

# On The Interdomain Topology of Africa

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## Introduction & Problem Setup

- Lack of knowledge of ISPs peering or transit habits**
  - A few previous studies on some specific countries (KE, TN, NG)
  - Initiatives to localize transit emerge
- Some knowledge of physical infrastructure**
  - Satellite links, submarine cables, fragmented terrestrial optical infrastructures, a few (24) IXPs not well spread in Africa
- Perceived QoS is poor**
  - High latency & low bandwidth
- Transit costs are high**
  - About US \$600 millions yearly spent in transit fees for intra-African traffic

## Goals & challenges

- Contributions**
  - Investigate **access to access networks connectivity**
  - Identify ISPs playing major role in transit in Africa
  - Analyze the impacts of the characteristics of the observed inter-domain paths in the end-to-end delay
  - Compare v4 to v6 routing infrastructure
  - Discover new peering links and IXPs
- Challenges**
  - Find a relevant number of hosting locations in Africa
  - Choose cheap & robust devices (power outages and surges)
  - Fulfill legitimate security and privacy conditions of ISPs

## Methodology: 3 Measurement Campaigns over 6 months, IP geolocation, IP to AS mapping & Data filtering

### RIPE Atlas Infrastructure

Over 7700 probes scattered in the world & over 350 probes in Africa



### Data collection

CC	Country	ASes	Used	% ASes	% IPs
AO	Angola	36907, 17400	2	6.1%	4.8%
BJ	Benin*	37090, 28683, 37292	15	37.5%	73.2%
BF	Burkina Faso*	25543, 8513, 37073	4	28.6%	64.9%
BW	Botswana	14988, 37678	3	11.1%	81.7%
CI	Ivory Coast*	36974, 29571	3	16.7%	68.8%
CM	Cameroun	16637, 15964	2	7.7%	32.9%
ET	Ethiopia	24757	2	50%	33.3%
GA	Gabon	16058	1	11.1%	81.2%
GH	Ghana*	30988, 29614, 37140	2	6%	19.5%
GM	Gambia	37309, 37524, 327719, 37323, 25250	5	71.4%	80.8%
KE	Kenya	12556, 37061, 15399	4	3.9%	5.5%
LS	Lesotho	37057	1	10%	68.5%
MA	Morocco*	30983, 6713	2	25%	61.6%
MG	Madagascar	37054, 37608	3	25%	48.8%
MR	Mauritania*	8657	1	33.3%	24.6%
MU	Mauritius	37006, 37100, 23889, 30844, 327681, 3215	10	12.5%	80.5%
MZ	Mozambique	30619, 42235, 31960, 6939*	4	37.5%	8.9%
NA	Namibia	36996, 37863	4	13.3%	31.1%
NG	Nigeria*	30988, 30984	3	1.5%	0.9%
NE	Niger*	37205, 37385	4	28.6%	33.3%
RW	Rwanda	37228, 37006	2	12.5%	66.5%
SC	Seychelles	36867, 36958, 36902, 37343	20	50%	34.7%
SD	Sudan	37197	1	14.3%	4.1%
SN	Senegal*	8346, 37196	4	66.7%	76.8%
SZ	Swaziland	19711	1	16.7%	68.6%
TG	Togo*	30982	1	50%	41.4%
TN	Tunisia	2609	2	10%	27%
TZ	Tanzania	37045, 36909, 37084, 37182, 33765	4	10.4%	24.1%
UG	Uganda	37063	2	2.9%	12.3%
ZA	South-Africa	32653, 10474, 36877, 37542, 2018, 37172, 12258, 6968, 33762, 37497, 37520, 3741, 11845, 37618, 37403, 36937, 37457, 6083, 37358, 5713, 16637, 22355, 37105, 18931*, 37251, 29975, 37253, 37043, 37154, 30844	100	7.8%	40.2%
ZM	Zambia	37043, 37154, 30844	2	18.8%	5.9%
ZW	Zimbabwe	30844	1	6.2%	3.2%

### 3 Measurement campaigns

- 1st campaign: 675k v4 paris-traceroutes**
  - All v4 probes
  - Entire continent
  - Nov 30, 2013 - Apr 06, 2014
- 2nd campaign: 408k v4 & 21k v6 paris-traceroutes**
  - All the v4 & v6 probes
  - Southern Africa
  - June 01 - August 01, 2014
- 3rd campaign: 3k v4 paris-traceroutes**
  - v4 probes
  - Gambia (GM)
  - August 06 - 16, 2014

### Dataset treatment

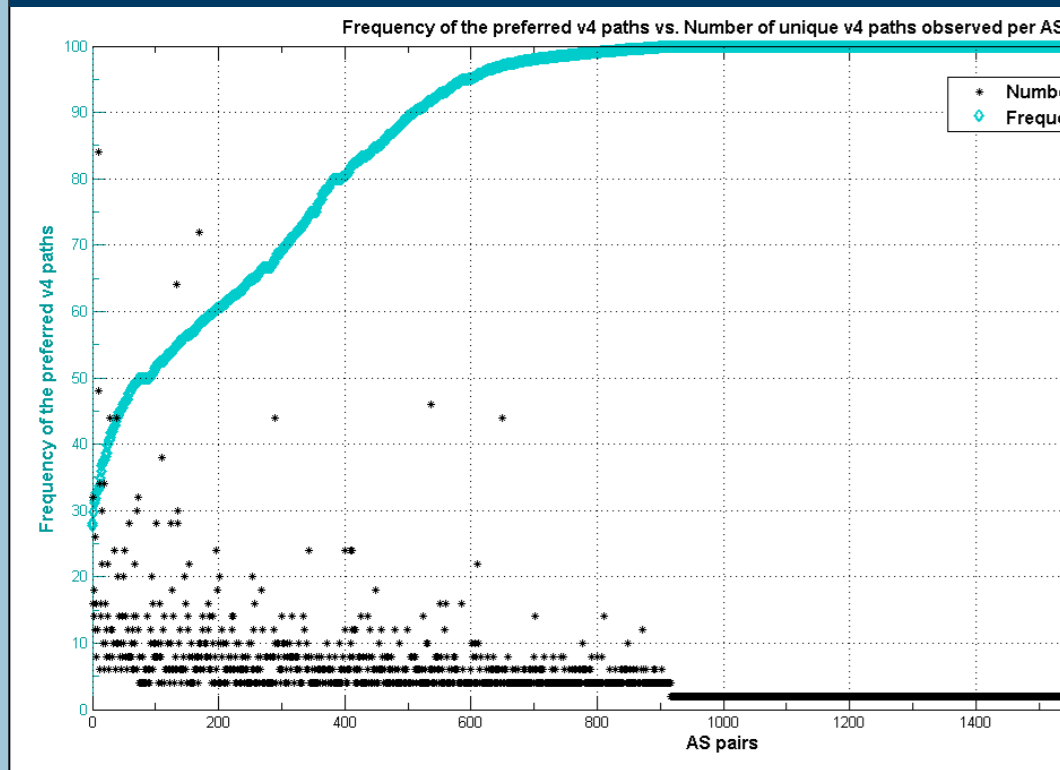
- IP to AS mapping with TC**
  - 164 Ases classified in *Waf, Eaf, Saf, Raf, Int*
- Raw data Sanity check**
  - Store paths whose AS source and destination match those of the probes
  - Try and complete remaining paths ends based on learned adjacencies
  - Convert AS path into AS sequence
- IP to CC lookup with 6DBs**
  - 8,328 v4 & 456 v6 IPs
  - 94.1% v4 & 98.1% v6 IPs geolocated : Country path inference

DB	IPv4 entries Cover.	Trust	IPv6 entries Cover.	Trust	DB	IPv4 entries Cover.	Trust	IPv6 entries Cover.	Trust
OIM	26%	93.8%	30.1%	92.8%	TC	86.7%	71%	99.1%	79.4%
RDNS	56.7%	88.8%	46.7%	78.5%	AF	36.2%	93%	56.7%	83.7%
MM	83.9%	74%	99.1%	71.4%	Whois	85.6%	68%	43.2%	67.7%

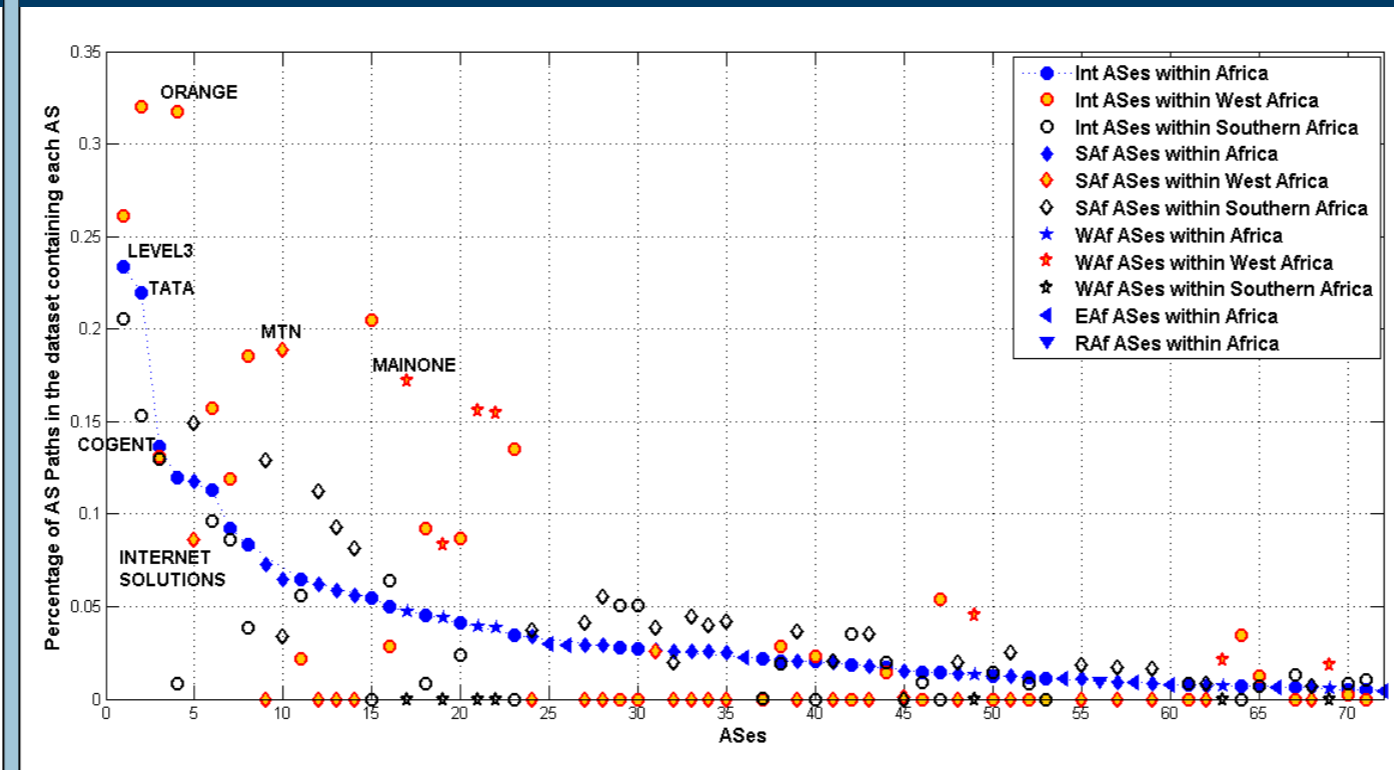
Infrastructure coverage in Africa & RIPE Atlas probes deployed on March 2015  
Source: <https://atlas.ripe.net/results/maps/network-coverage/>

214 probes & 90 ASes involved covering 32 countries

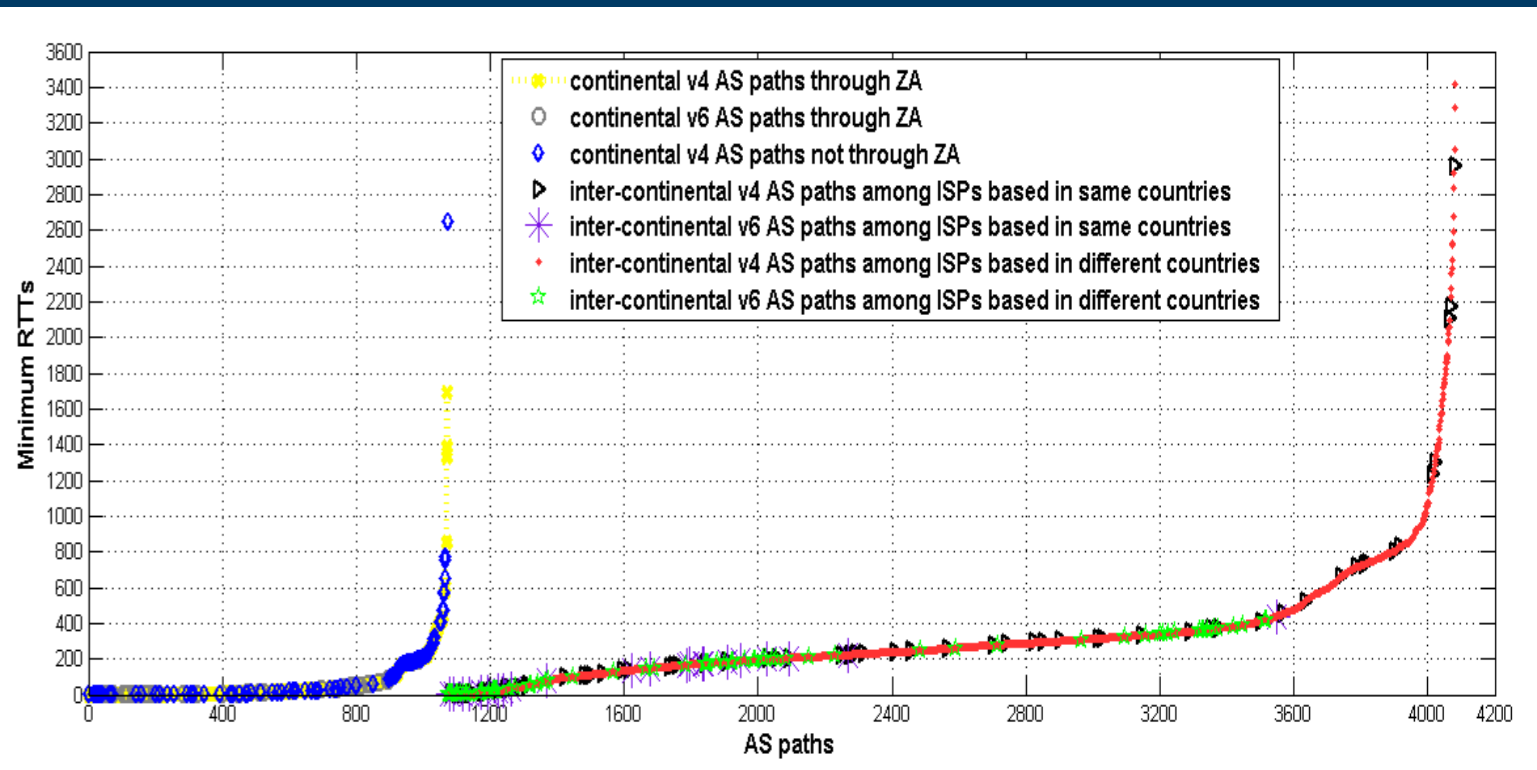
### Path dynamics



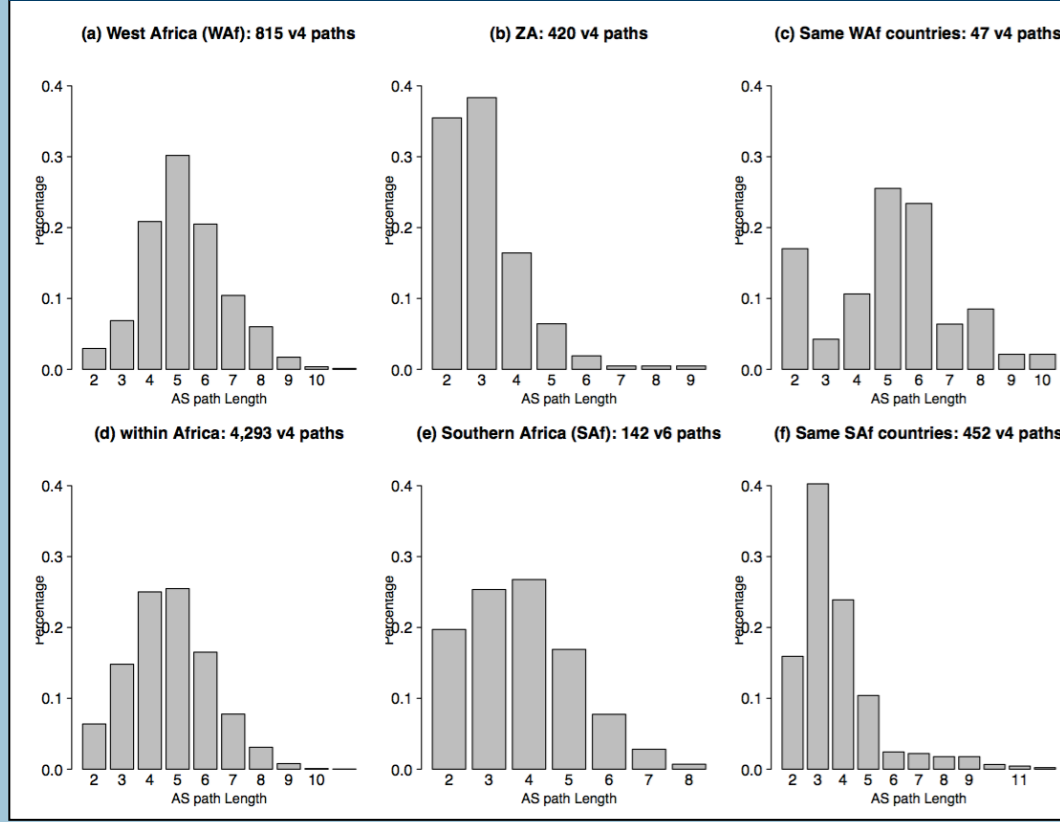
### AS-centrality: Market share



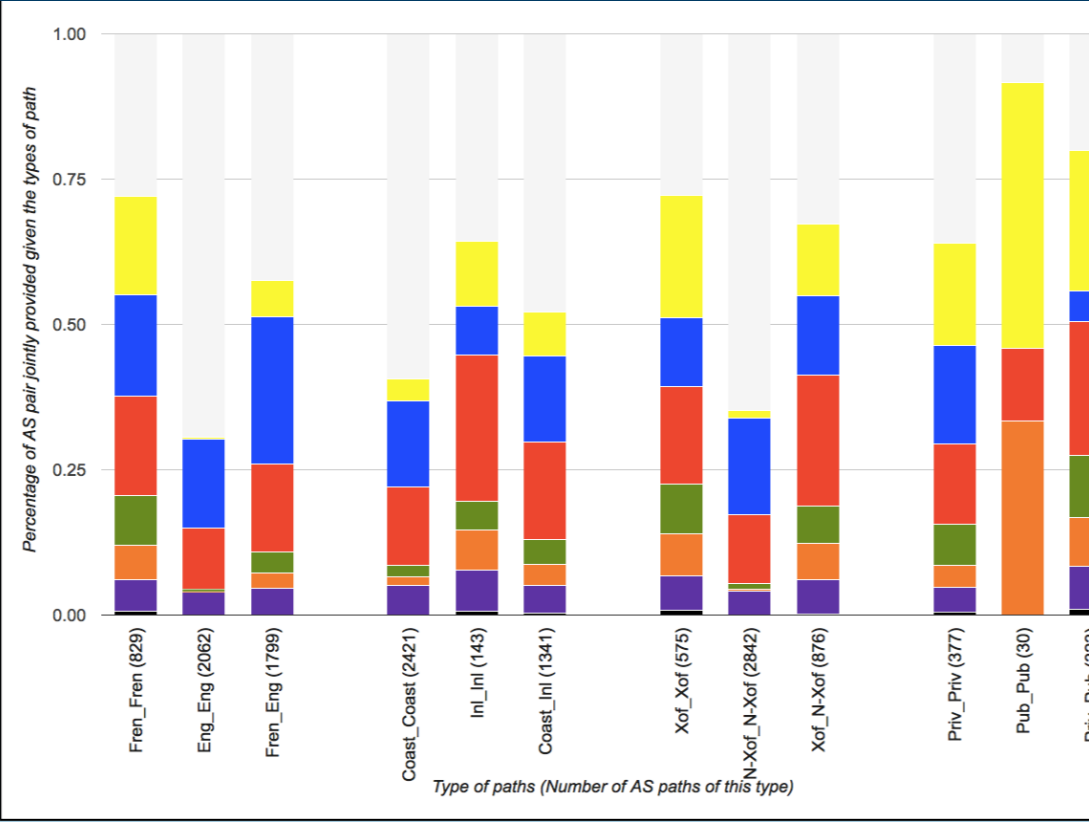
### Distribution of Minimum RTT per AS pair



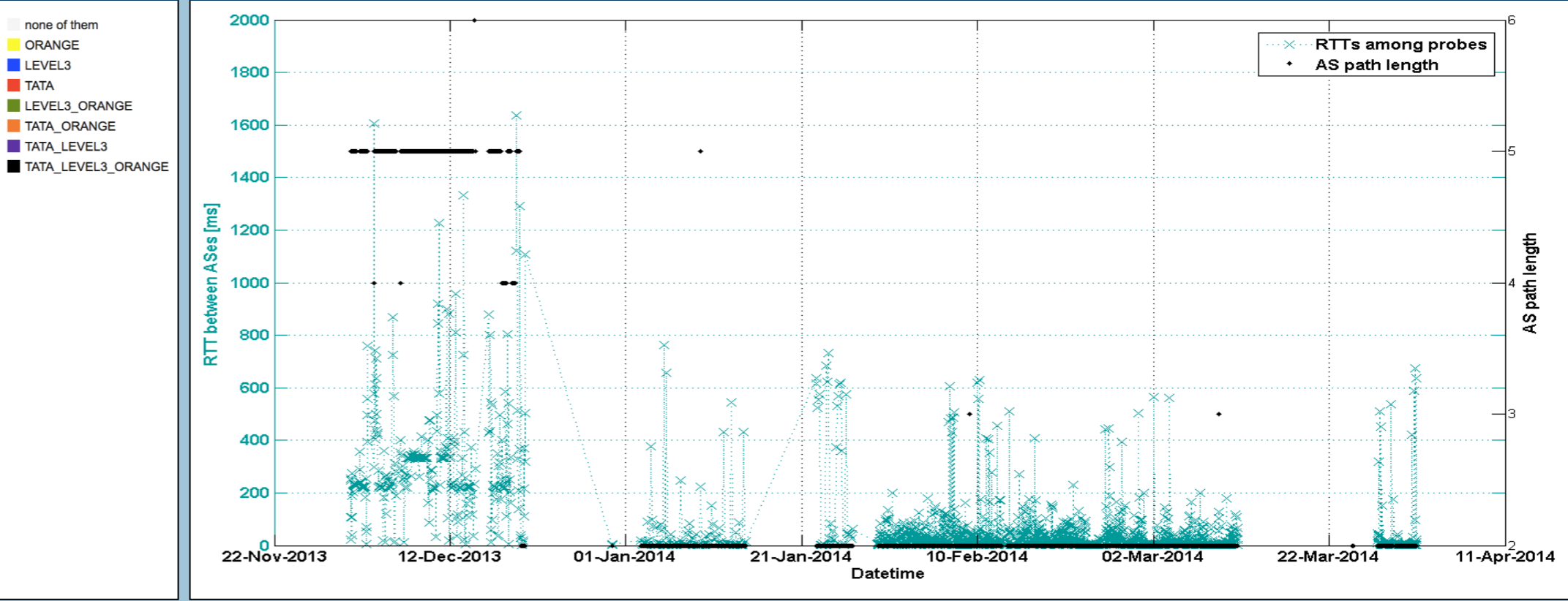
### AS path length distribution



### Technico-economic Insights



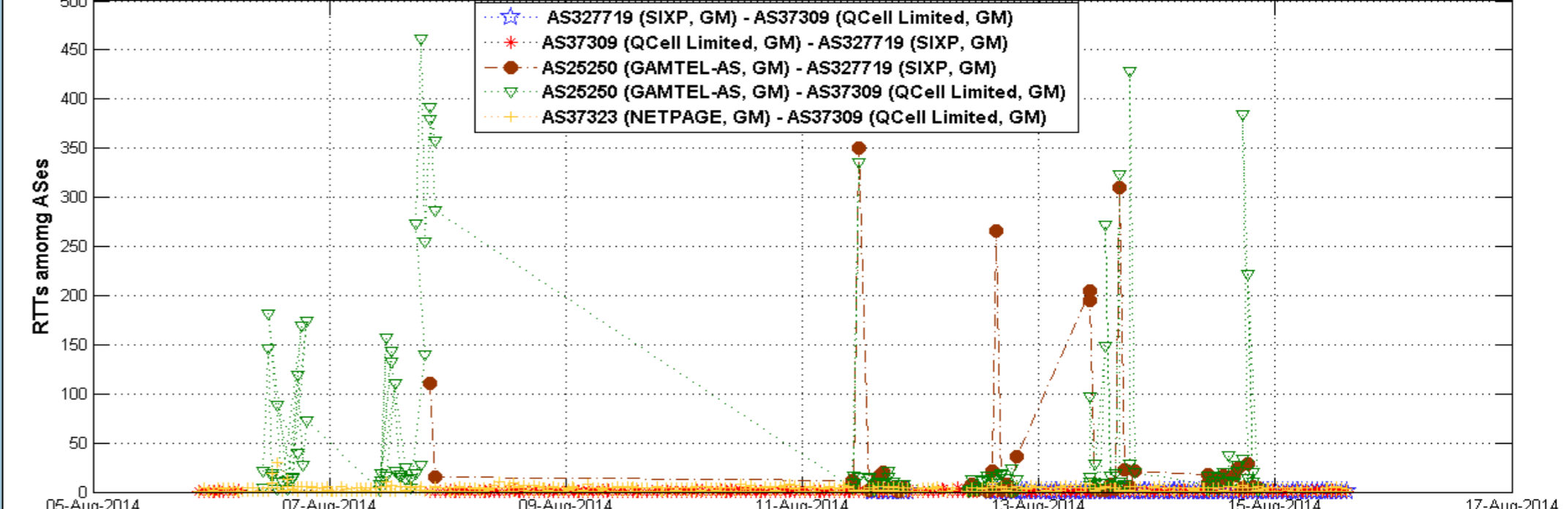
### Emergence of new IXPs: Benin-IX (BJ) - 3 peers



### Conclusions

- The African interdomain topology is quite stable over time
- Observing it from a couple of location gives a biased view
- Lack of interconnection among African ISPs (ZA being an exception)
  - ZA is **adopted as a hub for West-East communications**
  - IXPs in ZA appears on 58% paths traversing ZA
- Long AS paths and RTTs, sometimes among ISPs in the region or country
- Transit habits vary** throughout the continent
- Frequent usage of IXPs such as **JINX, DINX, CINX, NAPAfrica**, etc
- Emergence of **new IXPs**, first benefits of initiatives promoting peering

### Emergence of new IXPs: case of SIXP (GM) - 3 peers



[1] R. Fanou, P. Francois and E. Aben, On the Diversity of Interdomain routing in Africa, in PAM, p. 12, March 2015  
[2] R. Fanou, P. Francois and E. Aben, "African Measurement Campaigns: Technical report", [https://fourier.networks.imdea.org/external/techrep\\_amc/](https://fourier.networks.imdea.org/external/techrep_amc/), Sept. 2014