Quantifying the Effects of Circuitous Routes on the Latency of Intra-Africa Internet Traffic: A Study of Research and Education Networks

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Traffic Engineering in Pan African Research and Education Networks

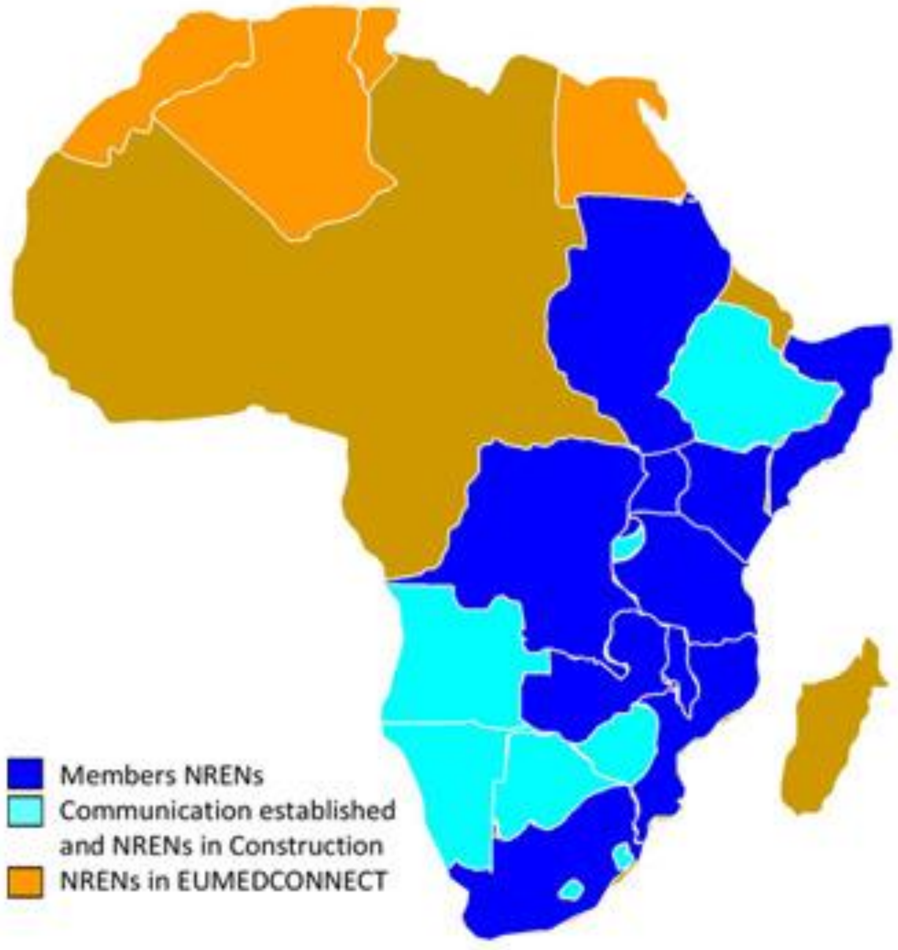
- Motivation
- Latency and Routing Problem
- Opportunities
- Software Defined Internet Exchange
- Summary

Motivation: Research and Education Networks

- Cross-border inter-university **open virtual learning**
- Real-time remote lectures?
- Remote access to high-performance computing

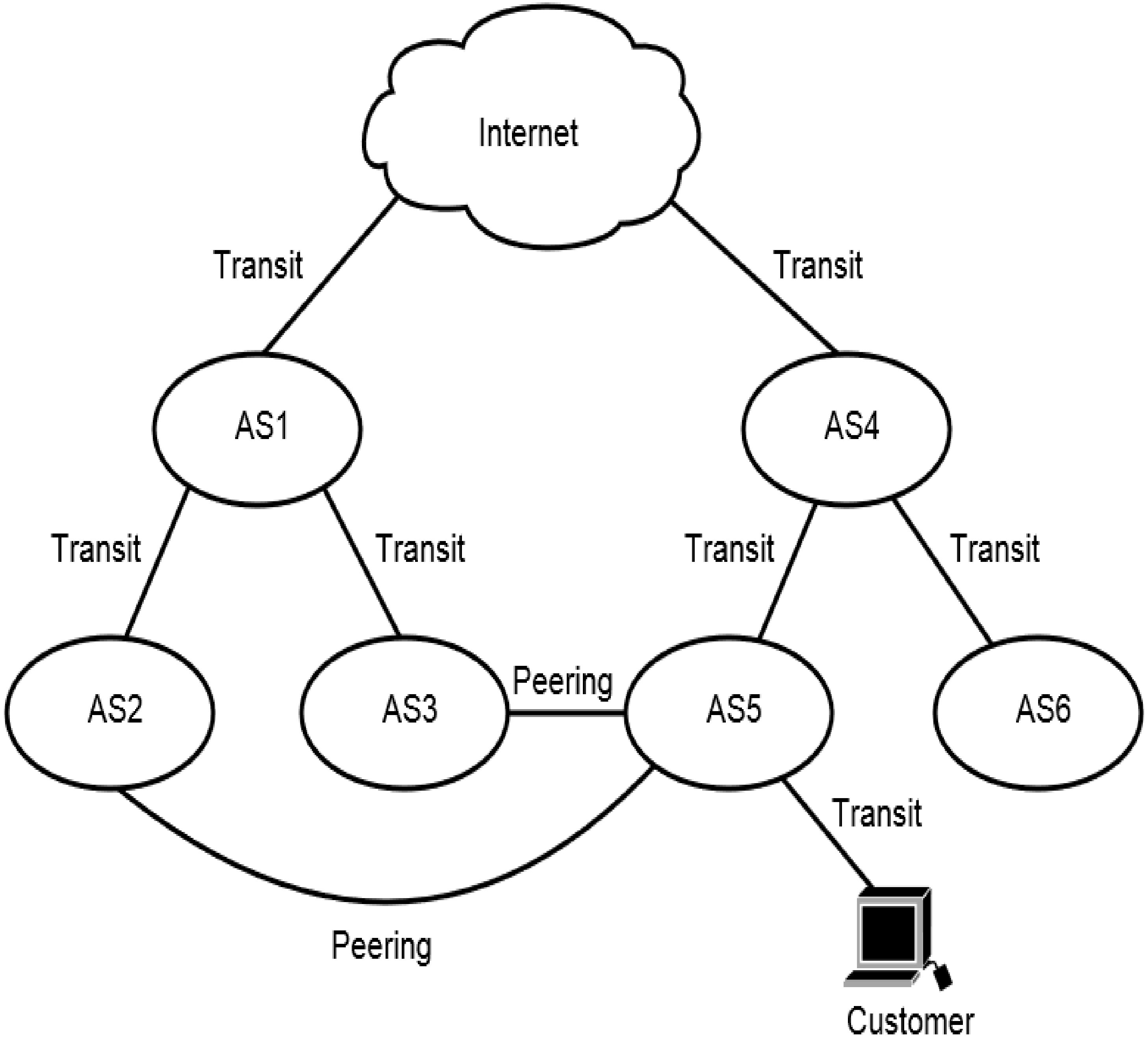
Pan-African Research and Education Network

- Includes **UbuntuNet Alliance**, West and Central African Research and Education Network (**WACREN**)
- Aim for:
  - Exclusive data networks for education and research
  - Cost effective bandwidth management
  - Traffic engineering (QoS requirements)



Internet Routing and Peering

- Internet made up of Autonomous Systems (AS)
- Peering vs Transit business relationships



Background and Related Work

- Recent work by Gupta et al.(2013) reported :
  - African ISPs do not peer much at national or regional IXPs, but rather at larger European IXPs such as London and Amsterdam
  - **66%** of traffic between South African Internet users and Africa-based Google cache servers was routed outside the continent
- Gilmore et al.(2007) showed that TENET Internet traffic destined to African networks was mostly routed via the UK, Scandinavia and the USA.

Pan-African NRENs Internet Topology

- What is the general **logical topology** of the African NRENs internet?
- What is the performance (**latency**) of Africa's inter-university Internet traffic ?
- To what extent does the **logical topology impact** latency?

Dataset: Topology Measurements

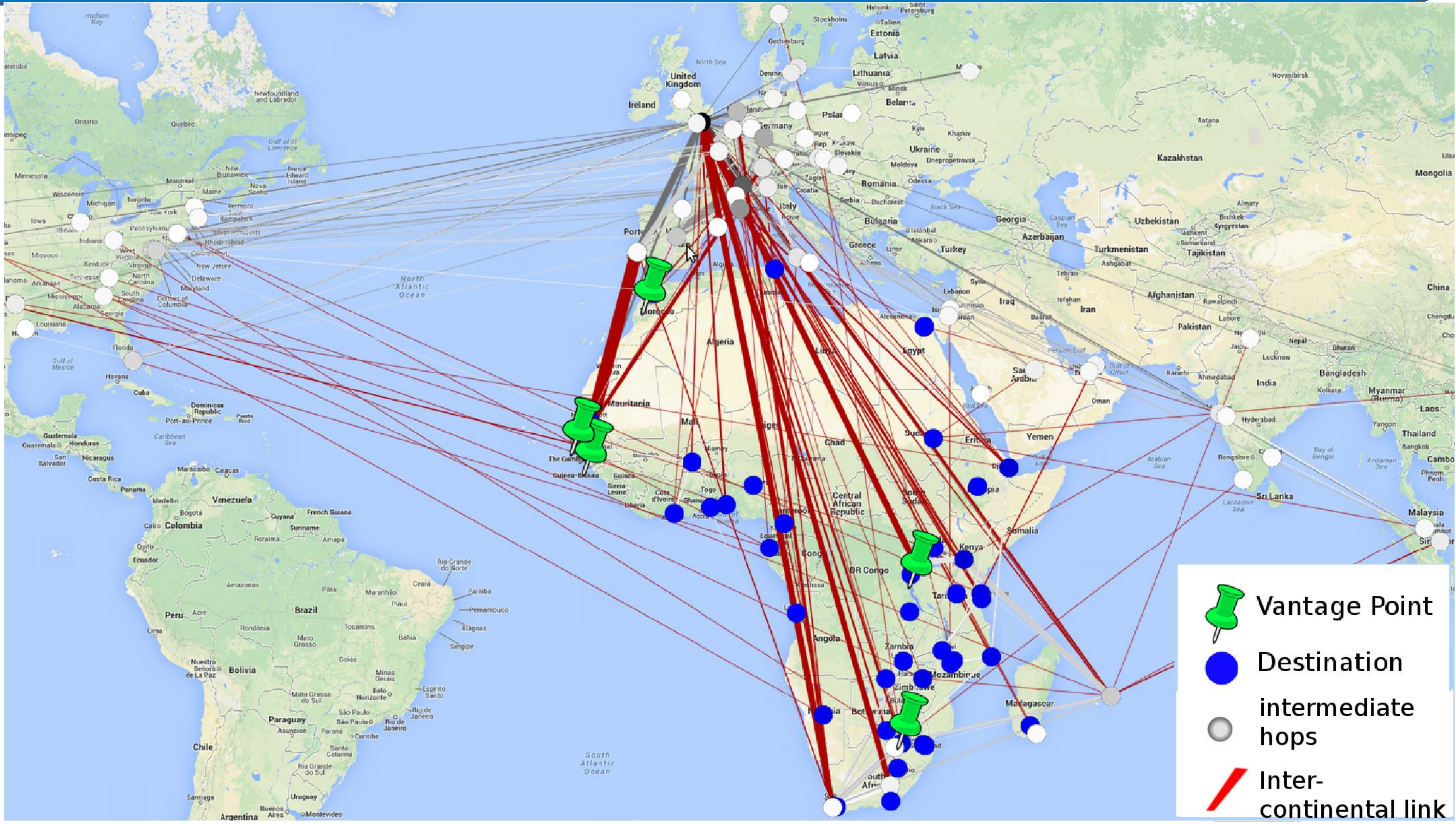
- **Active topology discovery techniques:**
  - Traceroute probes, 6 April to 20 April, 2014
  - 95 university locations in 29 African countries
- **5 African vantage points**: Morocco, Gambia, Senegal, South Africa and Rwanda
  - Cooperative Association for Internet Data Analysis (CAIDA) Archipelago Internet measurement infrastructure

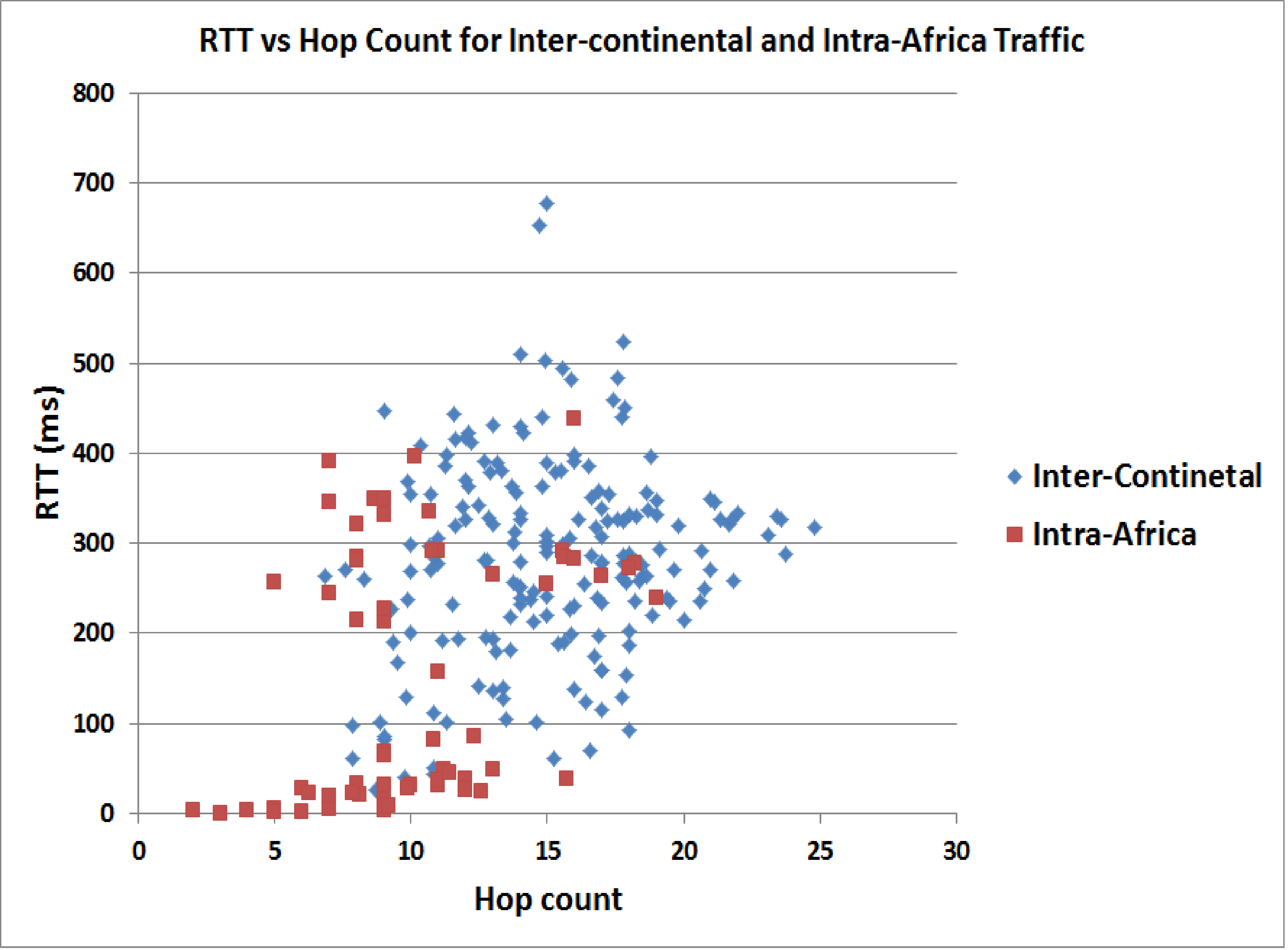
Datasets Analysis

- Round-trip time (RTT) for each source/destination pair
- Mapping of IPs to Autonomous System Numbers (ASNs)
  – Whois database
- Geo-location of the IP path hops (City/Country level)
  – MaxMind GeoIP database
- Inter-continental traffic vs intra-Africa traffic
- For inter-continetal traffic, how far (in terms of latency) is remote inter-continental gateway?

Results: Logical Topology

- **75%** of traffic routed in Europe & USA
- % of inter-continental traffic:
  - **95%** West Africa
  - **70%** Central Africa
  - **60%** South Africa

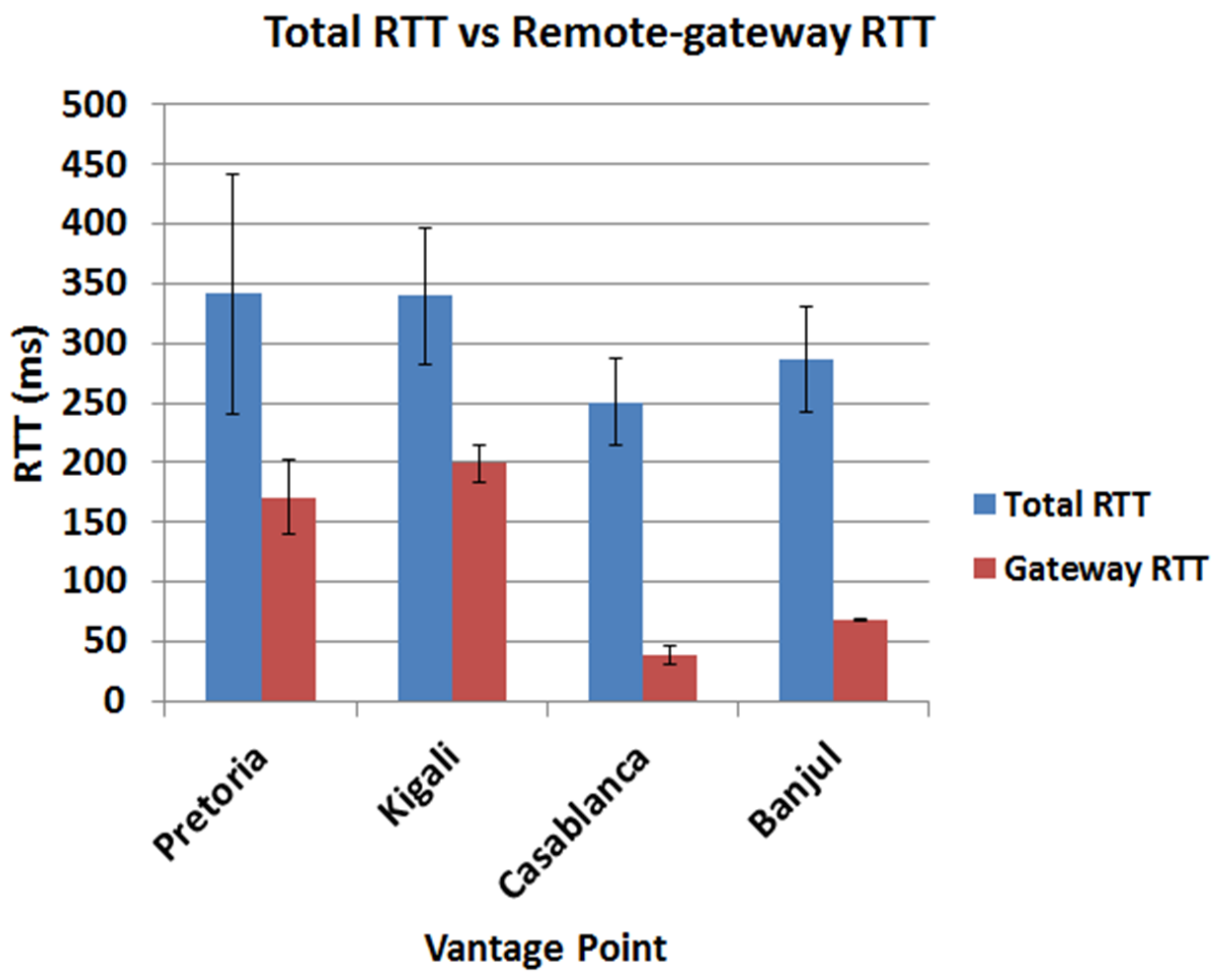




- intra-Africa traffic: **140ms**
- inter-continental traffic: **300ms**

Impact of inter-Continental Latency

- RTT from the vantage points to the remote gateway average **150ms** (more than the average RTT for intra-Africa Traffic.



Impact of linearized path length

- Traffic from southern Africa to southern Africa via London covers a distance of roughly **30,000km (round trip 60,000km)** (14,530 km WACS cable), hence **minimum RTT of ~300ms**
  - in practice latency is about **370ms**
  - **80% of the RTT** due to distance!

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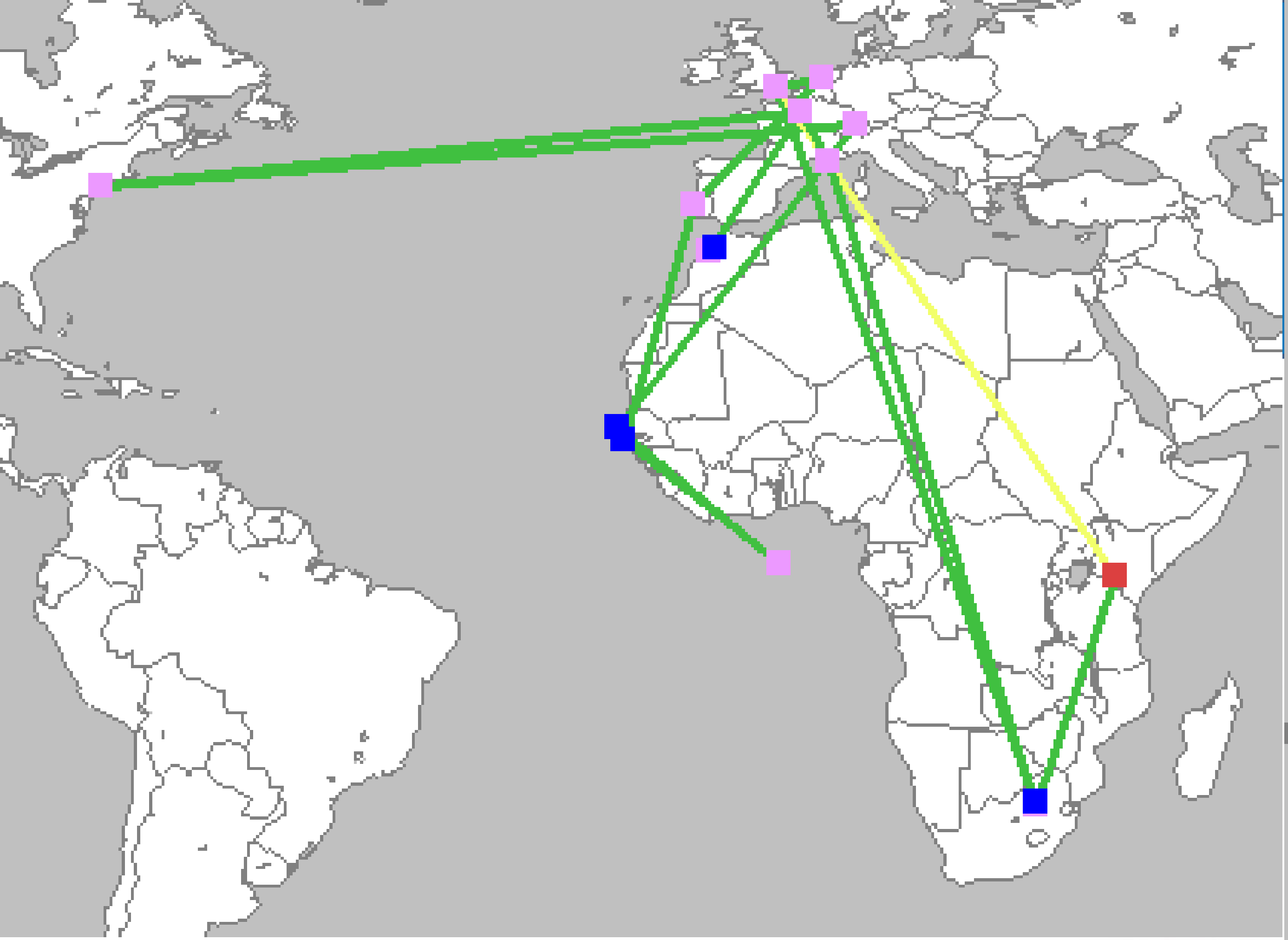
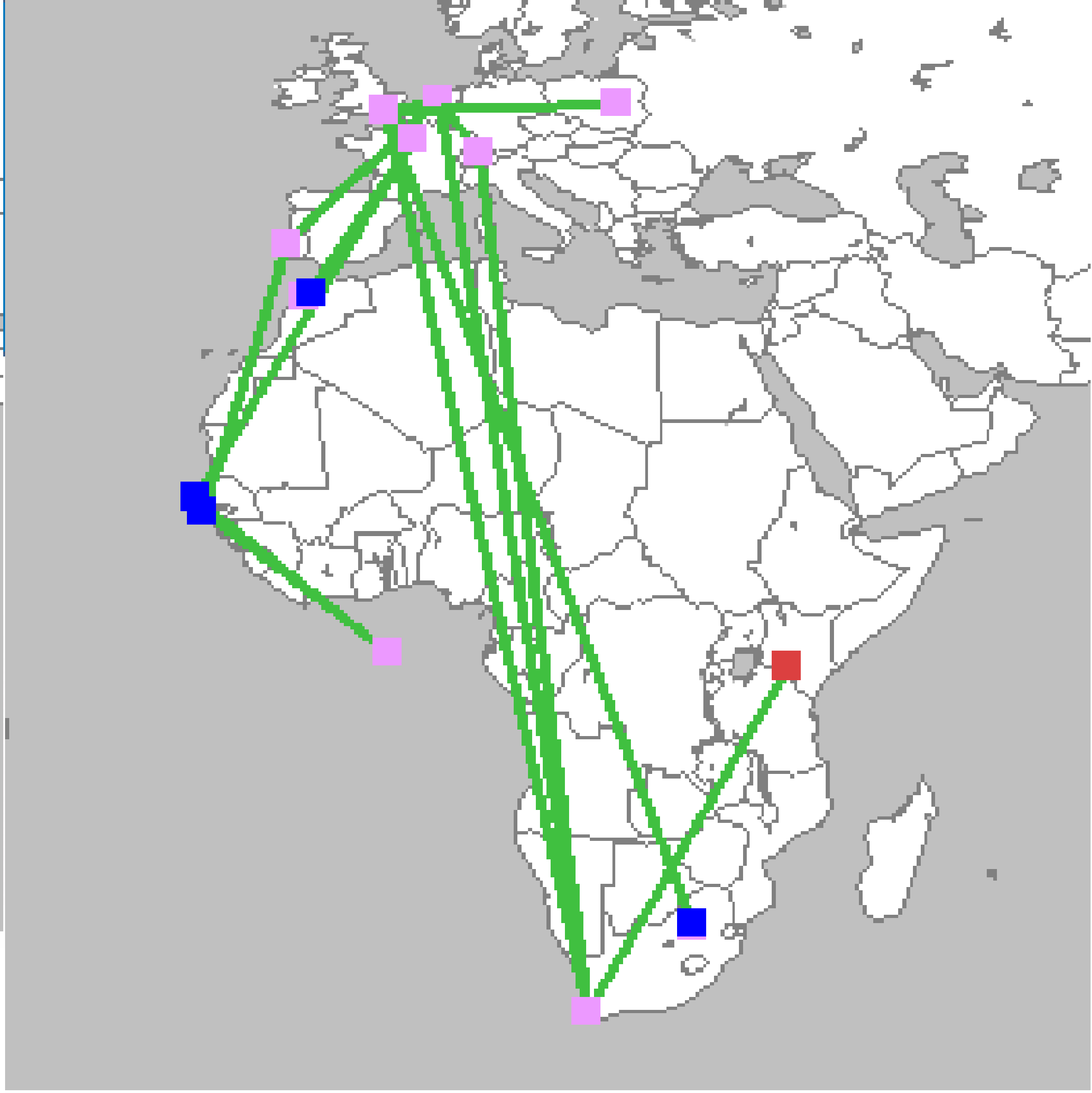
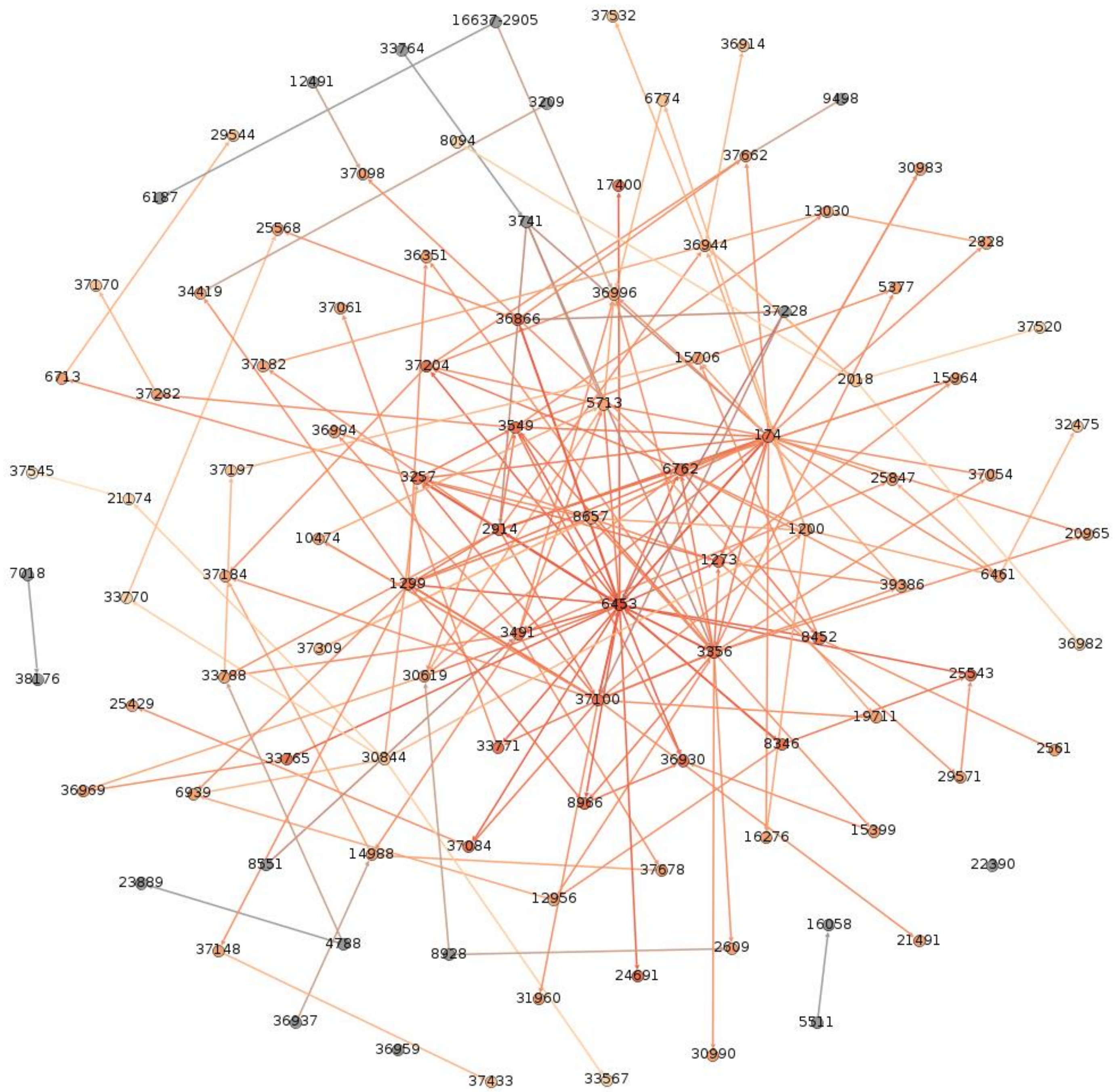




- Kenya example: direct vs circuitous route => 80ms vs 400ms

Logical Topology: Autonomous System Level Peering



Key Autonomous Systems:

- Cogent Communications(ASN 174)
- TATA (ASN 6453)
- Level3 (ASN 3356)
- SEACOM (ASN 37100)

Key Peering locations:

- London (LINX)
- Amsterdam (AMS-IX)
- Frankfurt (DE-CIX)

Opportunities: Africa Internet Exchange Points

- **22 national IXPs** in 17 countries
  >> SA alone has 5 IXPs

- Very limited Internet peering within and between most African countries

How do we improve the situation?

- National and Regional Internet Exchange Points (IXPs)?
- End to end traffic engineering strategies?
  - How to leverage multi-homing?
  - How to grant edge networks more control for their end to end paths?

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Possibilities

- **Software Defined Networking in IXPs: dynamic forwarding paths**
  - Programmatic, remote and dynamic configuration of forwarding tables
  - Global view of network topology through a central network controller
  - Allow edge networks more control over end to end routing
- **Multi-path traffic engineering** for collaborative and dynamic selection of ‘shorter’ paths
  - Eg using topology metrics, QoS and policy preferences
  - Locator/Identifier Separation Protocol (LISP)
- **Application specific traffic engineering** (delay-sensitive vs delay-tolerant, bandwidth vs latency)

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Summary

- Circuitous routes have huge impact on latency for Africa's Internet traffic
- Software Defined Internet eXchange points can help create more flexible and dynamic peering environment
  - **SDN** offers new opportunities for peering and traffic engineering

Thank you!