Measuring Internet region: Africa
• Qrator Labs
  • DDoS mitigation company
  • 10+ years in business
  • Global anycast network

• Radar
  • Research unit
  • Largest BGP collector
  • Monitoring connectivity and security incidents (product)
Plan of the report

- About measurements
- General overview
- Stability overview
- Prefix violation (Hijacking)
- IPv6 adoption
About measurements

General overview
Stability overview
Prefix violation (Hijacking)
IPv6 adoption
About measurements

How to measure – what data sources to use for measurements
What to measure – what algorithm to use
How to visualize – what aspects we want to study
Only ~15 Sessions in Africa

- Not enough local PoP
- Worse peering links coverage
- Worse local prefix coverage

800 + BGP session in total
- AS info db
- Route objects
- ROA
- Geo info
- RIPE db
- Afrinic IRR
- RPKI validator
- MaxMind/RIPE
100+ different ways

* If we consider only graph ranking
There is no universal and best rating system

- You can choose measurements that have a logical explanation
  - And add weights to the nodes
- Or create your own measurements
Ways of comparison

- Metric overview
- How region is compared to the rest of the world
- Ranking inside the region
- Overview of the most interesting cases
Plan of the report

About measurements

General overview

Stability overview

Prefix violation (Hijacking)

IPv6 adoption
• We will look at number of ISPs
  ○ Registered in IRRs
  ○ Still Active

• It gave an overview on diversity and competitiveness of local market
## General Overview

<table>
<thead>
<tr>
<th>iso</th>
<th>name</th>
<th>#Registered ASNs</th>
<th>#Announced ASNs</th>
<th>#Announced Prefixes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>iso</td>
<td>name</td>
<td>Value</td>
<td>Percentage</td>
</tr>
<tr>
<td>US</td>
<td>United States</td>
<td>29499</td>
<td>27.39%</td>
<td>1</td>
</tr>
<tr>
<td>BR</td>
<td>Brazil</td>
<td>8946</td>
<td>8.30%</td>
<td>2</td>
</tr>
<tr>
<td>RU</td>
<td>Russian Federation</td>
<td>5893</td>
<td>5.47%</td>
<td>3</td>
</tr>
<tr>
<td>IN</td>
<td>India</td>
<td>3563</td>
<td>3.31%</td>
<td>4</td>
</tr>
<tr>
<td>DE</td>
<td>Germany</td>
<td>3009</td>
<td>2.79%</td>
<td>6</td>
</tr>
<tr>
<td>ZA</td>
<td>South Africa</td>
<td>709</td>
<td>0.66%</td>
<td>30</td>
</tr>
<tr>
<td>NG</td>
<td>Nigeria</td>
<td>230</td>
<td>0.21%</td>
<td>52</td>
</tr>
<tr>
<td>KE</td>
<td>Kenya</td>
<td>155</td>
<td>0.14%</td>
<td>67</td>
</tr>
<tr>
<td>GH</td>
<td>Ghana</td>
<td>95</td>
<td>0.09%</td>
<td>84</td>
</tr>
<tr>
<td>TZ</td>
<td>Tanzania, United Republic of</td>
<td>89</td>
<td>0.08%</td>
<td>85</td>
</tr>
<tr>
<td>EG</td>
<td>Egypt</td>
<td>82</td>
<td>0.08%</td>
<td>88</td>
</tr>
<tr>
<td>AO</td>
<td>Angola</td>
<td>60</td>
<td>0.06%</td>
<td>96</td>
</tr>
<tr>
<td>UG</td>
<td>Uganda</td>
<td>51</td>
<td>0.05%</td>
<td>101</td>
</tr>
<tr>
<td>RW</td>
<td>Rwanda</td>
<td>21</td>
<td>0.02%</td>
<td>137</td>
</tr>
</tbody>
</table>
• ~54 countries to display
  ○ Differ from individual country reports

• Either aggregation or top displaying is needed
• Top 3 countries by number of ISPs:
  ○ South Africa
  ○ Nigeria
  ○ Kenya

• Only about 80% of all ASs are still in operation.
  ○ Compared to 70% for the rest of the world

• Number of prefixes to ASN is average
  ○ Excluding Egypt, Cote d'Ivoire and Sudan
Types of operators

- Stubs - don’t provide transit to others
  - Multihomed - have two or more providers
  - Clear stub - have only one provider
- Transit networks - provide transit to others
  - Differs in size and traffic volume
Types of Network (percentage of registered ASN)

- Stub, one provider: 32.0%
- Stub, multihomed: 30.0%
- Provide transit: 18.0%
- Without neighbors: 20.0%
• Biggest Tier-1s - Cogent (AS174), Telia (AS1299), Level3 (3356)

• Biggest Regional Providers - ?
  ○ Consumer cone analysis not working (Tier-1 will overtake it)
  ○ We will try to use flow analysis

• The border of the regions was taken from the African Union
Flow analysis

- Each country’s ISP has a default weight
  - Weight can be as a number of Prefixes/PTRs/clients/etc
  - All country ISPs have equal weight in our case

- The transit provider will get the extra weight of their customers
  - All weights in = All weights out
  - The client gives each provider the same part of its own weight
  - Similar to PageRank
- South + East - Seacom(AS37100), Liquid(AS30844), WIOCC(AS37662)
- North - TE-AS(AS8452)
- West - Mainone(AS37282), Dolphin-Telecom-AS(AS37613)
- Central - CamNet-AS(AS15964)
About half of the countries have at least 1 ISP with more than 50% flow control.

Most of them are countries with 10 or fewer ISPs.

The most notable exceptions are:
  - Egypt - TE-AS(AS8452) (65 ASNs, ~52%)
  - Angola - ANGOLA-CABLES(AS37468) (51 ASNs, ~70%)

A notable example of flow diversity:
  - Seychelles - most ISPs are directly connected to Tier-1s
Plan of the report

- About measurements
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- Prefix violation (Hijacking)
- IPv6 adoption
- Measurement was created several years ago
  - And is updated on a regular basis
- Allows a single point of failure
- Finds which part of country will be isolated
• The main PoF is usually the main stub provider.
• More ASNs - less default weight for each one
• It is also necessary to take into account the general connection with the backbone
<table>
<thead>
<tr>
<th>iso</th>
<th>name</th>
<th>World_Place</th>
<th>Regional_Place</th>
<th>Critical ASN</th>
<th>#Depended ASNs</th>
<th>Critical %</th>
<th>Partial %</th>
</tr>
</thead>
<tbody>
<tr>
<td>BR</td>
<td>Brazil</td>
<td>1</td>
<td></td>
<td>61832</td>
<td>127</td>
<td>1.54%</td>
<td>0.28%</td>
</tr>
<tr>
<td>DE</td>
<td>Germany</td>
<td>2</td>
<td></td>
<td>3320</td>
<td>53</td>
<td>2.49%</td>
<td>0.33%</td>
</tr>
<tr>
<td>RU</td>
<td>Russian Federation</td>
<td>12</td>
<td></td>
<td>12389</td>
<td>272</td>
<td>5.39%</td>
<td>0.67%</td>
</tr>
<tr>
<td>SC</td>
<td>Seychelles</td>
<td>13</td>
<td>1</td>
<td>50673</td>
<td>2</td>
<td>5.41%</td>
<td>0.00%</td>
</tr>
<tr>
<td>KE</td>
<td>Kenya</td>
<td>33</td>
<td>2</td>
<td>33771</td>
<td>10</td>
<td>8.26%</td>
<td>1.65%</td>
</tr>
<tr>
<td>MU</td>
<td>Mauritius</td>
<td>48</td>
<td>3</td>
<td>33764</td>
<td>3</td>
<td>11.11%</td>
<td>7.41%</td>
</tr>
<tr>
<td>ZA</td>
<td>South Africa</td>
<td>61</td>
<td>7</td>
<td>37100</td>
<td>69</td>
<td>12.87%</td>
<td>2.43%</td>
</tr>
<tr>
<td>NG</td>
<td>Nigeria</td>
<td>76</td>
<td>9</td>
<td>37282</td>
<td>29</td>
<td>15.34%</td>
<td>1.59%</td>
</tr>
<tr>
<td>RW</td>
<td>Rwanda</td>
<td>83</td>
<td>11</td>
<td>16637</td>
<td>3</td>
<td>16.67%</td>
<td>0.00%</td>
</tr>
<tr>
<td>EG</td>
<td>Egypt</td>
<td>96</td>
<td>12</td>
<td>8452</td>
<td>13</td>
<td>20.00%</td>
<td>1.54%</td>
</tr>
<tr>
<td>AO</td>
<td>Angola</td>
<td>150</td>
<td>33</td>
<td>37468</td>
<td>20</td>
<td>39.22%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>
About measurements
General overview
Stability overview
Prefix violation (Hijacking)
IPv6 adoption
Who is a legitimate sender?

- **IRR**
  - Worked on AS_SET + route objects basis
  - Routes are usually filtered by prefix whitelist of created Customer Cone
  - Is needed for global connectivity

- **ROA/RPKI**
  - Worked as <Prefix, origin ASN> pair check
  - Is needed to prevent others from malicious activity
  - Has a side question - which maxLength to use?
- **Valid** - `<prefix, origin ASN>` is covered by legitimate object
- **Unknown** - there is no legitimate object for a prefix
- **Invalid** - prefix belonged to another origin ASN
## Validation stats

### What to measure - the percentage of prefixes?

<table>
<thead>
<tr>
<th></th>
<th>prefixes</th>
<th>route_valid</th>
<th>route_unknown</th>
<th>route_invalid</th>
<th>roa_valid</th>
<th>roa_unknown</th>
<th>roa_invalid</th>
</tr>
</thead>
<tbody>
<tr>
<td>All countries</td>
<td>1118441</td>
<td>82.75%</td>
<td>8.54%</td>
<td>8.71%</td>
<td>35.06%</td>
<td>58.35%</td>
<td>6.59%</td>
</tr>
<tr>
<td>Africa</td>
<td>40535</td>
<td>91.87%</td>
<td>4.68%</td>
<td>3.45%</td>
<td>15.79%</td>
<td>75.50%</td>
<td>8.71%</td>
</tr>
<tr>
<td>Without ZA</td>
<td>27632</td>
<td>89.71%</td>
<td>6.24%</td>
<td>4.05%</td>
<td>14.52%</td>
<td>85.04%</td>
<td>0.43%</td>
</tr>
</tbody>
</table>
What are you trying to measure?

- Routes can be crafted
  - By BGP Optimisers or by similar tools
- Routes can be local
  - And accidently be leaked to BGP collector
- Routes can be filtered locally
  - And they will not be seen by other projects
## Validation stats [2]

### Same metrics after filtering low visible routes

seen by at least 10 different ASNs

<table>
<thead>
<tr>
<th></th>
<th>prefixes</th>
<th>route_valid</th>
<th>route_unknown</th>
<th>route_invalid</th>
<th>roa_valid</th>
<th>roa_unknown</th>
<th>roa_invalid</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>965536</td>
<td>86.07%</td>
<td>6.53%</td>
<td>7.40%</td>
<td>38.32%</td>
<td>61.09%</td>
<td>0.58%</td>
</tr>
<tr>
<td>Africa</td>
<td>33532</td>
<td>91.27%</td>
<td>5.33%</td>
<td>3.40%</td>
<td>18.57%</td>
<td>81.09%</td>
<td>0.34%</td>
</tr>
<tr>
<td>Without ZA</td>
<td>26813</td>
<td>90.34%</td>
<td>6.03%</td>
<td>3.63%</td>
<td>14.63%</td>
<td>84.99%</td>
<td>0.38%</td>
</tr>
</tbody>
</table>
Most hijackers are not real hijackers

Data scrubbing required

Real analysis needs AS_PATH

- The problem was highlighted on ENOG a few years ago (link)
Plan of the report

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- Prefix violation (Hijacking)
- IPv6 adoption
only ~35% ASNs announced IPv6 prefixes

(compared to IPv4)
<table>
<thead>
<tr>
<th>iso</th>
<th>name</th>
<th># Registered ASNs</th>
<th># Announced ASNs</th>
<th>Rate v6/v4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Value</td>
<td>Place</td>
<td>Value</td>
</tr>
<tr>
<td>BR</td>
<td>Brazil</td>
<td>8946</td>
<td>8</td>
<td>6227</td>
</tr>
<tr>
<td>US</td>
<td>United States</td>
<td>29499</td>
<td>1</td>
<td>3921</td>
</tr>
<tr>
<td>DE</td>
<td>Germany</td>
<td>3009</td>
<td>6</td>
<td>1429</td>
</tr>
<tr>
<td>ZA</td>
<td>South Africa</td>
<td>709</td>
<td>30</td>
<td>226</td>
</tr>
<tr>
<td>NG</td>
<td>Nigeria</td>
<td>230</td>
<td>52</td>
<td>39</td>
</tr>
<tr>
<td>KE</td>
<td>Kenya</td>
<td>155</td>
<td>67</td>
<td>34</td>
</tr>
<tr>
<td>TZ</td>
<td>Tanzania, United Republic of</td>
<td>89</td>
<td>85</td>
<td>31</td>
</tr>
<tr>
<td>SC</td>
<td>Seychelles</td>
<td>55</td>
<td>100</td>
<td>18</td>
</tr>
<tr>
<td>AO</td>
<td>Angola</td>
<td>60</td>
<td>96</td>
<td>13</td>
</tr>
<tr>
<td>MU</td>
<td>Mauritius</td>
<td>47</td>
<td>106</td>
<td>12</td>
</tr>
<tr>
<td>GH</td>
<td>Ghana</td>
<td>95</td>
<td>84</td>
<td>12</td>
</tr>
<tr>
<td>EG</td>
<td>Egypt</td>
<td>82</td>
<td>88</td>
<td>11</td>
</tr>
<tr>
<td>MA</td>
<td>Morocco</td>
<td>24</td>
<td>127</td>
<td>10</td>
</tr>
<tr>
<td>UG</td>
<td>Uganda</td>
<td>51</td>
<td>101</td>
<td>10</td>
</tr>
<tr>
<td>RW</td>
<td>Rwanda</td>
<td>21</td>
<td>137</td>
<td>3</td>
</tr>
</tbody>
</table>
Other interesting IPv6 changes:

- Main Tier-1 provider changed from Cogent to HE
- Large number of connections to HK-IX (opaque IX)
- The flow stream diversity - big ISPs take smaller part. Reasons:
  - More providers per customer
  - Direct connections to Tier-1
<table>
<thead>
<tr>
<th>prefixes</th>
<th>route_valid</th>
<th>route_unknown</th>
<th>route_invalid</th>
<th>roa_valid</th>
<th>roa_unknown</th>
<th>roa_invalid</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>241798</td>
<td>83.14%</td>
<td>7.74%</td>
<td>9.12%</td>
<td>29.76%</td>
<td>53.62%</td>
<td>16.62%</td>
</tr>
<tr>
<td>Africa</td>
<td>2076</td>
<td>87.24%</td>
<td>8.82%</td>
<td>3.95%</td>
<td>37.52%</td>
<td>61.61%</td>
<td>0.87%</td>
</tr>
<tr>
<td>Without ZA</td>
<td>1261</td>
<td>84.93%</td>
<td>12.37%</td>
<td>2.70%</td>
<td>19.98%</td>
<td>79.78%</td>
<td>0.24%</td>
</tr>
</tbody>
</table>

IPv6 prefix validation stats

**Without/With filtration by threshold propagation**

<table>
<thead>
<tr>
<th>prefixes</th>
<th>route_valid</th>
<th>route_unknown</th>
<th>route_invalid</th>
<th>roa_valid</th>
<th>roa_unknown</th>
<th>roa_invalid</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>168478</td>
<td>78.80%</td>
<td>10.26%</td>
<td>10.95%</td>
<td>40.39%</td>
<td>58.82%</td>
<td>0.78%</td>
</tr>
<tr>
<td>Africa</td>
<td>1732</td>
<td>85.28%</td>
<td>10.05%</td>
<td>4.68%</td>
<td>29.85%</td>
<td>69.75%</td>
<td>0.40%</td>
</tr>
<tr>
<td>Without ZA</td>
<td>1217</td>
<td>84.72%</td>
<td>12.49%</td>
<td>2.79%</td>
<td>19.64%</td>
<td>80.12%</td>
<td>0.25%</td>
</tr>
</tbody>
</table>
Plan of the report

- About measurements
- General overview
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- Prefix violation (Hijacking)
- IPv6 adoption
- Final remarks
In future plans:

- Add IX Analysis
- Highlight the difference of coastline availability
- Create more explicit country and ISP metrics
- Include your ISP knowledge in the future region overview
If you have:

- Question about the position of your ISP or your country
- Suggestions for what else you would like to see at country/provider level
- Suggestions for what can be improved/corrected

or you want to set up a BGP session with our BGP collector, I’m here or you can find me at the conference.