

# MIRA – a platform to measure Internet resilience in real-time

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# Motivation


 The Straits Times

## Why am I not getting the broadband speeds I paid for?

SINGAPORE - Singapore is gearing up to equip more households with 10Gbps broadband networks, providing \$100 million worth of grants to help...

5 Aug 2024

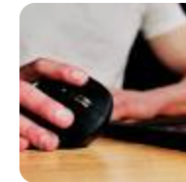


 Security.org

## ISP Throttling: How Do You Know If You're Being Throttled?

One way you can tell if your ISP is throttling your speeds is by using a VPN. In many cases, ISPs throttle you based on your IP address.

3 Oct 2021



# Real-time measurements

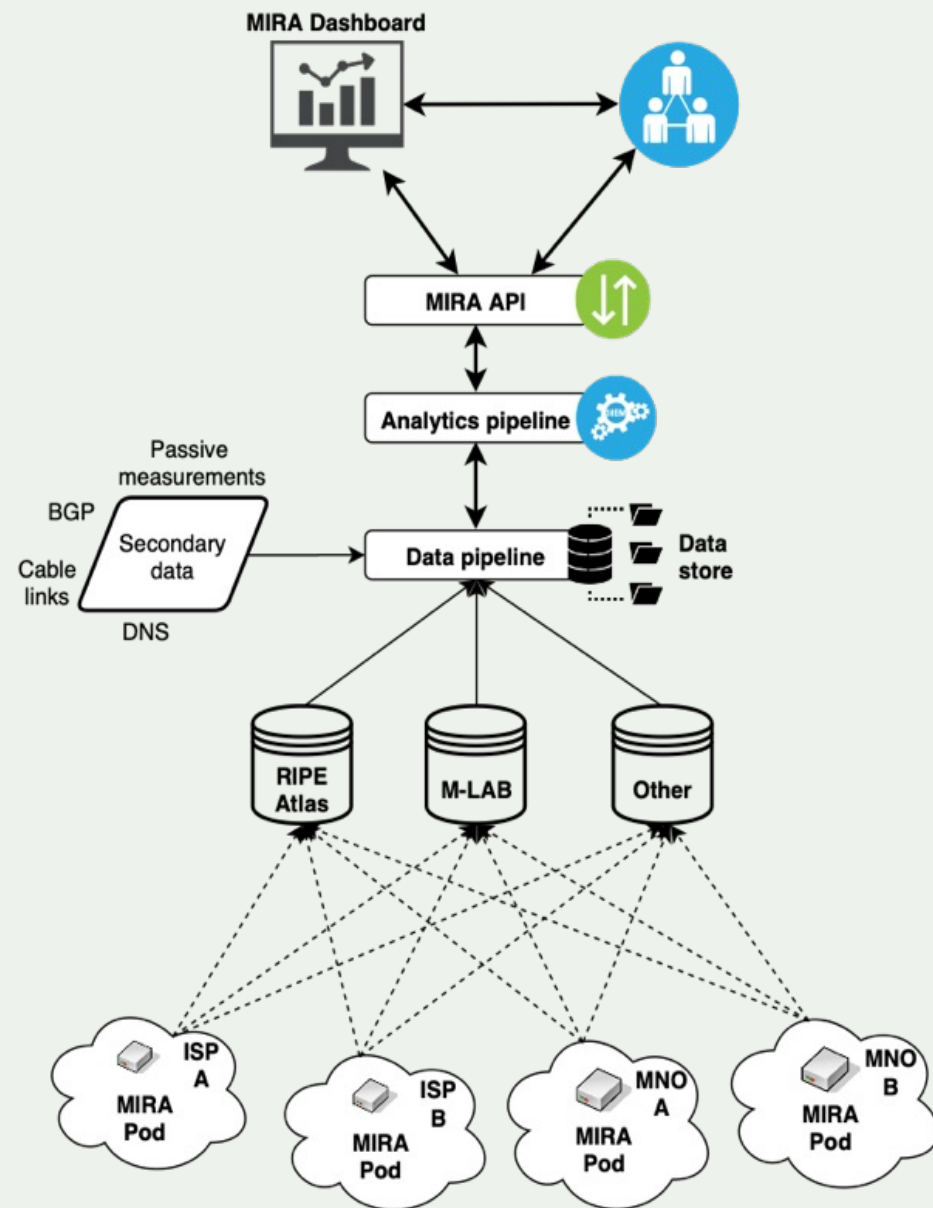


## Why we need real time measurements?

- Real time measurements help show an accurate picture of the Internet experience on the ground
- Using an active measurement platform allows for real time measurements to be conducted.
- Such measurements can be done on a small network or over a large geographical area.
- As part of the initial phase of the Internet Resilience project, the Internet Society developed a proof-of-concept active measurement infrastructure consisting of measurement devices (pods), OpenBalena management server and client, and Data aggregation server.
- More of a blueprint that others can replicate

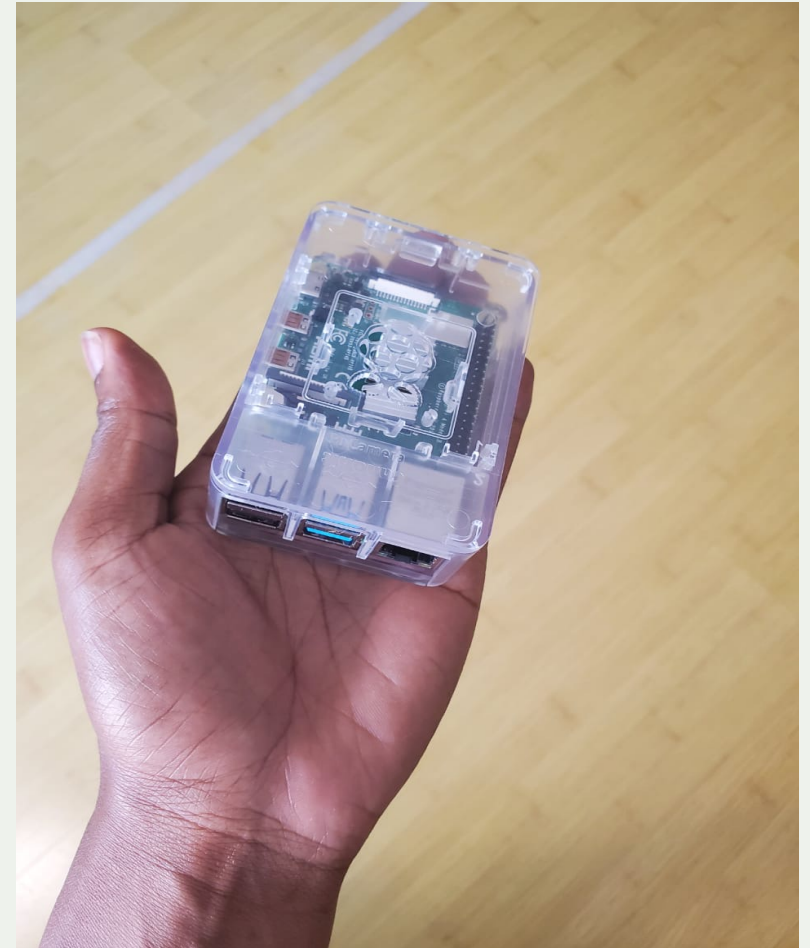
# Prototype active measurements infrastructure

- Use of Raspberry Pis as hosts to run the RIPE Atlas & M-Lab clients for real time measurements (MIRA Pods)
  - NDT7: Speed and latency
  - RIPE Atlas: Traceroute, ping, DNS, SSL, etc
- Devices send data to a local server for storage and visualization (M-Lab).
- Documentation of this project available allowing for the management and deployment of a distributed measurement network to city wide or national scale

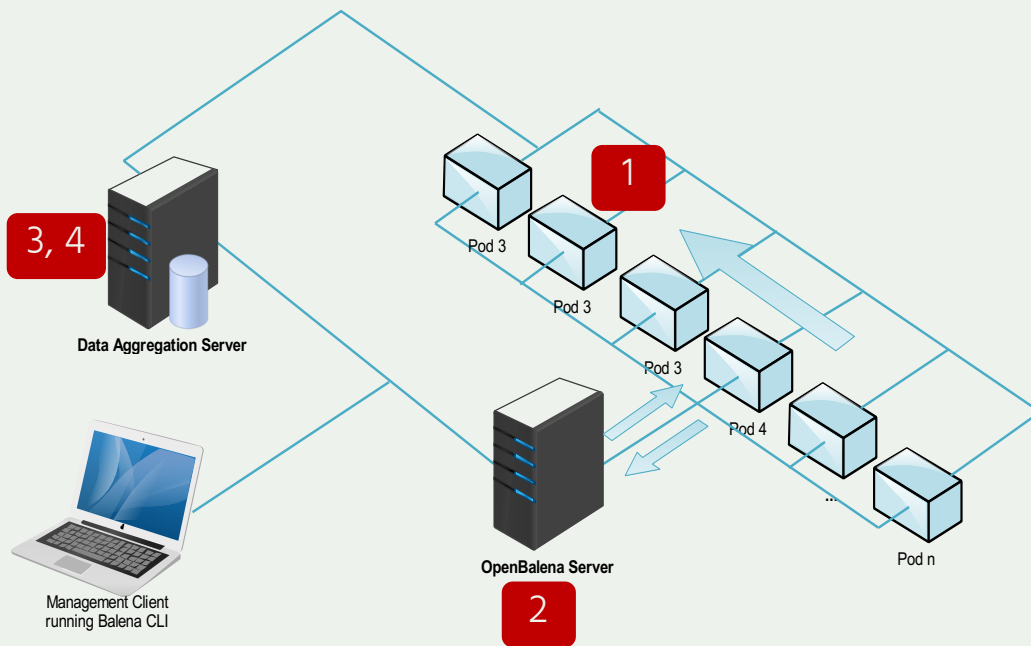


# Measurement infrastructure in the project

- RIPE Atlas & M-Lab clients/servers were used in 10 countries
- Raspberry Pis used as hosts to run the RIPE Atlas & M-Lab clients on Balena OS
- Measurements carried out every 6 hours (NDT7 -> Target servers)
- Measurement servers setup to increase measurement targets in Africa

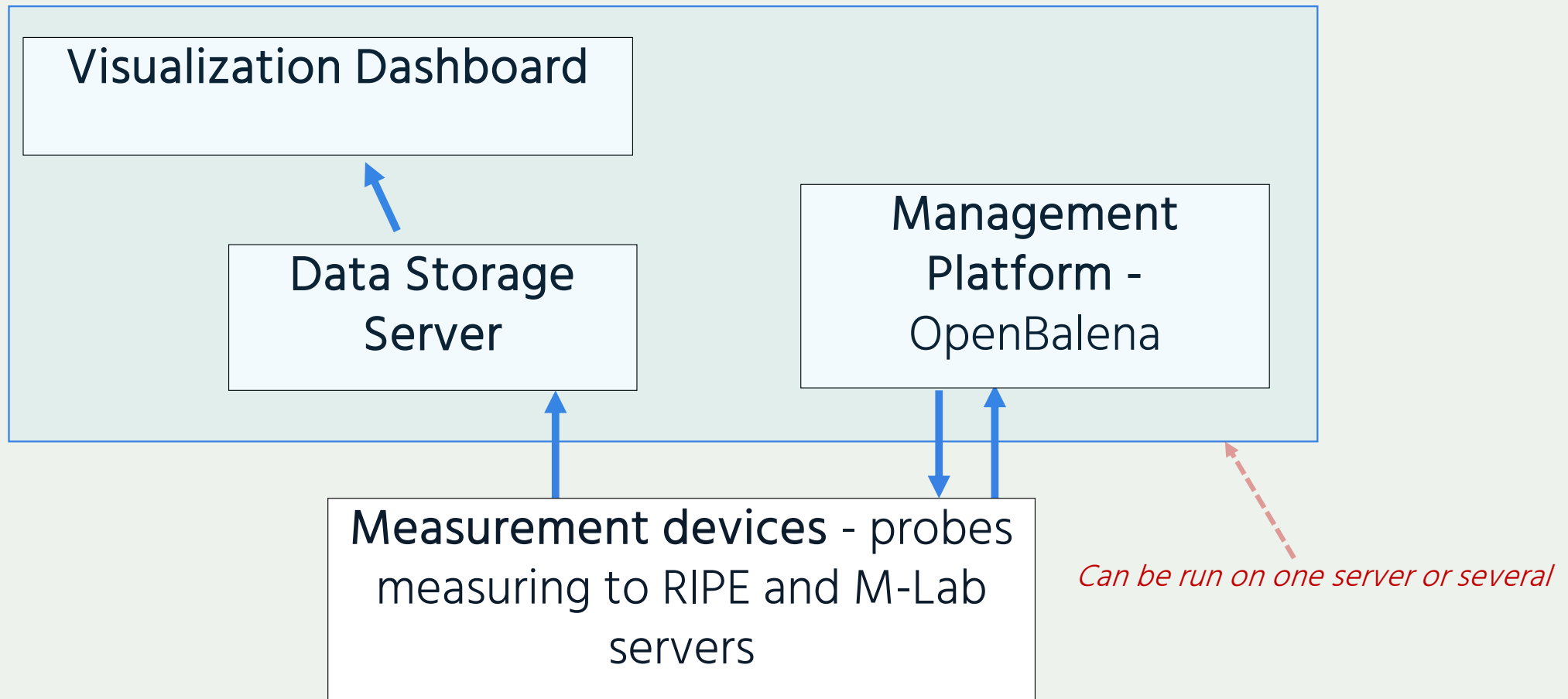


# Components of the active measurements



1. **Measurement devices (pods):** These are low power and lightweight measurement devices deployed in various parts of the network to carry out the actual measurements
2. **Management Platform:** The platform allows management of pods remotely over the Internet.
3. **Data Aggregation Server:** As measurements are carried out, data is received from pods and stored in a data collection server for processing.
4. **Visualization Dashboard:** To visualize the data being collected and extract meaningful information,

## Overview of the design of the process





# Features of OpenBalena Management Platform

1. Device Management: View device status, update software, monitor performance, and troubleshoot issues remotely.
2. Application Deployment: (OTA) over the air updates using OpenBalena. This makes it easy to distribute and update software on a large number of devices.
3. Security: It supports secure communication between devices and the central management server.
4. Customization: Customize OpenBalena to suit your specific IoT project requirements. Eg: defining device types, configuring network settings, etc
5. Cost-Efficiency: As an open-source solution, OpenBalena can help reduce the costs associated with managing IoT devices compared to proprietary alternatives such as BalenaCloud

## Server Setup

1. OpenBalena server – any Linux distro (used Debian/Ubuntu)
2. Storage server – any Linux/Unix distro that can run SSH (used Debian/Ubuntu)
3. Visualization server – any Linux distro (used Debian/Ubuntu)

## RPi Setup

1. Create installable image on a PC for each fleet
2. Copy image to the RPi's removable SSD disk
3. Boot the RPi
4. RPi is then visible on the OpenBalena dashboard

# Fleet Design

**Fleetname:**  
Kenya



**Fleet devices:**

- Nairobi
- Mombasa
- Kisumu

**Fleetname:**  
South Africa



**Fleet devices:**

- Jo'Burg
- Cape Town
- Durban

**Fleetname:**  
Tanzania



**Fleet devices:**

- Dar Es Salam

# OpenBalena Frontend

Dashboard



- Dashboard
- Access
- Fleets
- Devices
- Images
- Releases
- Services
- Static Data

## Welcome to Open Balena Admin

An open source management tool for your Open Balena instance

ORGS

USERS

API KEYS



## Fleets

### harmoni-client-prod

harmoni

harmoni-h1-pilot

# Devices 0  
# Online 0



### harmoni-client-dev

harmoni

harmoni-h1-pilot

# Devices 3  
# Online 2

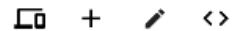


### harmoni-client-test

harmoni

harmoni-h1-pilot

# Devices 0  
# Online 0



## Devices

### Available

harmoni-client-dev

harmoni-h1-pilot

Status Online  
OS 2.95.8+rev1



### AELLIS

harmoni-client-dev

harmoni-h1-pilot

Status Offline  
OS 2.95.8+rev1



### dark-night

harmoni-client-dev

harmoni-h1-pilot

Status Online  
OS 2.95.8+rev1



# Device management on OpenBalena

Device Dashboard 🔄 👤

- Dashboard
- Access
- Fleets
- Devices
  - Devices
  - Config Vars
  - Environment Vars
  - Service Vars
  - Tags
- Images
- Releases
- Services
- Static Data

### Device "harmoni-test"

UUID: bbb15d71ff3684c60133f5f935692348  
Fleet: harmoni-client-prod

🔦 BLINK 🔄 REBOOT 🔌 SHUTDOWN

CPU ▬ 6%  
Temp ▬ 43°C  
SD ▬ 0%  
RAM ▬ 0%

SUMMARY LOGS CONNECT CONTROL

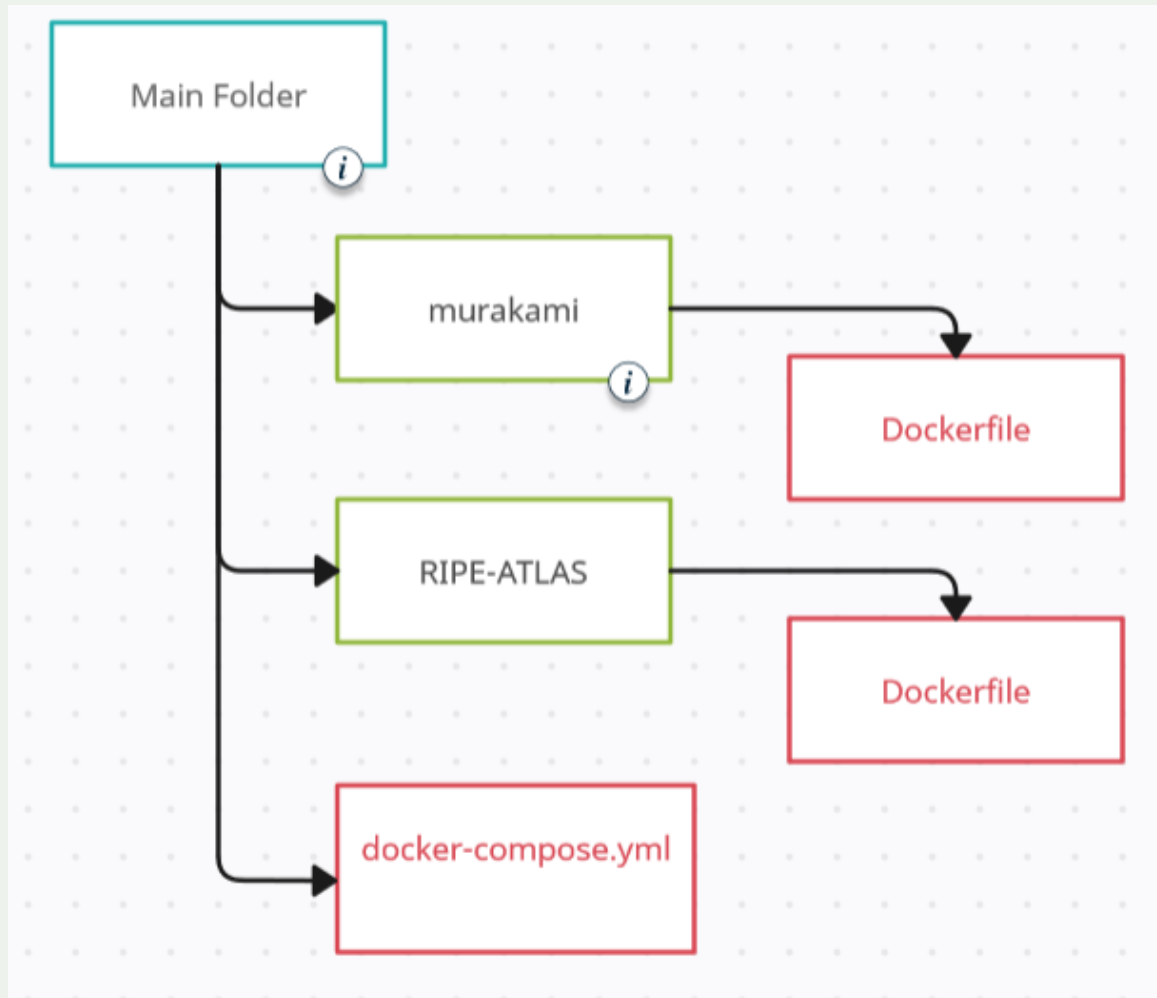
Device Status			Device Services			
<b>Device State</b>	<b>Fleet</b>	harmoni-client-prod	<b>Image</b>	<b>Status</b>	<b>Install Date</b>	
<b>Release Revision</b>	0	<b>Target Revision</b>	app-mic	Running	25-Mar-22 7:21:52 PM EDT	
<b>OS</b>		<b>Supervisor</b>	app-display	Running	25-Mar-22 7:21:51 PM EDT	
<b>Connectivity</b>	Online	<b>As of</b>	25-Mar-22 6:47:03 PM EDT	app-network	Running	25-Mar-22 7:21:51 PM EDT
<b>VPN State</b>	Connected	<b>As of</b>	25-Mar-22 6:47:03 PM EDT	app-camera	Running	25-Mar-22 7:21:51 PM EDT
<b>Public Address</b>		<b>VPN Address</b>	app-node-red	Running	25-Mar-22 7:21:51 PM EDT	
<b>IP Address</b>	192.168.1.203	<b>Mac Addresses</b>	app-mtc-adapter	Running	25-Mar-22 7:21:51 PM EDT	
<b>Memory Usage</b>	2429mb	<b>Total Memory</b>	0mb	app-rfid	Running	25-Mar-22 7:21:51 PM EDT
<b>Storage Usage</b>	3514mb	<b>Total Storage</b>	0mb	app-mtc-agent	Running	25-Mar-22 7:21:51 PM EDT
<b>CPU Usage</b>	6%	<b>CPU Temp</b>	43°C			
<b>CPU ID</b>		<b>Undervolted</b>	No			

# Accessing a device on OpenBalena

The screenshot shows the OpenBalena Device Dashboard for a device named "harmoni-test". The dashboard is divided into several sections:

- Header:** "Device Dashboard" with a refresh icon and a user profile icon.
- Left Sidebar:** A navigation menu with the following items: Dashboard, Access, Fleets, Devices (expanded), Devices, Config Vars, Environment Vars, Service Vars, Tags, Images, Releases, Services, and Static Data.
- Device Information:** "Device 'harmoni-test'", "UUID: bbb15d71ff3684c60133f5f935692348", and "Fleet: harmoni-client-prod".
- Control Buttons:** Three buttons: "BLINK" (with a lightbulb icon), "REBOOT" (with a circular arrow icon), and "SHUTDOWN" (with a power icon).
- System Metrics:** Four progress bars showing system status: CPU (6%), Temp (43°C), SD (0%), and RAM (0%).
- Connect Section:** A tabbed interface with "SUMMARY", "LOGS", "CONNECT" (selected), and "CONTROL" tabs. Below the tabs, there are two dropdown menus: "Container" set to "app-display" and "Service" set to "SSH". A blue "CONNECT" button with a terminal icon is positioned to the right of the "Service" dropdown.
- Terminal:** A large black terminal window showing the prompt "bbb15d7/app-display:/usr/src/app\$".

## Internal storage design on RPi device



- Consists of docker containers of the Murakami client and the RIPE atlas software client
- Other software can be run as docker clients
- Device is configured to be sent to an SSH server for Murakami or to a Google Cloud Storage (GCS) instance

## Sample output JSON File

```
{
  "TestName": "ndt7",
  "TestStartTime": "2021-05-27T03:37:11.637526",
  "TestEndTime": "2021-05-27T03:37:33.857756",
  "MurakamiLocation": "BF-OUA",
  "MurakamiConnectionType": "ONATEL-Fibre",
  "MurakamiNetworkType": "15Mbps",
  "MurakamiDeviceID": "df20f76726f7ee88db5e007756f00f59",
  "ServerName": "ndt-mlab1-los02.mlab-oti.measurement-lab.org",
  "ServerIP": "102.88.1.139",
  "ClientIP": "196.....",
  "DownloadUUID": "ndt-6mrgq_1619897333_00000000000D33BA",
  "DownloadValue": 44.28560905250475,
  "DownloadUnit": "Mbit/s",
  "DownloadError": null,
  "UploadValue": 31.392730603544052,
  "UploadUnit": "Mbit/s",
  "UploadError": null,
  "DownloadRetransValue": 0.0024454155278487515,
  "DownloadRetransUnit": "%",
  "MinRTTValue": 219.432,
  "MinRTTUnit": "ms"
}
```




- All tests were using NDT7
- NDT7 uses well known ports which are normally not blocked by firewalls (port 443 and port 80)



# Data Visualization

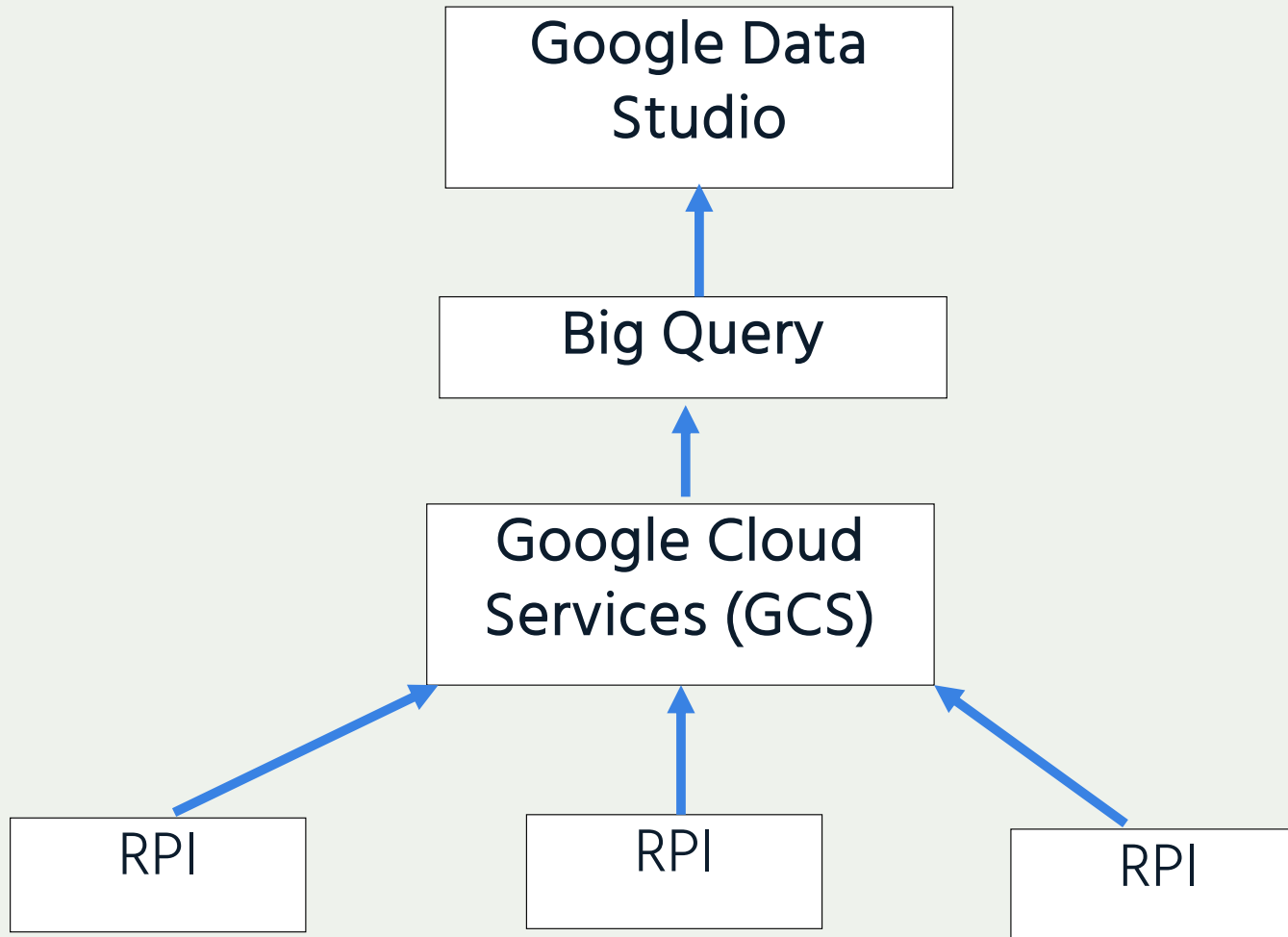


# Countries measured during the PoC

Country	Active MIRA Pods	ISPs being measured
Benin 	✓ (2 probes)	JENY, ISOCEL
Burkina Faso 	✓ (5 probes)	RISINA, ONATEL, Orange, VTS, IP Plus
Cameroon	✓ (2 probes)	CAMTEL
Ethiopia 	✓ (1 probe)	EthioTel
Kenya 	✓ (3 probes)	JTL, Safaricom, Liquid (HAI)
Madagascar 	✓ (3 probes)	Orange, Telma, Blueline
Mauritius 	✓ (2 probes)	Emtel, TelecomPLUS
South Africa 	✓ (2 probes)	Afrihost Ltd
Zimbabwe	✓ (2 probes)	TBC
Rwanda	✓ (2 probes)	MTN

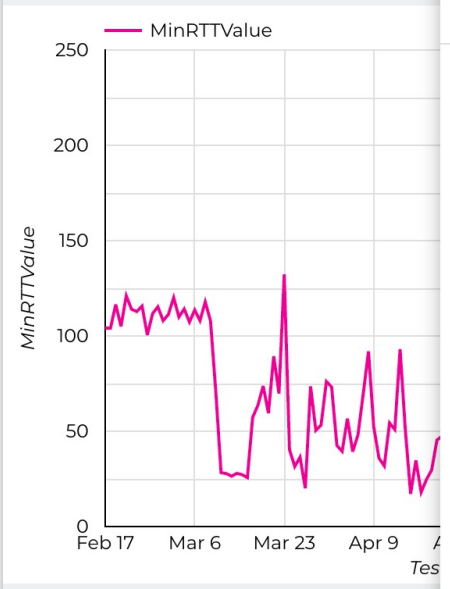
- We also added measurement servers in Burkina Faso and Mauritius
- Measurements could be run across Africa facilitating comparison of inter country links

# Visualization Pipeline when using GCS

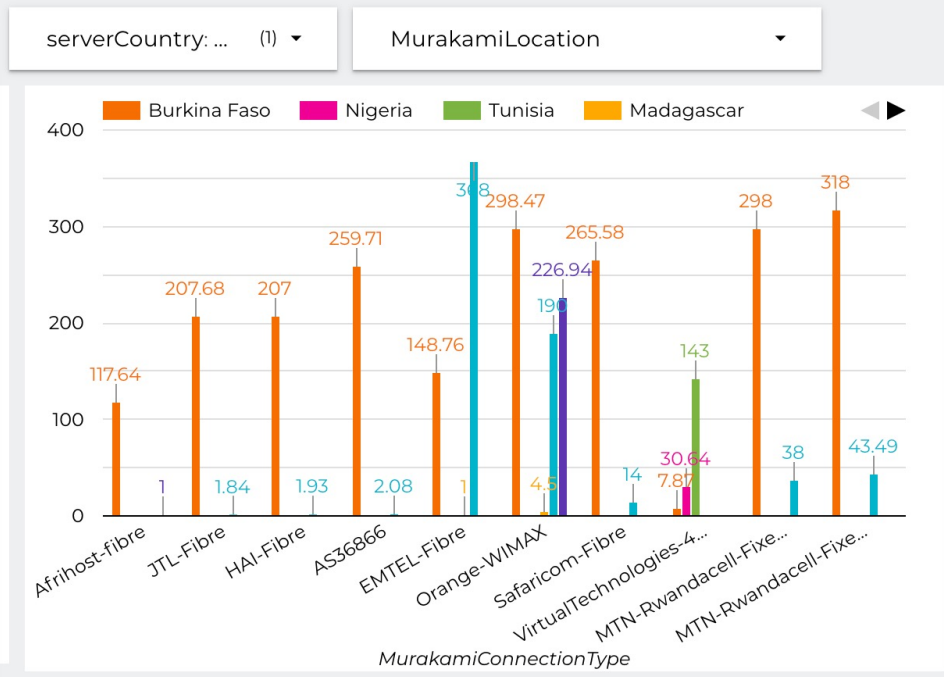


# Google Data Studio Visualization Dashboard

## Metric : MinRTT

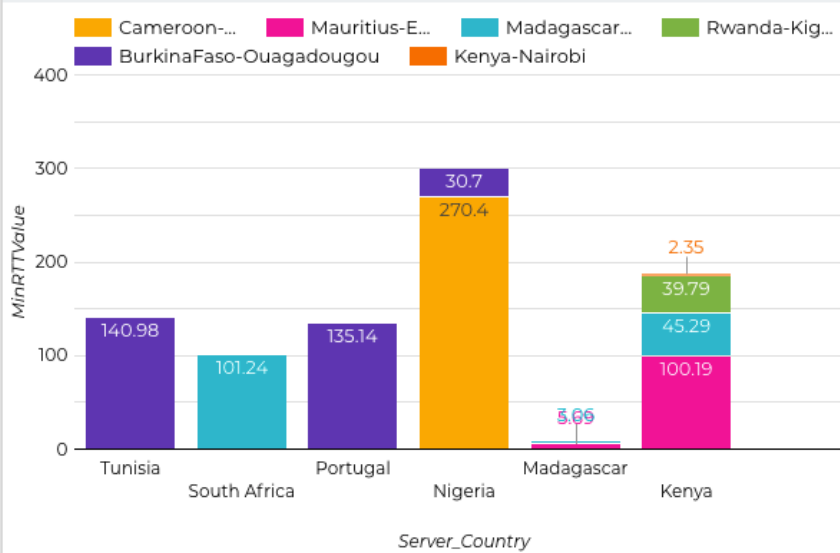


<input checked="" type="checkbox"/>	MurakamiConne...	MinRTTValue
<input checked="" type="checkbox"/>	VirtualTechnologies-4G-L...	30
<input checked="" type="checkbox"/>	Safaricom-Fibre	14.3
<input checked="" type="checkbox"/>	Orange-WIMAX	5.8
<input checked="" type="checkbox"/>	ONATEL-Fibre	219.2
<input checked="" type="checkbox"/>	Nexttel-3G/4G	243.5
<input checked="" type="checkbox"/>	MU-TELECOMPLUS-Fibre	92
<input checked="" type="checkbox"/>	MTN-Rwandacell-Fixed-W...	39.7
<input checked="" type="checkbox"/>	MTN-Rwandacell-Fixed W...	45
<input checked="" type="checkbox"/>	JTL-Fibre	1.9
<input checked="" type="checkbox"/>	HAI-Fibre	2
<input checked="" type="checkbox"/>	EthioTel-ADSL	260.9
<input checked="" type="checkbox"/>	EMTEL-Fibre	2



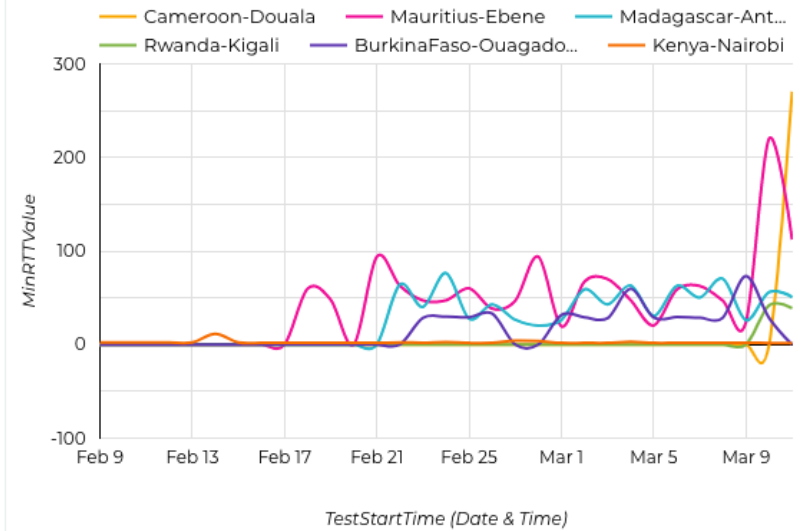
# Google Visualization Dashboard

### Differences in MinRTT per Murakami Location

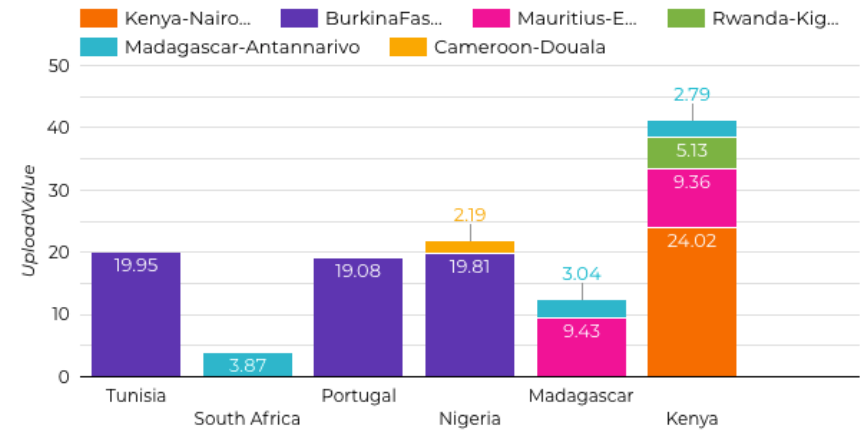
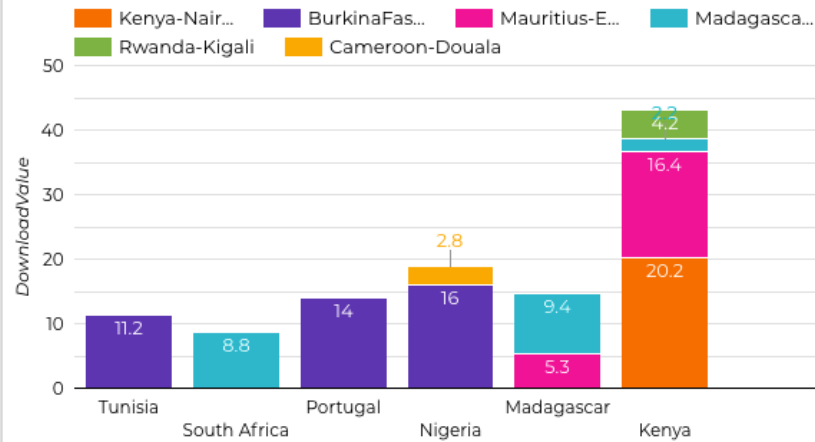


MurakamiLocation

ServerName

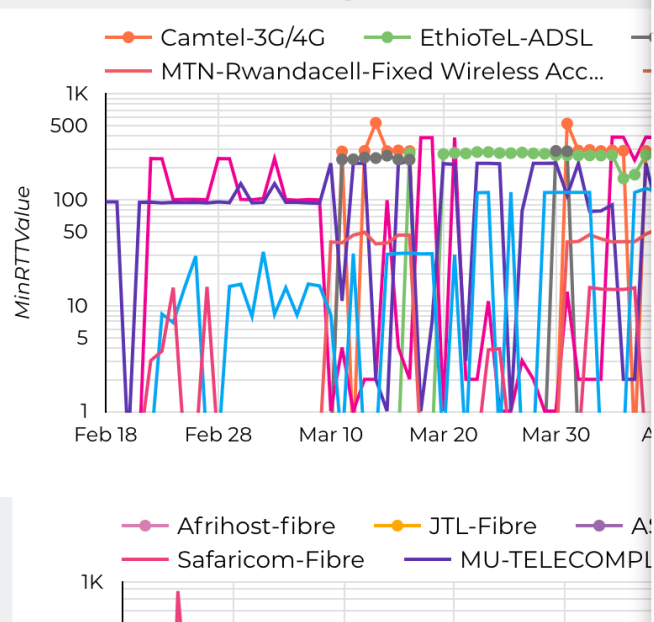


### Differences in Download and Upload speeds

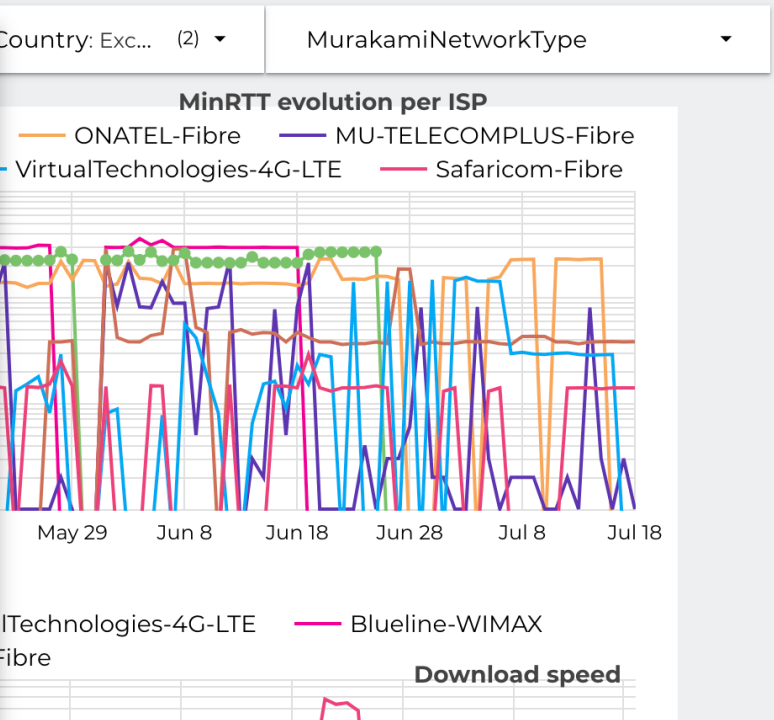


# Google Data Studio Visualization Dashboard

## MURAKAMI MEASUREMENTS EVOLUTION : ISP Comparison



<input checked="" type="checkbox"/> clientCountry	Record Count
Type to search	
<input checked="" type="checkbox"/> Kenya	1.6M
<input checked="" type="checkbox"/> South Africa	178.4K
<input checked="" type="checkbox"/> Madagascar	139.5K
<input checked="" type="checkbox"/> Burkina Faso	39.4K
<input checked="" type="checkbox"/> Ethiopia	30.2K
<input checked="" type="checkbox"/> Mauritius	6.3K
<input checked="" type="checkbox"/> Rwanda	5.6K
<input checked="" type="checkbox"/> Cameroon	4.7K



# Lessons learned



## Insights – lessons learned from the project

- Covering an entire continent with devices is challenging and requires partnerships with organizations with similar interests.
- A private measurement platform is simple to design. Scaling requires planning for staff time to monitor devices, report downtimes, schedule updates, etc
- Free software solutions exist and work well. Improvements can be made to these open-source tools.
- More measurement targets are needed in Africa as well as measurement clients to increase vantage points.



Thank You

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