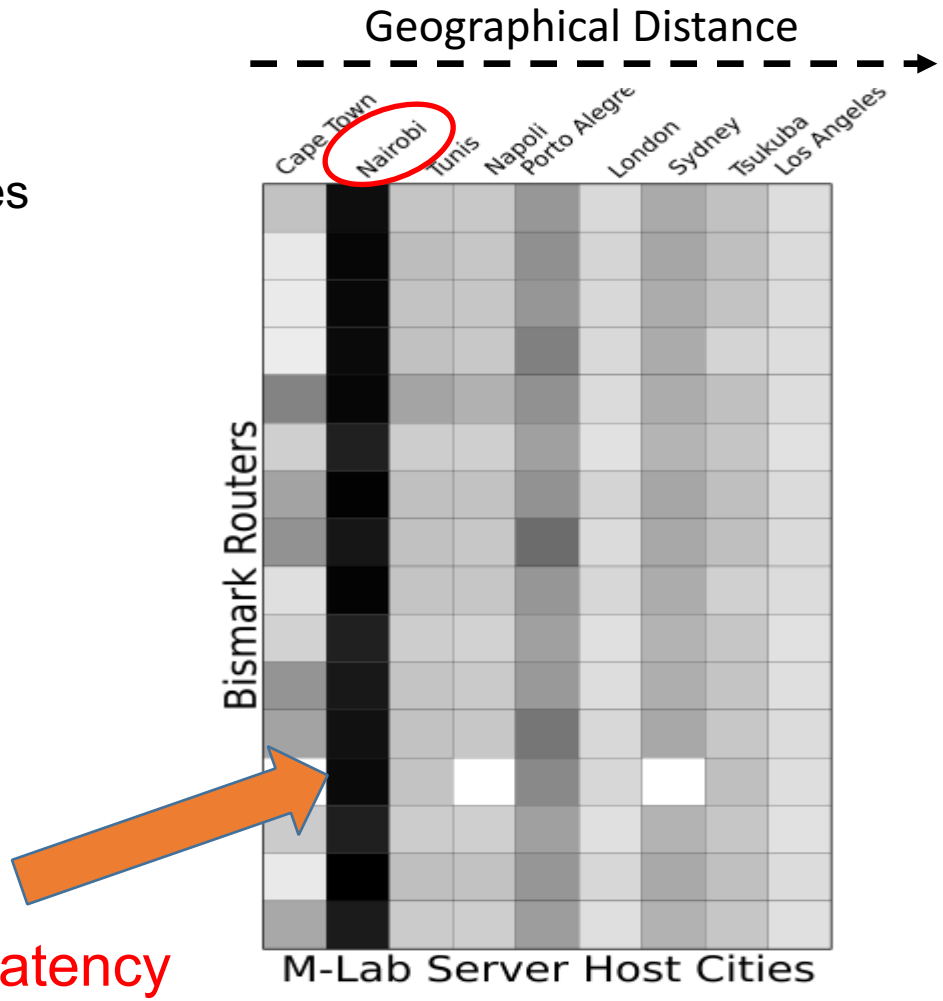
Backup Slides

High Latency Paths within Africa

- Normalized Latency:
  - Ratio of observed and speed of light propagation latencies
  - Darker blocks imply higher latency penalties
- High Penalties for routes to M-Lab server in Nairobi



M-Lab Servers



High Normalized Latency

IXP Prevalence

- Quantifies presence of IXPs for routing paths
- Similar to routing path prevalence
- Lower IXP prevalence observed for circuitous routing paths