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MoRENet as a Platform for Intra-country Collaboration in Research and Education: Evidence Based on Analysis of Usage Patterns and Network Data Flows

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AGENDA

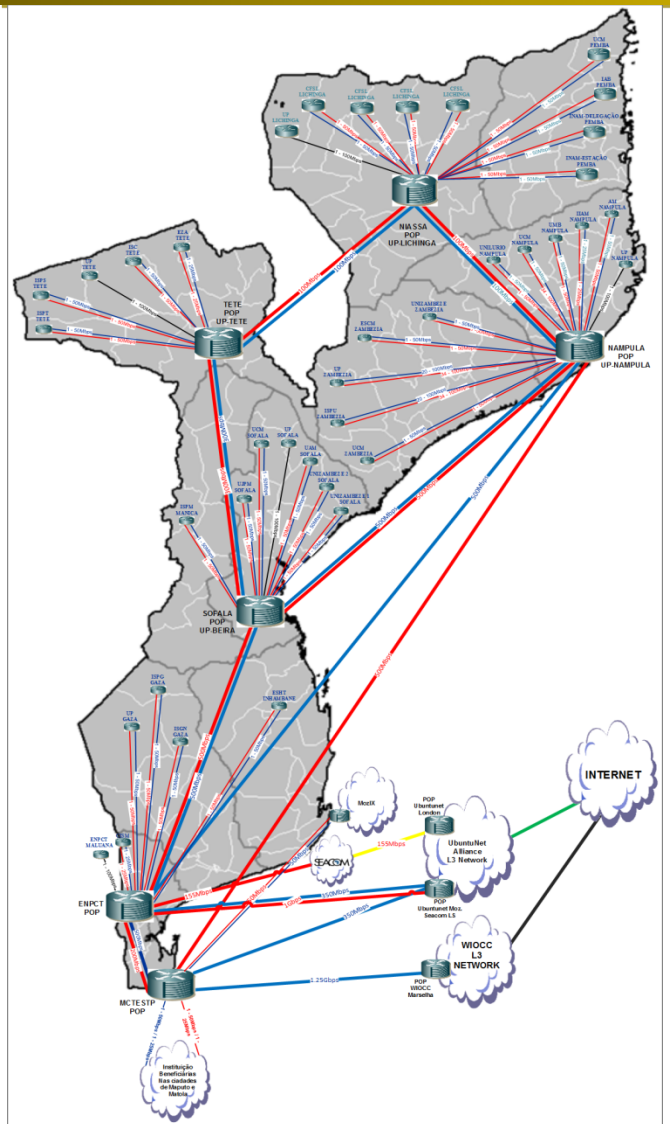
1. Introduction: MoRENet Context;
2. Research Objectives;
3. MoRENet Data Flow Analysis:
    - 2.1 Data Collection Method and Tools; and
    - 2.2 Results.
4. Conclusion

1. Introduction: MoRENet Context

- MoRENet – Mozambican NREN;
- Part of the Mozambique ICT Policy Implementation Strategy approved in 2002;
- MoRENet's Operations started in 2005;
- Founding Member of UbuntuNet;
- In 2017 connects 109 Academic and Research Instititutions; and
- Government supported initiative.

1. Introduction: MoRENet Context

Network Architecture



Network Segments	Capacity [Mbps]	
Local Network		16 Wireless LANs in University Campus
Last Mile	100 Mbps	Universities
	60 Mbps	Research Institutions
	20 Mbps	Techncal Vocational Education Institutions
Backbone	500 Mbps	5 Points of Presence (PoPs)
International Links	3 Gbps	WIOCC (Eassy): 1,25 Gbps
		UbuntuNet/Seacom: 1,86 Mbps

Two Network Operation Centers (NOCs):

- National Science and Technology Park, in Maputo Province;
- Ministry of Science and Technology, Higher and Technic Professional Education, in Maputo City.

Two Network Management Tools:

- ZABBIX - Monitors availability, latency and bandwidth occupation of links; and
- WHATSUP GOLD - Network data flow analysis.

1. Introduction: MoRENet Context

MoRENet Services

Current Services:

- Connectivity, including Internet Access;
- Hosting of web sites and applications;
- Co-Location
- E-Mail
- Eduroam
- Identity Federation (CAF-MOZ)
- Training (Capacity Building)

Planned Services:

- Virtual Libraries;
- VoIP;
- Video and Web Conferences;
- File Sender; and
- Cloud Services.

Government of Mozambique National Data Center: Launched in 2015

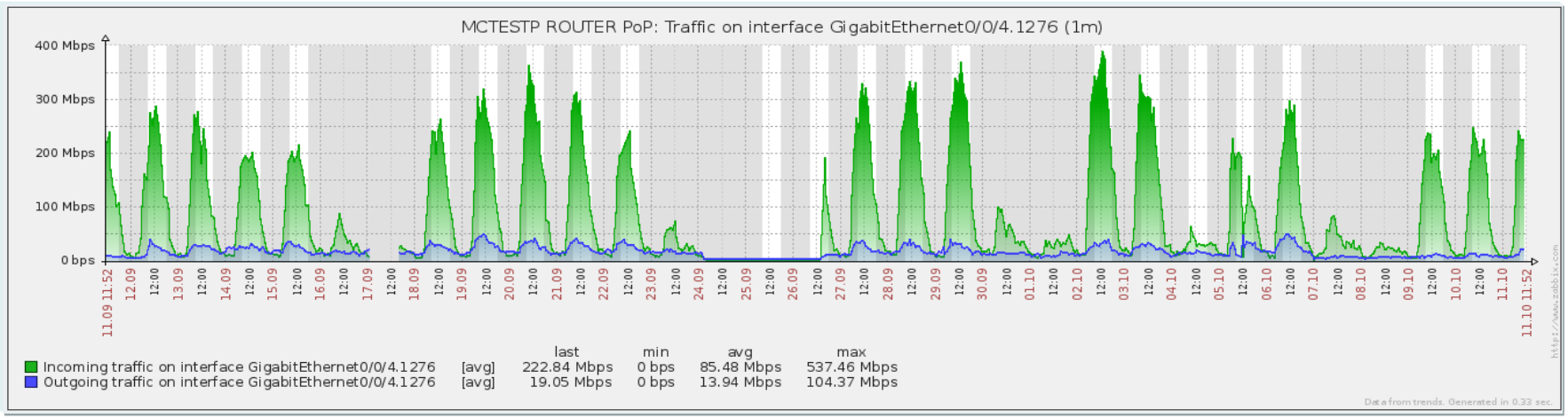
1. Introduction: MoRENet Context

MoRENet Services: MoRENet Eduroam Website

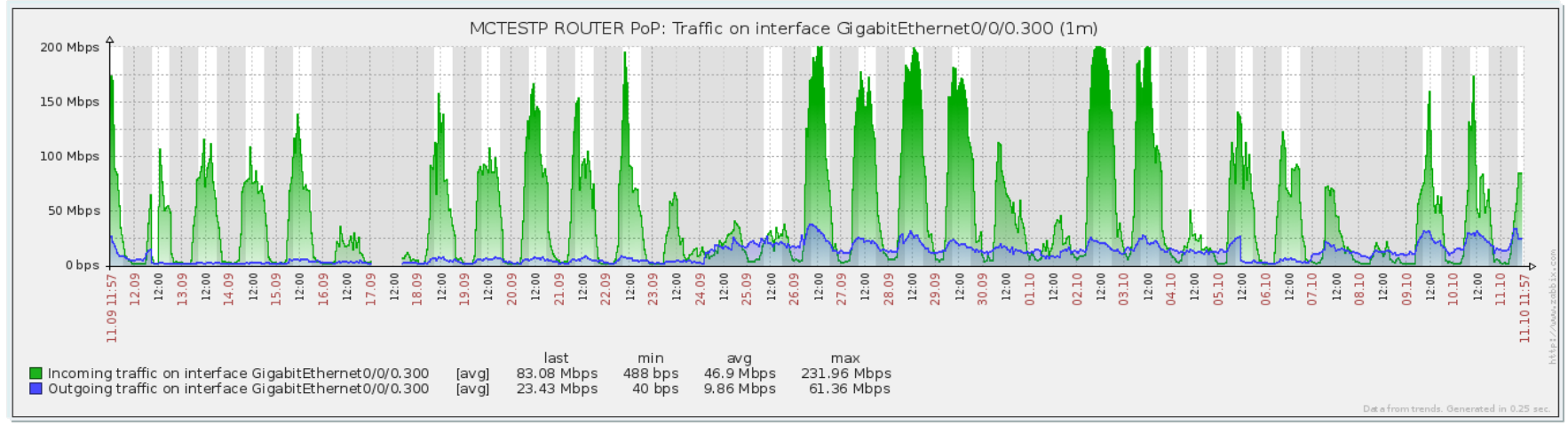
1. Introduction: MoRENet Context

Network Management: Bandwidth Usage

Link Connecting MoRENet to WIOCC PoP in Marseille



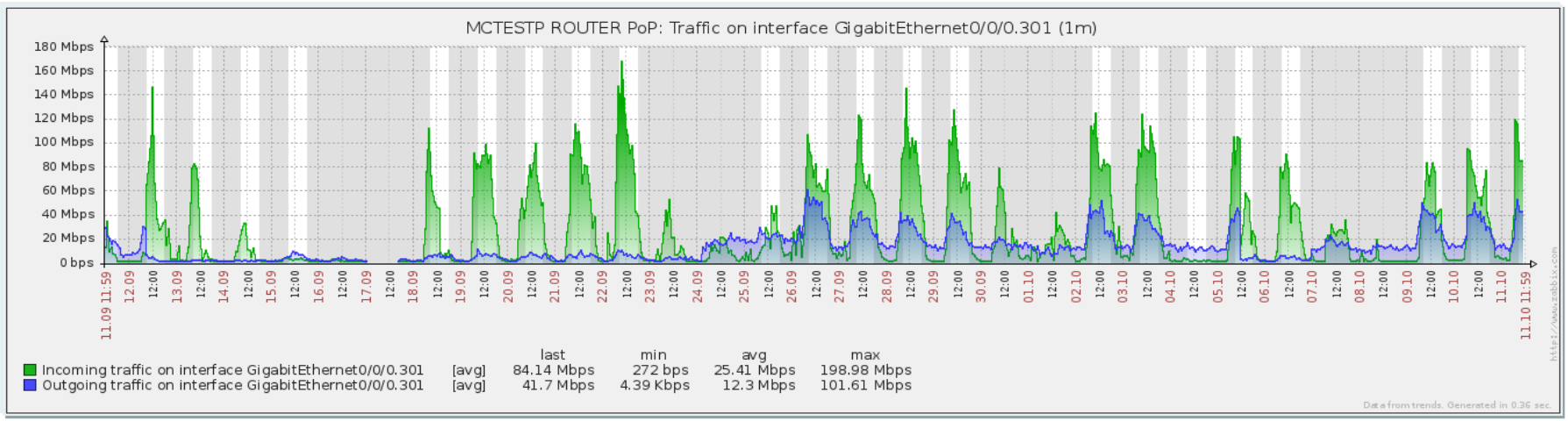
1st Link Connecting MoRENet PoP in Maputo City to UA PoP in Maputo



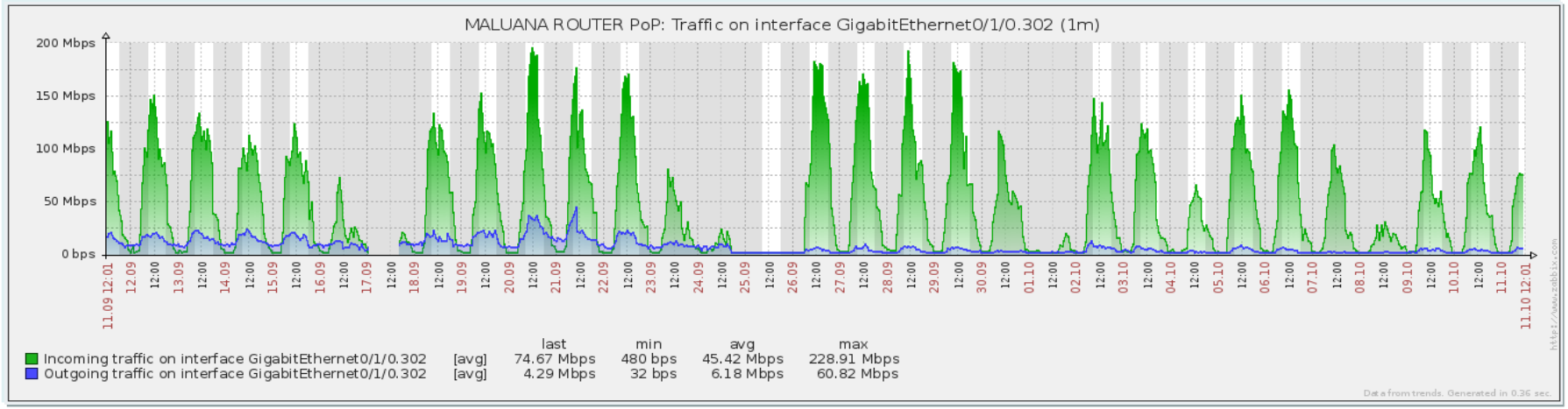
1. Introduction: MoRENet Context

Network Management: Bandwidth Usage

2nd Link Connecting MoRENet PoP in Maputo City to UA PoP in Maputo



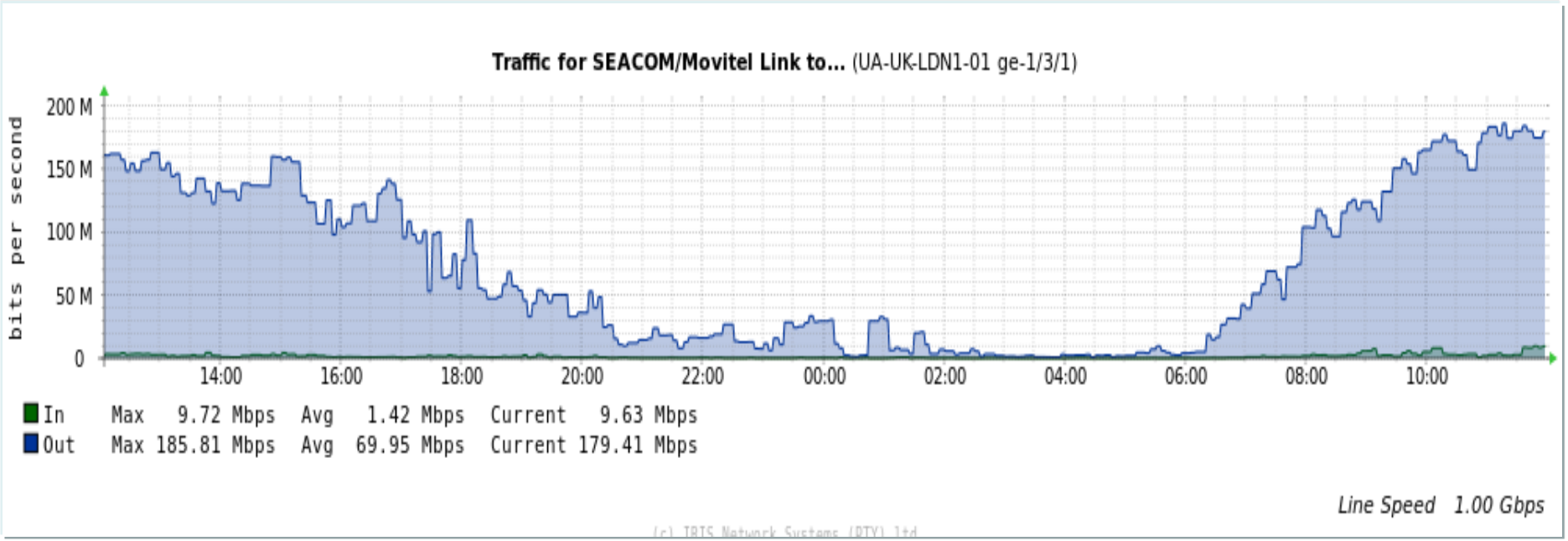
Link Connecting MoRENet PoP in Maputo Province to UA PoP in Maputo



1. Introduction: MoRENet Context

Network Management: Bandwidth Usage

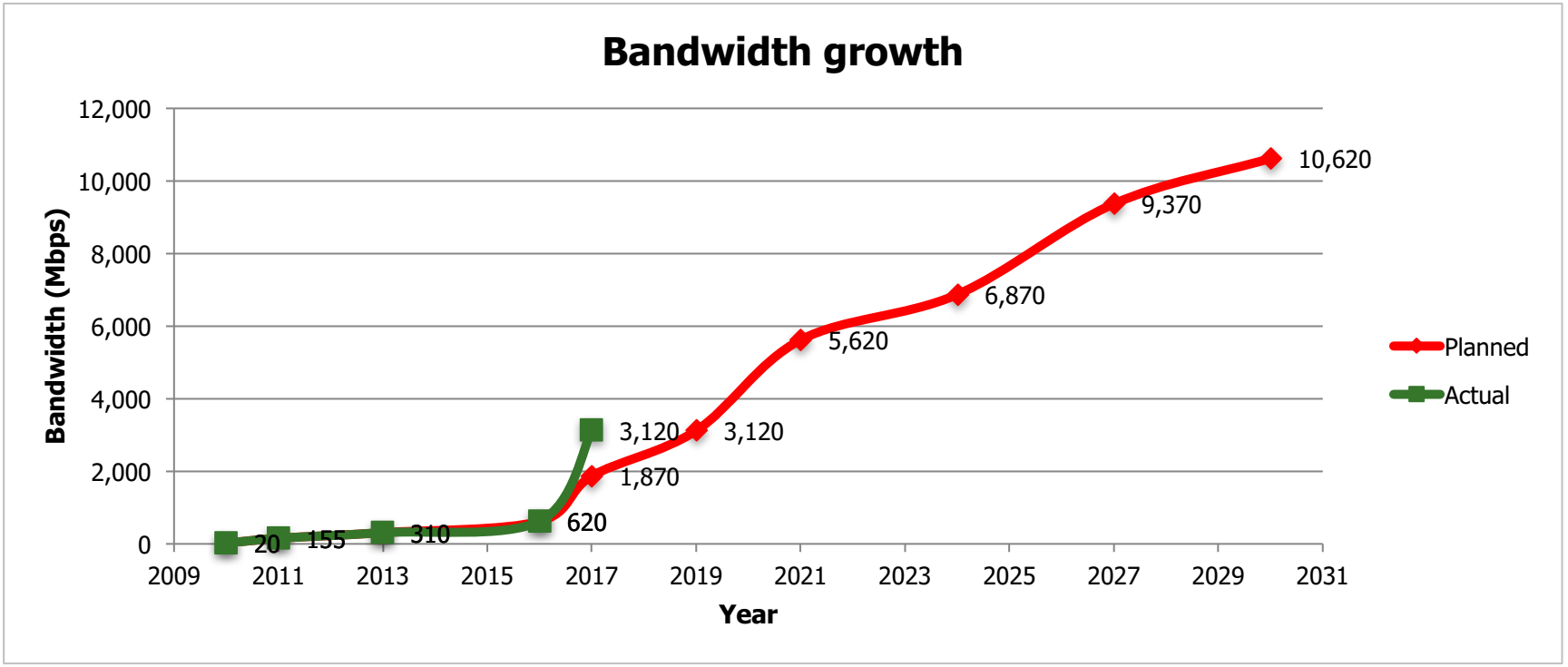
Link Connecting MoRENet PoP in Maputo Province to UA PoP in London



1. Introduction: MoRENet Context

Network Bandwidth Growth

Year	2010	2011	2013	2016	2017	2019	2021	2024	2027	2030
Planned (Mbps)	20	155	310	620	**1.870**	3.120	5.620	6.870	9.370	10.620
Actual (Mbps)	20	155	310	620	**3.120**					



2. Research Objectives

1. Investigate the usage of MoRENet as a platform to promote and support the collaboration between different actors of the scientific and academic community within Mozambique;
2. Provide Evidence of the potential role of MoRENet's policies, strategies, architecture, and controls in promoting or hindering the growth of the academic network; and
3. Provide advice for policy recommendations and management decisions about the usage of applications, their localization and the possible peering agreements between MoRENet and other networks, including African NRENs.

3. MoRENet Data Flow Analysis Using Netflow
Data Collection Method and Tools

Protocols for data flow analysis considered:

- IPFIX (IP Flow Information Export) – IETF;
- NETFLOW – CISCO Systems, Inc;
- Netstream – Huawei;
- Jflow – Juniper-

Netflow Advantages:

- Operations as cache; and
- Export of information in cache, facilitating collection of data for future analysis without having to place an analyzer in every link.

3. MoRENet Data Flow Analysis Using Netflow

Data Collection Method and Tools

- For this analysis, Netflow has been configured in the entrance direction, in the interfaces of the POP routers directly connected to the international transit providers, in the Maputo province POP, Maputo city POP and PoPs of the center and north provinces of Mozambique;
- Address block of 41.94.0.0/16 defined as MoRENet's internal addresses and all other as external.
- Netflow export data flow to the WHATSUP GOLD collector in port 9999, and the collector monitors the devices in port 161.

3. MoRENet Data Flow Analysis Using Netflow

Data Collection Method and Tools

- The configured tool highlights the tendencies on the network traffic, which allows change to be done in an anticipated and smart manner in overloaded links.

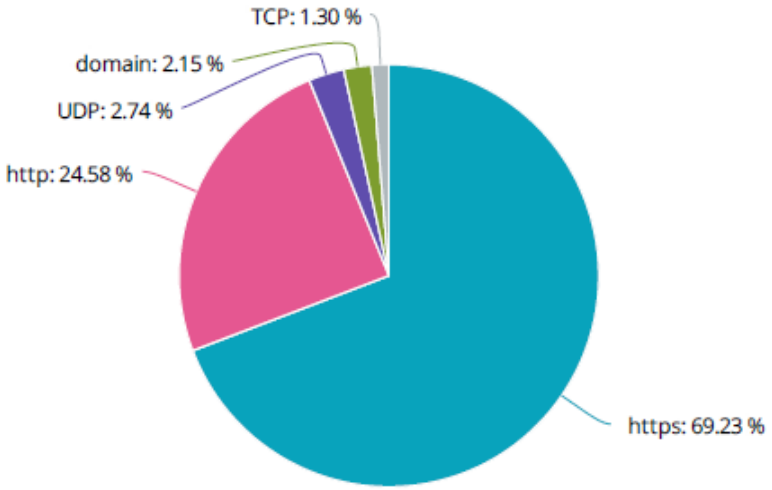
- Also provides reports about the main applications (protocols) being used, the origin and destinations of most of the traffic by domain, Autonomous System Number (ASN) and IP address groups.

3. MoRENet Data Flow Analysis Using Netflow

Results: Flow of the Main Applications

Top Applications

[MALUANA POP] | No advanced filters configured | Yesterday



Application	Bytes	Bit Rate	Packets	Packet ...	Packet ...	Flows	Flow Rate	Flow Pe...	Utilizati...	Byte Pe...
https	621.71 GB	61.81 M...	613.99 ...	7.11 Kpps	64.4%	3.78 Mf	2.62 Kfp...	17.0%	"N/A"	69.2%
http	220.73 GB	21.94 M...	202.51 ...	2.34 Kpps	21.2%	1.40 Mf	969.25 f...	6.3%	"N/A"	24.6%
UDP Unclassified	24.59 GB	2.44 Mb...	21.97 Mp	254.23 ...	2.3%	232.42 Kf	161.40 f...	1.0%	"N/A"	2.7%
domain	19.32 GB	1.92 Mb...	99.88 Mp	1.16 Kpps	10.5%	16.55 Mf	11.49 Kf...	74.5%	"N/A"	2.2%
TCP Unclassified	11.70 GB	1.16 Mb...	14.93 Mp	172.82 ...	1.6%	255.66 Kf	177.54 f...	1.2%	"N/A"	1.3%

Overview of the statistical analysis collected by Netflow per application, on the Maputo Province POP.

3. MoRENet Data Flow Analysis Using Netflow

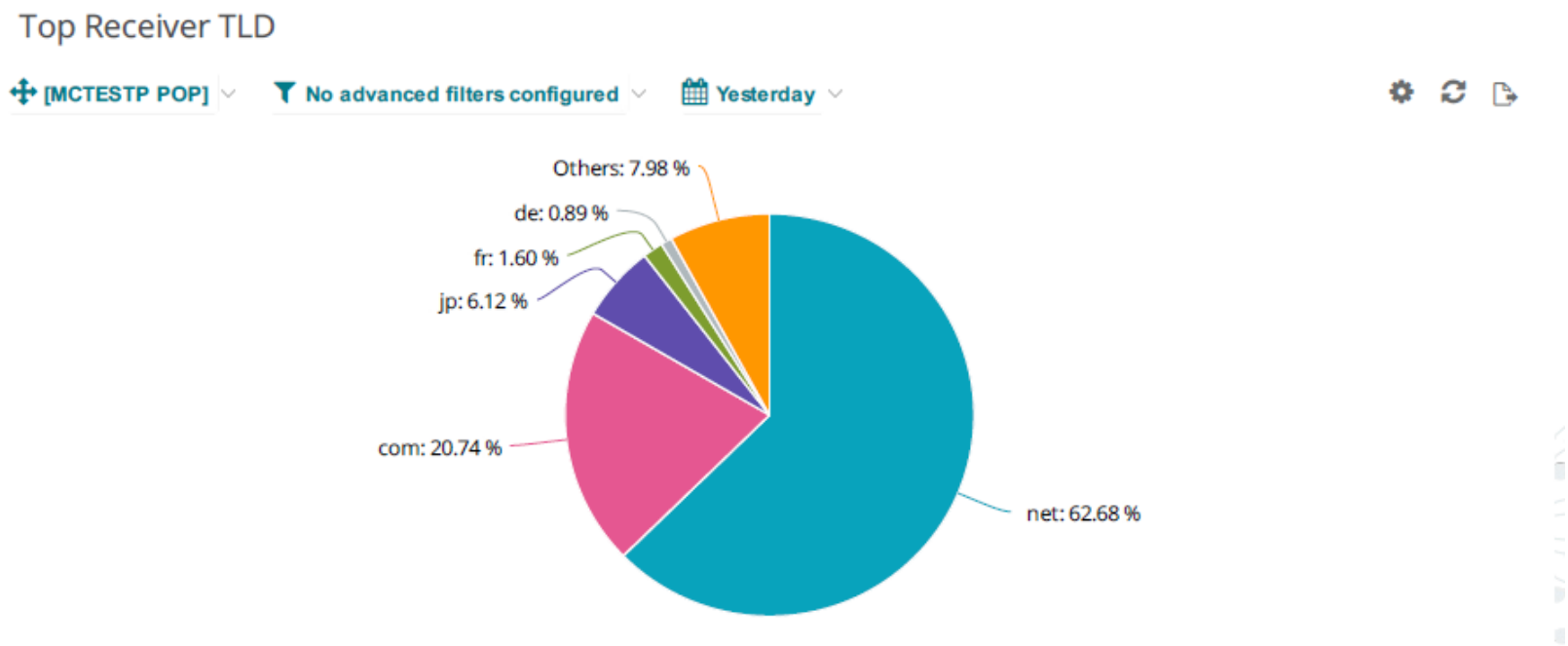
Results: Flow of the Main Applications

- Approximately 69% of the data flow in the international links in Maputo Province POP originate from encrypted web pages;
- 33% from unencrypted web pages;
- 2% from applications using UDP protocols;
- 2% from DNS requests, and;
- Remaining percentage have their origin in applications using TCP.

This information aids the network infrastructure managers in making decisions related to the creation of policies for the prioritizing or blocking of data flow from certain applications which are useful to the network users.

3. MoRENet Data Flow Analysis Using Netflow

Results: Flow of the Main Domains



	TLD	Type	Bytes	Bit Rate	Packets	Packet...	Packet...	Flows	Flow R...	Flow P...	Utilizat...	Byte P...
•••	net	Network	59.54 GB	5.92 M...	134.04 ...	1.55 K...	56.9%	5.55 Mf	3.86 Kf...	53.7%	"N/A"	62.7%
•••	com	Commercial organi...	19.69 GB	1.96 M...	72.19 ...	835.51 ...	30.7%	4.18 Mf	2.90 Kf...	40.4%	"N/A"	20.7%
•••	jp	Japan	5.81 GB	577.44 ...	6.01 Mp	69.55 ...	2.6%	89.39 Kf	62.07 f...	0.9%	"N/A"	6.1%
•••	fr	France	1.52 GB	151.53 ...	1.99 Mp	23.00 ...	0.8%	3.10 Kf	2.15 fpm	0.0%	"N/A"	1.6%
•••	de	Germany	860.89 ...	83.58 k...	2.34 Mp	27.03 ...	1.0%	54.29 Kf	37.70 f...	0.5%	"N/A"	0.9%
	Others		7.57 GB	753.06 ...	18.83 ...	217.98 ...	8.0%	458.69 ...	318.53 ...	4.4%	"N/A"	8.0%

Overview of the statistical analysis collected by Netflow per domain, on the Maputo City POP.

3. MoRENet Data Flow Analysis Using Netflow

Results: Flow of the Main Domains

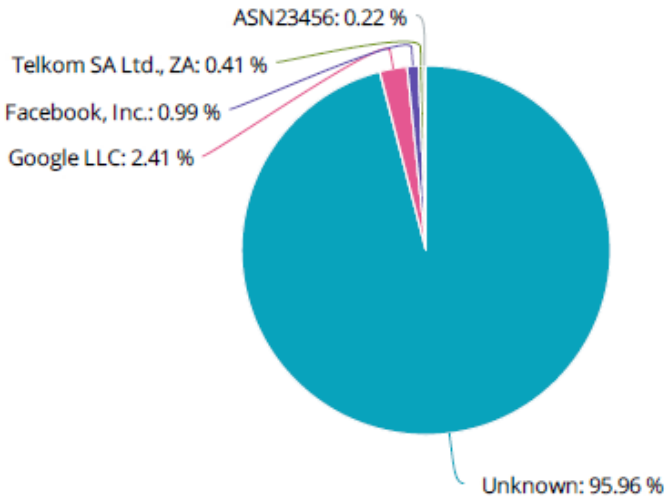
- Approximately 63% of the data flow in the international links of Maputo City POP have their origin in .net domains - Network technology organizations;
- 21% in .com domains mainly hosted in the US;
- 6% in .jp domains - from Japan,
- 2% in .fr domains from France;
- 1% in .de domains from Germany;
- 8% distributed amongst other countries.

3. MoRENet Data Flow Analysis Using Netflow

Results: Flow of the Main ASNs

Top Receiver ASN

[MALUANA POP] | No advanced filters configured | Past 30 Minutes



	ASN	Organization	Bytes	Bit Rate	Packets	Packe...	Packe...	Flows	Flow ...	Flow ...	Utiliz...	Byte ...
•••		Unknown	8.42 GB	40.18 ...	8.43 Mp	4.68 K...	75.6%	241.6...	8.05 K...	81.4%	"N/A"	96.0%
•••	15169	Google LLC	216.7...	1.01 ...	2.53 Mp	1.41 K...	22.7%	52.63 Kf	1.75 K...	17.7%	"N/A"	2.4%
•••	32934	Facebook, Inc.	89.28 ...	416.0...	118.1...	65.65 ...	1.1%	1.41 Kf	46.90 ...	0.5%	"N/A"	1.0%
•••	37457	Telkom SA Ltd., ZA	37.09 ...	172.8...	35.12 ...	19.51 ...	0.3%	155 f	5.17 f...	0.1%	"N/A"	0.4%
•••	23456	ASN23456	19.91 ...	92.80 ...	31.58 ...	17.55 ...	0.3%	1.04 Kf	34.60 ...	0.3%	"N/A"	0.2%

Overview of the statistical analysis collected by Netflow per domain, on the Maputo City POP

3. MoRENet Data Flow Analysis Using Netflow

Results: Flow of the Main ASNs

- Approximately 2% of the data flow in the international links in Maputo Province POP have their origin at ASN15169 - Google;
- 1% at ASN32934 - Facebook;
- 0.5% at ASN23456 – Nipa Technology; and
- 96% on the various ASNs.

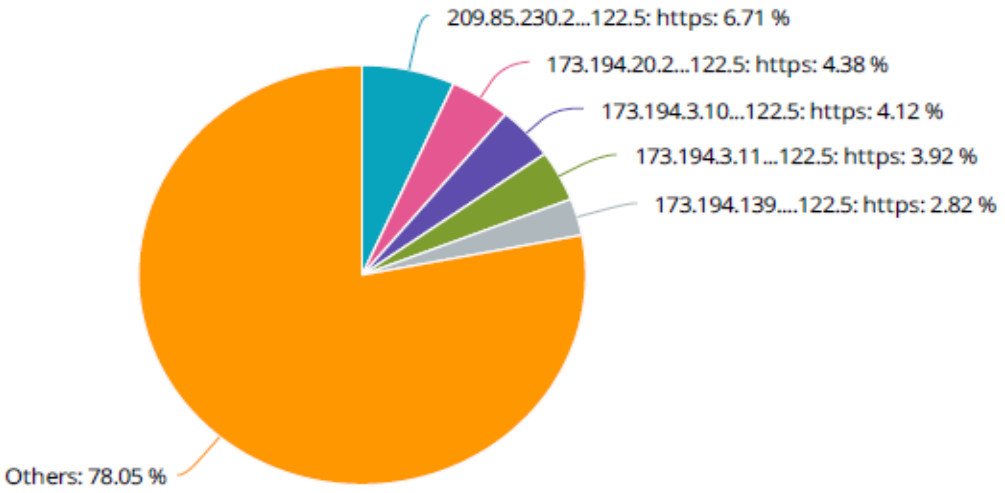
With this information managers can easily decide to which ASN MoRENet should establish direct links, with the aim of reducing latency.

3. MoRENet Data Flow Analysis Using Netflow

Results: Flow of the main transactions between IP Groups

Top Conversations

[MALUANA POP] | No advanced filters configured | Past 30 Minutes



	Conversation	Applic...	Bytes	Bit Rate	Packets	Packe...	Packe...	Flows	Flow ...	Flow ...	Utiliz...	Byte ...
•••	209.85.230.234 -> 41.94.122.5...	https	628.4...	2.93 ...	450.3...	250.2...	3.6%	1 f	0.03 f...	0.0%	"N/A"	6.7%
•••	173.194.20.217 -> 41.94.122.5...	https	410.5...	1.91 ...	293.3...	162.9...	2.4%	1 f	0.03 f...	0.0%	"N/A"	4.4%
•••	173.194.3.105 -> 41.94.122.5: ...	https	386.0...	1.80 ...	276.5...	153.6...	2.2%	10 f	0.33 f...	0.0%	"N/A"	4.1%
•••	173.194.3.115 -> 41.94.122.5: ...	https	367.3...	1.71 ...	263.6...	146.4...	2.1%	1 f	0.03 f...	0.0%	"N/A"	3.9%
•••	173.194.139.250 -> 41.94.122....	https	264.3...	1.23 ...	189.4...	105.2...	1.5%	8 f	0.27 f...	0.0%	"N/A"	2.8%
	Others		7.14 GB	34.07 ...	10.89 ...	6.05 K...	88.1%	343.9...	11.47 ...	100.0%	"N/A"	78.0%

Overview of the statistical analysis collected by Netflow per IP transaction, on the Maputo City POP.

3. MoRENet Data Flow Analysis Using Netflow

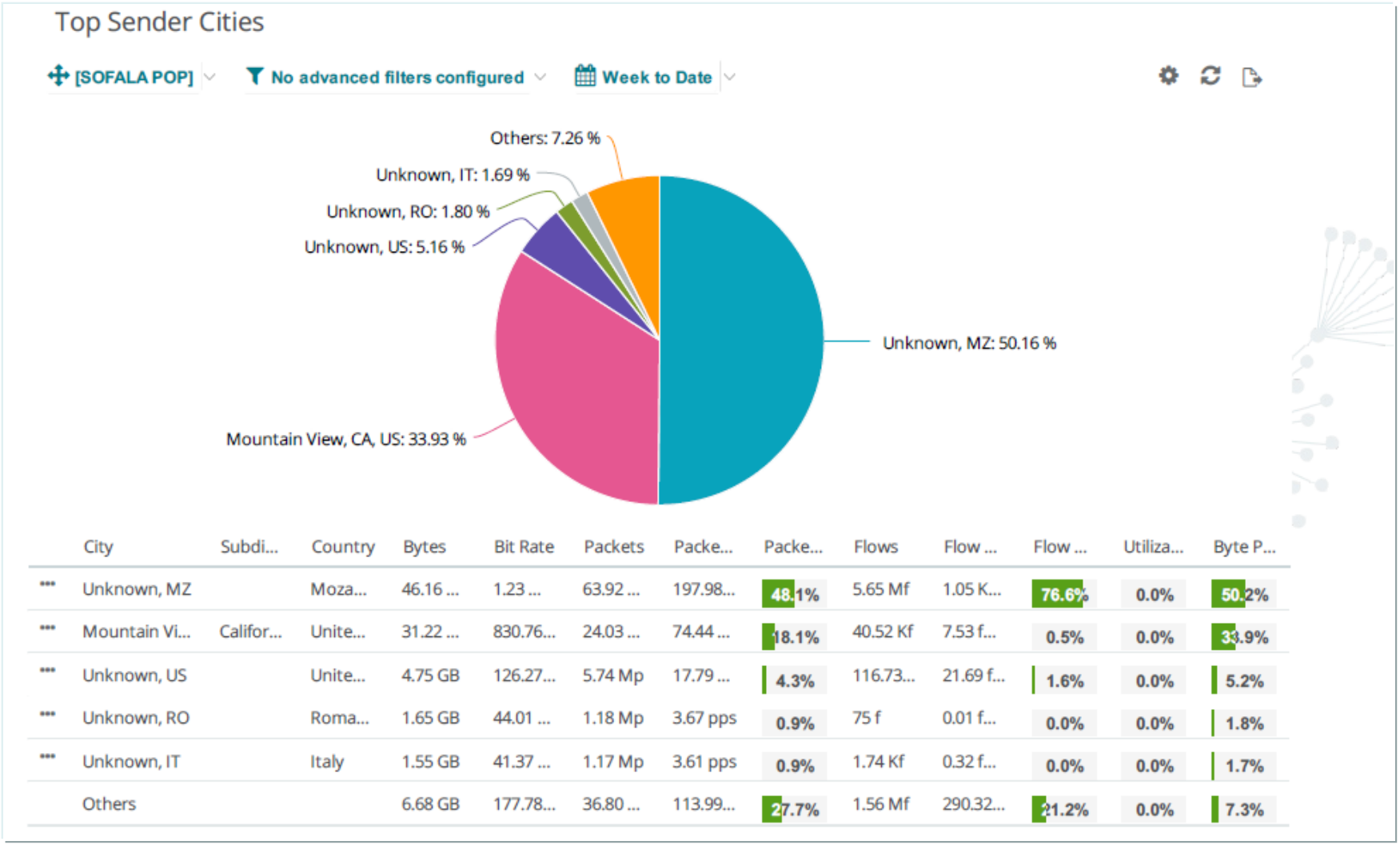
Results: Flow of the main transactions between IP Groups

- Around 7% of the data flow in the international link to Maputo Province POP was generated by the conversation between the IP addresses 209.85.230.234 and 41.94.122.5;
- 4% between address on network 173.194.0.0 and 41.94.122.5;and;
- 78% between the various internal and external addresses.

This statistical data may indicate the occurrence of a denial of service attack during the period of data collection with origin at 173.194.0.0 network to the machine 41.94.122.5;

3. MoRENet Data Flow Analysis Using Netflow

Results: Flow of the Main cities



	City	Subdi...	Country	Bytes	Bit Rate	Packets	Packe...	Packe...	Flows	Flow ...	Flow ...	Utiliza...	Byte P...
•••	Unknown, MZ		Moza...	46.16 ...	1.23 ...	63.92 ...	197.98...	48.1%	5.65 Mf	1.05 K...	76.6%	0.0%	50.2%
•••	Mountain Vi...	Califor...	Unite...	31.22 ...	830.76...	24.03 ...	74.44 ...	18.1%	40.52 Kf	7.53 f...	0.5%	0.0%	33.9%
•••	Unknown, US		Unite...	4.75 GB	126.27...	5.74 Mp	17.79 ...	4.3%	116.73...	21.69 f...	1.6%	0.0%	5.2%
•••	Unknown, RO		Roma...	1.65 GB	44.01 ...	1.18 Mp	3.67 pps	0.9%	75 f	0.01 f...	0.0%	0.0%	1.8%
•••	Unknown, IT		Italy	1.55 GB	41.37 ...	1.17 Mp	3.61 pps	0.9%	1.74 Kf	0.32 f...	0.0%	0.0%	1.7%
	Others			6.68 GB	177.78...	36.80 ...	113.99...	27.7%	1.56 Mf	290.32...	21.2%	0.0%	7.3%

Overview of the statistical analysis collected by Netflow per City, on the Maputo City POP.

3. MoRENet data flow analysis using Netflow

Flow of the main cities

- Approximately 50% of the data flow in the links of Sofala province PoP have their origin in networks located in Mozambican cities;
  - 34% in networks located in California/US;
  - 6% in networks located in other cities of US,
  - 2% in networks located in cities of Romania;
  - 2% in networks located in cities of Italy;
  - 7% distributed amongst many cities from other countries.

- Large amount of the traffic that circulates in the MoRENet backbone corresponds to the transactions between the institutions directly connected to MoRENet.
- This can be an indication that MoRENet has been contributing significantly to the collaboration between the national research and education institutions.

4. Conclusion

- MoRENet network has been playing a growing role in Intra-country Collaboration between research and higher education institutions in Mozambique;
- There is insignificant traffic flow between MoRENet and African universities (African NRENs);
- Data Flow Analysis helps in:
  - Understanding “how”, “what”, “when”, and “by who” the MoRENet bandwidth is used;
  - Generating data and information that can help in making strategic decisions to improve network performance;
  - Identifying possible network malware infections; and
  - Evaluating the impact of new services implemented on the network.

Thank you!

Muito Obrigado

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