Mapping African Internet Topology

Visualizing Internet Topology At AS-level and Router-Level

Introduction

As the internet continues to evolve and expand, understanding the underlying infrastructure that supports it has become increasingly crucial. Mapping the physical and logical topology of the internet infrastructure can provide valuable insights into the network's connectivity, performance, and potential bottlenecks.

Methodology

This project adopts a user-centered approach and human-computer interaction principles to design and evaluate topology visualization tools, optimizing usability for target users like network administrators, researchers, and students. This helps to create a more effective and user-friendly product that can meet user needs and accommodate changes.

Problem

Although techniques for internet topology visualisation are constantly being developed and refined. There is little effort invested in visualisations tools specifically for the African Internet topology. The tools that have been described in existing literature do not effectively communicate the interconnections in the African internet topology.

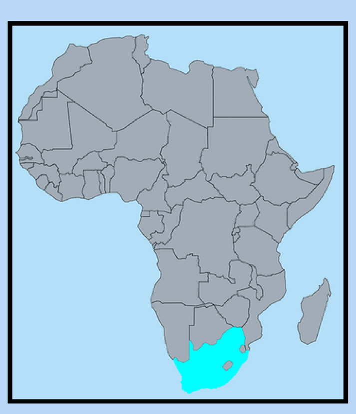
Aims

1. Determine whether the visualization of interconnections between ISPs can effectively communicate the AS-level of internet topology in Africa.

2. How can we accurately map and visualise the African internet topology at router level. Furthermore, how can we improve the usability, accuracy, and reliability of the visualisation tool by leveraging user cantered design techniques?

Visualisation Tools

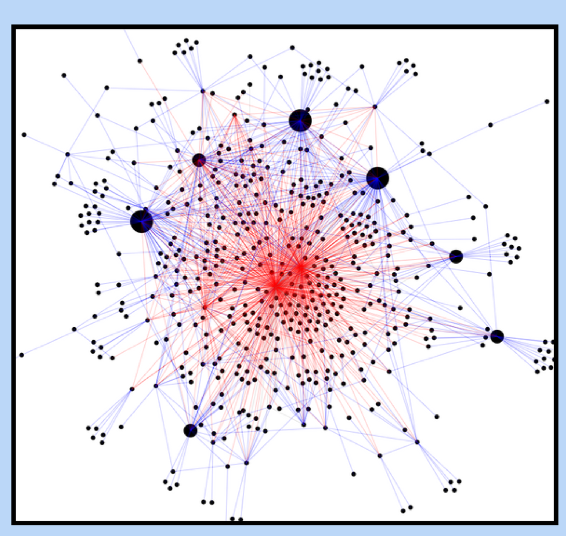
a) AS-level



Interactive Map

An interactive map of Africa continent where users can click on one of the countries to view the topology visualisation. After selecting a country, users will be able select the type of relationships they want to see. One of the types of relationship is AS relationship which shows the relationships between ASes.

A node graph of network topology in South Africa. The nodes represent Autonomous Systems (ASes) and the links represent the relationships between ASes. The blue colour is the provider-to-customer (C2P) relationship and red is the peer-to-peer relationship. The sizes of nodes indicate the number of customers each AS has. The bigger the nodes the more customers it has and vice versa.



AS Relationship

b) Router-level

Pipeline :

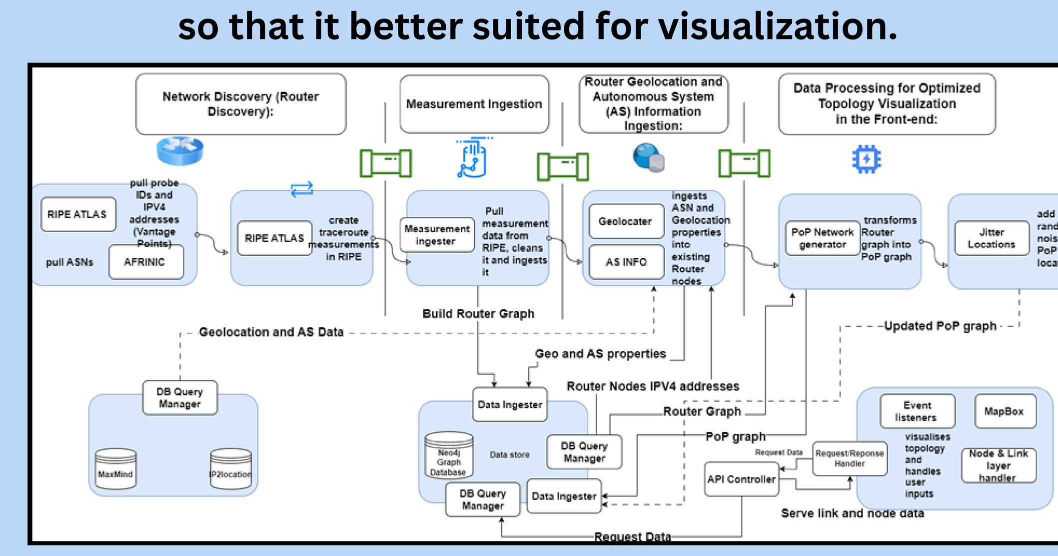
1. Network Discovery (Router Discovery):
   - Tool: RIPE Atlas API for periodic traceroute measurements.
   - Objective: Obtain router IP addresses and discover the African internet topology.

2. Measurement Ingestion - Building the Router Topology:
   - Database: Neo4j graph database for representing router interconnectivity.
   - Process: Fetch measurement data, identify each hop/router, establish relationships, and create the router graph.

3. Router Geolocation and Autonomous System (AS) Information Ingestion:
   - Primary Tool: MaxMind GeoLite2 database for router geolocation and AS data.

4. Data Processing Approach:
   - Outcome: Reduced computational load, better visualization responsiveness, and eliminated need for alias resolution.

We present the design and implementation of a tool that map and visualize Africa's router-level internet topology. Utilizing the Ripe Atlas platform, we created an extensive dataset of traceroute measurements as the primary technique for topology discovery. The gathered data underwent processing so that it better suited for visualization.



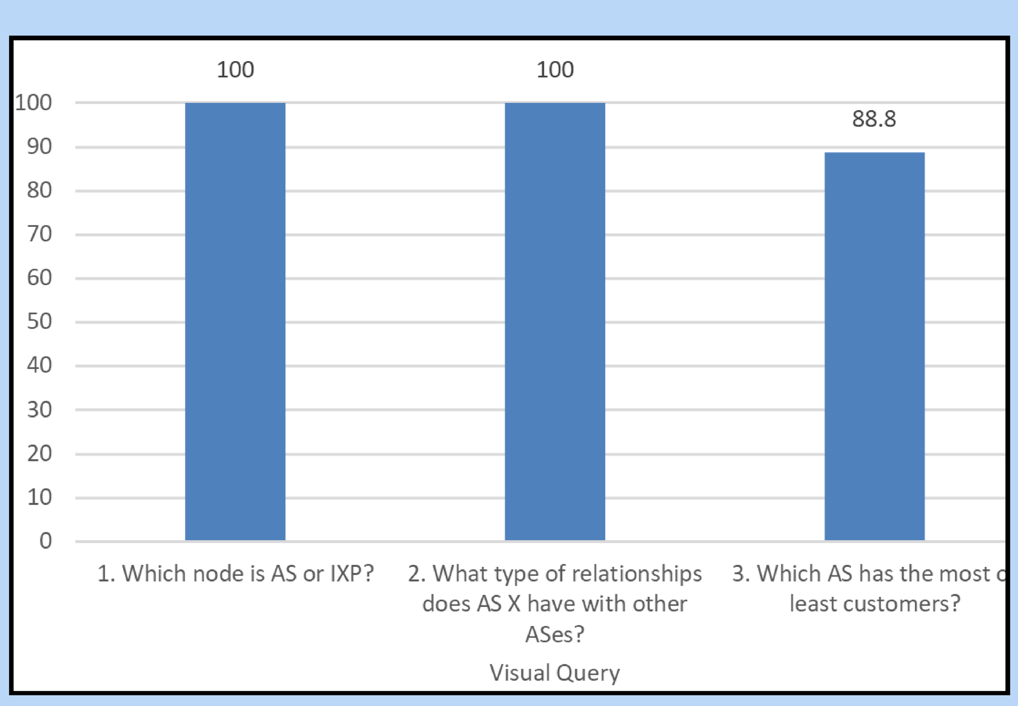
System Architecture

Results

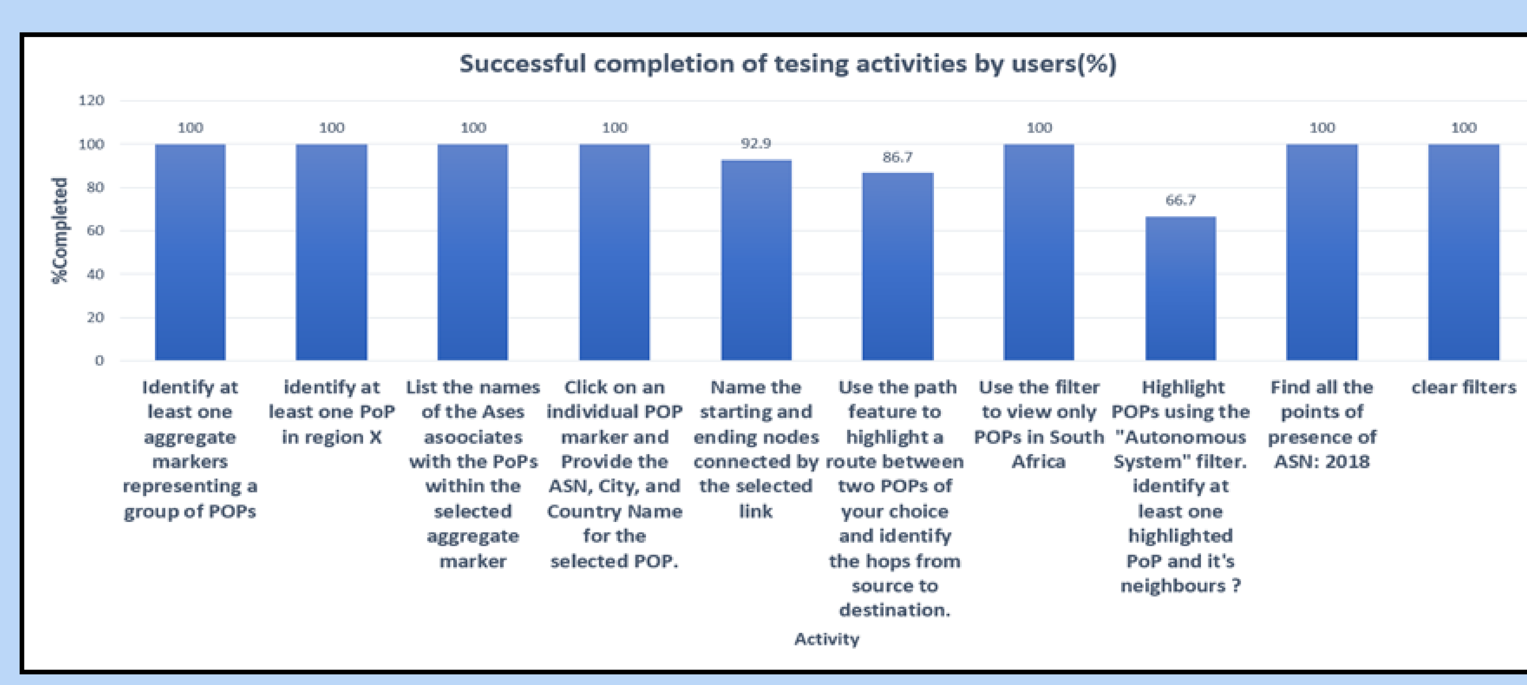
Most users are able to answer questions related to visual queries when interacting with the visualisation tool.

Users are able to tell which node is AS or IXP easily since the nodes have different colours. Another visual query achieved 100% acccuray is identifying the type of relationships for each AS. This is due to the differential colours of relationships.

However, some users are unable to tell which AS has the most or least customers since the sizes of nodes all look similar. This problem can be resolved if participants zoom into the nodes to view their exact sizes, but this is unintuitive.



Accuracy of Visual Queries answered



Usability testing of the topology visualization tool was conducted with experts engaged in computer network research, combining both quantitative and qualitative methodologies. Overall, users, including these experts, found the tool intuitive. They lauded the tool's similarity to other recognized mapping platforms and its user-centric features. The System Usability Scale reaffirmed the tool's usability. While the majority of feedback was positive, there was consensus on the potential for further refinement to improve the user experience.

Conclusion

At AS-level: The visualisation is able to show the interconnections between ISPs and the relationships between ISPs effectively. The results showed that users are able to answer most visual queries successfully but not the visual query that is related to the size of the nodes. This can be improved by increasing the size variants of node which allows the users to differentiate the sizes more easily.

At router-level: We developed a user-friendly tool to visualize the African router topology. An expert validated its accuracy and functionality, while usability assessments highlighted strengths and areas for refinement. The System Usability Scale rated it favorably.

University of Cape Town · iYunivesithi yaseKapa · Universiteit van Kaapstad

Team Members

Elias Sihlangu (shlmag002@myuct.ac.za)

Houston Yu (yxxcha002@myuct.ac.za)

Supervisor

Josiah Chavula (josiah.chavula@uct.ac.za)

Second Reader

Tommie Meyer (tommie.meyer@uct.ac.za)