Mapping the African Internet Topology

Project proposal

Elias Sihlangu
Department of Computer Science
University of Cape Town
Cape Town, South Africa
shlmag002@myuct.ac.za

Houston Yu
Department of Computer Science
University of Cape Town
Cape Town, South Africa
yxxcha002@myuct.ac.za

1. Project Description.

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 [1]. Over the years, researchers have utilized various techniques such as BGP datasets, traceroute measurements, and network simulation to map the internet infrastructure. As a result, several studies have been published on mapping the internet infrastructure in different regions worldwide.

However, despite the various approaches to mapping the internet infrastructure, there is still a need for further research, particularly in Africa. Mapping the internet topology in Africa presents unique challenges due to the continent's diverse geography, limited infrastructure, and the prevalence of mobile networks [3]. Not being able to map the internet topology accurately means that it will be difficult for the network researchers to identify the routes that network traffic traverses between different networks. Therefore, there is a need for a comprehensive overview of mapping the internet topology in Africa that focuses on techniques used to infer and visualize relationships between ISPs across the continent [3] [4].

The primary objective of this research project is to infer and visualize relationships between Internet Service Providers (ISPs) across Africa. By analysing Border Gateway Protocol (BGP) datasets and Traceroute measurements, the general aim of the project is to map the logical paths between networks and countries. Additionally, we will map the physical and logical topology of the African internet infrastructure, including cables and Internet Exchange Points (IXPs), and visualize them on a map.

Project Split

The project comprises two distinct components, designed to provide a comprehensive understanding of the Internet's infrastructure. The first component delves into the intricate interconnections and relationships between Internet Service Providers (ISPs). This entails identifying Internet Exchange Points (IXPs) and peering links that facilitate the exchange of traffic between ISPs. By mapping the Internet topology at the Autonomous System (AS) level, the project aims to generate a logical topology that represents the interplay between various ISPs. Subsequently, this logical topology is visualized on a geographic map, providing an intuitive and informative representation of the underlying network structure.

The second component of the project focuses on mapping the Internet topology at the router level, encompassing routers and the links or cables that interconnect them. To achieve this, the project involves conducting traceroute measurements from multiple vantage points, which helps uncover router IP addresses and their corresponding geolocations. The acquired data is then utilized to create a visualization of routers and their connections.

Overview of 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 policymakers. Through user research, interviews, and surveys, the design team identifies user needs, goals, and tasks to guide prototype development and refinement based on user feedback. The iterative process, involving usability tests with real users and techniques like think-aloud protocols, task analysis, and heuristic evaluations, uncovers issues and areas of confusion. By incorporating these insights, the tool is refined into a more effective, user-friendly product that meets user needs and facilitates a deeper understanding of the complex interconnectivity within the African Internet infrastructure.

2. Problem Statement.

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, that is, routers are visualised as standalone points without any links between the routes, making it difficult to identify the logical paths between regions and countries in the internet topology. In the case of existing AS level topology maps within the African, the visualisations are highly complex 3d hyperbolic spaces making it difficult to identify the relationships between ISPs and Internet exchange points.

2.1 Aims

The following research questions have been established have been established for this research project:

Part A

How can the visualisation of interconnections between ISPs effectively communicate the AS level internet topology of Africa, allowing users to identify ISP, exchange points and peering links, and how the visualisation is able to improve the usability and time to extract useful information?

Part B

How can we accurately visualise the African internet topology at router level such that users are able to identify different routers making up the intra-continental topology, the geographic location of the routers, links/cables between routers, logical paths between regions and countries and ISP/organisations that own/manage the routers. Furthermore, can we improve the usability, accuracy and reliability of the visualisation tool by leveraging user cantered design techniques?

3. Procedures and Methods

3.1 Approach

The project will employ a software engineering approach to develop the topology visualisation tool. Some of the software engineering principles will be used such as requirement analysis which can provide us a clear vision of what to expect from the potential users. Another useful software engineering principle to follow is YAGNI (You ain't gonna need it) which means avoiding unnecessary features. Furthermore, the development process will adhere to software engineering best practices, including modular design, version control, and thorough testing throughout each stage. Collaboration between domain experts, developers, and target users will ensure that the tool meets both technical and usability requirements. User cantered design and human computer interaction principles will also be employed in the design and evaluation of this tool.

As previously mentioned, the project consists of two distinct parts. The first part of the project will attempt to infer and visualise relationships between Internet service providers while the second part of the project seeks to visualise the intra-continental topology at the router level.

3.2 Understanding users and participant selection

In both parts of the project, the crucial first step is identifying target users and gathering their requirements. Users will be involved from the inception of the projection all to the deployment of the tool. To identify target users, we will develop personas of the target users and randomly selecting participants around UCT campus.

Initially an open call to join the study will be made to the UCT community through DSA_research_invitations. The invitation will include a high-level description of the project as well expected outcomes at the convenience of the potential participants. A survey will be developed to help identify participants that best fit the user persona. Those who responded positively to the invitation will be required to respond to the survey. The preferred archetype includes those who have prior experience with topology visualisation tool and/or a topology visualisation tool will have some form of a contribution to their professional and or personal life. Therefore, participants who respond positively to questions such as, "have you interfaced with a topology visualisation tool before?" or "do you anticipate that the MAIT tool will be useful to you in some way?", will be selected. This may include but not limited to IT students, network administrators, researchers and network operators. The rationale behind this selection method is to sample participants who can contribute productively to the development of the topology visualisation tool and have a vested interest.

Once participants have been sampled, they will be invited for interviews and contextual inquiry. During the interviews, participants will be asked various questions to better understand their needs, preferences, and expectations. The questions will be designed to explore prior experiences with topology visualization tools, including specific tasks they have accomplished and challenges they have faced. They will also be asked about the primary tasks they expect to accomplish with the proposed MAIT tool and any specific use cases they envision for it. Furthermore, participants will be asked about their familiarity with various visualization techniques and their preferences for data representation. The interviews will also cover essential features and functionalities that participants believe a topology visualization tool should have to meet their needs effectively.

As part of the contextual enquiry, users will be observed as they interact with current topology visualisation tools, particularly a subset of the topology visualisation tools developed as part of previous honours and capstone projects. As users perform the predetermined set of tasks on the existing visualisation tools, their thought processes, the steps they take to accomplish specific tasks, and any challenges or confusion they encounter will be noted down. The tasks are related to specific use cases. This will include but not limited to, identifying peering links, locations of network components and identifying exchange points. Ultimately this exercise seeks to collect anecdotal data pertaining to how users interact with topology visualisation tools with the intention to extrapolate their needs, challenges they face, features they deem useful, usability pain points etc. Subsequently, these extrapolations will inform the development of the protype.

3.3 Prototyping and Evaluation

The prototype will be developed in accordance with the identified user needs. The presupposition is that prototype(s) will be based primarily on three approaches namely, node-link diagrams (graphs), adjacency matrices and geospatial maps. Node-link diagrams well suited for visualising interconnections between router [6] whereas geospatial maps are better suited for AS level mapping [4]. Anticipated features in prototype include filtering per region, pop-up information cards triggered by clicking on the visualised network components. For example, router level mapping cards will reveal the location of the router, its IP address, etc. In the case of AS level mapping this will include but not limited to the location of the IXP, the ASes connected via the identified IXP etc. The pototype will also support a zoom-in/zoom-out feature to allow fine grained detail as you zoom in and aggregated maps as you zoom out. By observing how users interact with and interpret each representation, we can gain insights into their preferences and the relative effectiveness of each approach. The basic feature that will be included in the initial prototype is allowing the users to visualise the internet topology using a sample of data. The prototype can help determine whether it has met the user needs or it requires more improvements. This means if the prototype is missing some features, they can request for certain features such as a filtering feature where they only want to view a specific region. Discount usability techniques, namely, wizard of Oz and usability heuristics will be used to evaluate the initial prototype. An iterative design process that involves multiple rounds of user feedback and testing, allowing for continuous improvement of the prototype's usability will be adopted.

3.4 Study Design

3.4.1 Evaluation of the topology

In order to evaluate the correctness of the visualised topology, we will rely on the feedback of network community to improve our visualisation tool. The project will incorporate a feedback mechanism where users and internet topology experts can go to a feedback page and provide information on the correctness of the visualised topology. For example, internet topology experts may have identified links that shouldn't exist on the map. By taking in feedback from the experts, we can evaluate whether the topology has been visualised correctly or not.

3.4.2 Data Collection

This project combines both quantitative and qualitative research methods to collect data on user behaviours, preferences, experiences, and interactions with the topology visualisation tool.

3.4.2.1 Quantitative data collection

This will entail designing and administering a structured survey or questionnaire to collect numerical data on the user preferences, behaviours and interactions with the tool during the prototyping phase. The users will take the survey or questionnaire after using the initial prototype to give us insight about their interactions with the visualisation tool. This will include data from surveys on the usability, effectiveness and time efficiency of the topology visualisation tool. The following is a subset of questions that may be part of the qualitative study:

- How long did it take for you to complete a specific task using the topology visualization tool? (Time in seconds/minutes). Measuring task completion time can help assess the efficiency of the tool, indicating whether users can quickly and effectively achieve their goals.
- How many attempts did it take for you to successfully identify an Internet Exchange Point (IXP) or a peering link in the visualization? (Number of attempts). Tracking the number of attempts can help determine the tool's ease of use and intuitiveness,

highlighting potential areas for improvement in the visualization or interface design.
- How many navigation actions (clicks, scrolls, etc.) were required to complete a specific task using the tool? (Number of actions). Analysing the number of navigation actions can provide insights into the tool's usability and efficiency, identifying potential bottlenecks or issues with the user interface that could be optimized.
- How many errors or incorrect selections did you make while trying to locate a specific ISP, IXP, or peering link? (Number of errors). Monitoring the number of errors or incorrect selections can help gauge the tool's accuracy and clarity, revealing possible areas of confusion or ambiguity that may require additional explanation or refinement.

3.4.2.2 Qualitative data collection

The qualitative study will entail exploring and understanding the experiences, perceptions, and preferences of the target users when interacting with the internet topology visualization tool. The qualitative study would focus on gaining insights into how users make sense of the tool, how it meets their needs, and any challenges they face while using it.

Participants will be asked to perform activities while thinking aloud. Then observational data pertaining to how users interact with the tool is collected.

Sample activities for users:

- Is there a path between region A and region B?
- Identify the possible hops between city A and city B?
- In what region is a certain router located?
- What is the IP address of a certain router?

By asking users to perform these activities and think aloud, we will be able to gain valuable insights into the users' thought processes. Ultimately this makes it possible to gauge how well the usage of the topology visualisation tool answers the research questions.

The combination of quantitative and qualitative data can provide a more comprehensive understanding of a research question, offering richer insights and a more nuanced perspective than either approach alone. The quantitative data can provide measurable metrics about the tool's performance, such as task completion times, error rates, or user satisfaction scores. While quantitative data can highlight trends and patterns in user behaviour, qualitative data can provide context and explanations for these patterns.

3.5 System Implementation details

3.5.1 Inferring relationships between ISPs

In inferring relationships between ISPs and visualising the AS level topology, the following technical approach is proposed:

Identifying ISPs/ASes

To clearly identify ISPs and ASes, BGP datasets that contain AS numbers and will be analysed (See Figure 2). BGP datasets can be sourced from various public repositories, such as RouteViews or RIPE RIS, providing valuable information about each AS such as the size of AS (number of IP addresses) and which tier does the AS belong to. It can also provide information about the relationships and interconnectivity between ASes.

Internet Exchange Points and Peering links

To identify ASes that share traffic through the same IXPs and peering links, the tool will use a combination of network probing techniques, such as traceroute measurements, and BGP datasets. These approaches help uncover important information about the physical locations where ISPs exchange traffic and whether they have some kind of relationships such as customer-provider or peer-peer relationships.

Geolocating the Exchange Points

Geolocating IXPs requires using a geolocation database, such as MaxMind or RIPE Atlas, which will be used to store geographic coordinates for IP addresses associated with the IXPs. Additional research into other geolocation databases may also be conducted to ensure accuracy and comprehensiveness.

Pinning the AS, IXP, and Peer-to-Peer links

With the geolocation data gathered, the tool will use a mapping API, such as Google Maps or OpenStreetMap, to pin the geolocations of ASes, IXPs, and peering links onto a digital geographic map of Africa.

Visualising the geolocations of AS,IXP and Peer-to-peer links

Different types of visualisations will be explored to identify the one that is most useful and appealing. For example, ASes can be visualised as binary trees where a group of nodes can represent an AS and links represent the relationships between them. Another example is visualising AS and IXPs on a geographic map as nodes and showing the links between them. The exact type of visualization can be determined during the prototyping phase where we will co-design with users and incorporate their requirements in the design of the visualisations. This visualization will be used to provide an intuitive and informative representation of the complex interconnectivity within the African Internet infrastructure.

3.5.2 Visualising the logical and physical topology

Network Discovery

To obtain router IP addresses, periodic traceroute measurements will be performed with the help of the RIPE Atlas tool. The measurements will be run from multiple vantage points to discover as many routers as possible and endure high coverage of the African internet topology. as shown in figure 3 (see Appendix).

The Internet is a complex mesh of interconnected networks, and the routing paths between two points can differ based on the source and destination locations. By using multiple vantage points, you can obtain a more accurate and comprehensive view of the network paths and topology [2][4].

Router Geolocation Discovery

The next step involves geographically locating the discovered routers. RIPE Atlas has a an API that accepts router IP addresses and returns the associated location, that is, latitude, longitude and city location.

Data Storage

The processed data, including router IP addresses, geographic locations, and connections, will be stored in a database. This will allow for efficient retrieval and manipulation of the data during visualization and analysis.

Build a router Graph

The backend implementation of the topology visualisation tool will include a graph representation of the router-level topology by treating routers as nodes and router interfaces as pointers. This information is stored in a graph data structure, and the NetworkJs Library is used to facilitate the creation and manipulation of the graph. Generally, graphs are well suited for representing interconnections [6]

Visualising the Router level topology

The type of visualisation that will be employed will be determined through co-design with users during the prototyping phase. However, the presupposition prior to collecting user requirements and needs is that the router-level interconections will be visualized using the Google Maps API. This API enables the overlay of the router-level topology onto a geographic map, creating an intuitive and informative representation of the internet infrastructure in Africa. By combining all these elements, the visualization tool provides users with a comprehensive view of the router-level internet topology, aiding in the analysis and understanding of the African internet landscape.

3.5.5 Expected challenges

See the design challenges in 6.3 section.

4. Ethical, Professional and Legal Issues

Mapping the African internet topology has several ethical, professional, legal, and societal implications that must be carefully considered. Addressing the digital gap is crucial from an ethical perspective. It is essential to make sure that the study findings and the topological visualization tool do not contribute significantly to the digital divide. The tool must be developed with an emphasis on inclusion, taking into consideration the varied requirements and settings of African nations, with the project's goal being to promote equitable access to information and resources. These ideals must be reflected in the design, functionality and distribution of the topology visualisation tool.

Moreover, it is crucial to emphasize the responsible use of the topology visualisation tool. The topology visualization tool has the potential to be used for both beneficial and harmful purposes, such as facilitating attacks to the internet infrastructure or exposing sensitive network information. Encouraging responsible use and implementing safeguards to prevent misuse are vital aspects of the project.

In order to accomplish this, it is necessary to continuously assess potential risks associated with the tool and devise strategies to mitigate them. This involves engaging in open dialogue with stakeholders, including the project supervisor, to identify possible vulnerabilities and areas of concern. By fostering a culture of collaboration and transparency, the project can work towards striking the right balance between harnessing the tool's benefits and minimizing the risks associated with its use. Additionally, the project must actively develop and promote educational resources, such as guidelines and training materials, to ensure users understand the ethical and responsible use of the topology visualization tool.

Furthermore, since the user centred design approach requires the involvement of human subjects, informed consent, privacy protection, and participants' well-being must be prioritized. Practically, adequate time and resources must be allocated to engaging a diverse range of users, to ensure a representative sample. Methodologically, appropriate data collection methods, such as interviews, surveys, and usability testing, should be employed, alongside triangulation of data sources for a comprehensive understanding of users' needs. As per departmental guidelines, an ethics clearance from the university's ethics committee/board will be required.

From a legal perspective, key considerations include privacy and data protection. The project will involve the collection, analysis, and visualization of data related to internet infrastructure, which may include sensitive information or have privacy implications for individuals and organizations. Ensuring that the data is collected, stored, and processed in compliance with relevant data protection regulations such as the POPI Act and industry best practices is crucial. Anonymizing data where possible is essential.

5. Related Work

Yang et al. [2016] introduced a topology visualisation tool called NetVizura to visualise the Network topology of National research and Education Networks (NREN) in Africa using traceroute data. This work adopted a user centered design approach where usability tests were conducted by recruiting human participants to assess the accuracy and the effectiveness of the visualisation. The visualisation shows traceroute information of all IP addresses to which traceroutes were sent on a map. The design of visualisation also allows multiple traceroutes to be sent from different vantage points which can be viewed on a map. It also displays the locations of the internet exchange points and the placement of fibre around Africa continent [5].

Many visualisation tools were developed to map the internet topology of Africa, but most of them do not effectively communicate the interconnections in the African internet topology and are too complex to identify the relationships between internet exchange points and autonomous systems. In the work by Gilmore et. al. [2007], uses the data collected from traceroute measurements and BGP datasets to generate router level and AS level maps. At router level, a java-based tool, Terrapix, was designed specifically to produce router level maps, where 2D and 3D visualisations were used to map nodes and links to geographic locations. At AS level, Walrus tool created by CAIRA was used to display AS level structure of the African internet topology in a 3D space [4]. The accuracy of the 3D visualisations is questionable since they look complex, and it is difficult to identify the AS level relationships between ASes.

6. Anticipated Outcomes

6.1 System

The project is expected to develop a web application where users can interactively explore the visualisations of the network structure in Africa based on the data collected from traceroute measurements and BGP dataset.

6.2 Key features

The newly developed web application will access a geolocation database for geographic locations of ISPs, IXPs and routers to render the visualisations. The visualisations will show the interconnections and relationships between ISPs across the African continent. The users can view the logical and physical topology of African internet at AS level and router level. For the router level, the nodes will be represented as routers while links represent the physical cables connecting the routers. The users will also be able to interact with the visualisations such as filtering by selecting specific ISPs. Another key feature is that the visualisations will constantly be updated after a certain period. This is done by fetching data from other data sources and use these data to update the visualisations.

6.3 Design challenges

Some organisations have more than one router in the same address range. This may result in many hops returned by the traceroute measurements. Visualise all these hops on a map proves to be a challenge. Pinning all of them on map lead to information overload. There must be a way to aggregate routers within same address range and represent them as single data point on a map. The big question is, how can we leverage software engineering techniques to visualise extensive data points on limited space?

To successfully visualise the router network on a map, some form of a graph representation of the routers is needed. The routers are represented as nodes in the graph and the links between the routers are represented as pointer. Building this graph representation from traceroute data proves to be a challenge. Presumably, to achieve this, the trace route data must be stored in some database such that each database entry relates to a single source router and each entry stores the next hop associated with the source. At a high level, mesh could be achieved by performing the operation recursively.

Another design challenges pertain to filtering private IP addresses. Network discovery with traceroute often returns private IP addresses. Since project is concerned with visualising the public internet topology, it is necessary to drop private IP addresses.

6.4 Expected impact

The expected impact of the project is that users such as network administrators, researchers and policymakers will be able to use the visualisation tool to infer the interconnections and the relationships between ISPs across Africa easily. The visualisation tool is expected to effectively communicate the logical and physical routes between networks and countries in the African internet topology.

6.5 Success factors

The success of the visualisation tool can be determined by the accuracy of the collected data (Traceroute measurements) and . The accuracy of the collected data can be measured based on comparisons with other traceroute tools, particularly the tool developed by Gilmore et al[4] and as well as the tool developed as part of former honours and capstone projects. The second success factor is the correctness of the topology. The topology will be evaluated by experts to ensure that the visualisation of topology is correct. The usability of the visualisation will also be evaluated by experts to ensure that all the basic requirements are met and any issues with the visualisation are resolved. Another success factor is the robustness of the system. It can be tested to see whether the system can recover from any errors or bugs.

7. Project Plan

7.1 Risk Management plan

See Table 1 in Appendix.

7.2 Timeline

See Figure 1 in Appendix.

7.3 Resources

7.3.1 Software

The software, RIPE ATLAS, is used for the collection of traceroute measurements and to discover the ISPs and IXPs. RIPE ATLAS can be accessed using the credits given to us by our supervisor. Database management system is required to store data such as the locations of the AS, routers and internet exchange points (MongoDB). A javascript library (NetworkJS) will be used to construct router mesh. RIPE ATLAS API is used for the geolocation of the routers and internet exchange points. Visualisation software such as Google Map API is required to visualise the ISPs, IXPs and routers on a physical map. A free and open-source software is also required to develop and host the web application and the visualisations. The tool will be implemented as a web application. ReactJs is the framework of choice for front end development and NodeJs will be employed for backend development.

7.3.2 Hardware

This project requires each team member to have access to their own laptops that are connected to the internet. The computers in the UCT Computer Science Honours lab can also be used for the development of the project.

7.3.3 Data

Traceroute data can be collected by running traceroute on the RIPE ATLAS platform. BGP datasets are provided by our supervisor and the datasets can also be accessed from public repositories.

7.3.4 Humans

This project will also recruit several human participants for usability evaluation. The human participants will need to have sufficient knowledge of networks to participate in user testing of the accuracy and effectiveness of visualisations. Usability heuristics expert can also participate in the user testing and evaluation so they can provide useful tips on improving the visualisation.

7.4 Deliverables

See Table 2 in Appendix.

7.5 Milestones

Part A – Inferring the relationships between ISPs (AS level relationships between ISPS)

1. Use the BGP dataset which include AS numbers to identify ISP/AS
2. Use RIPE with the BGP dataset to infer the interconnections between the ISP and identify the locations of the internet exchange points.
3. Store the locations of the internet exchange points in a database.
4. Traverse through the internet exchange point to identify the ISPs that are connecting to it.
5. Use the data stored in the database to build a mesh.
6. Use Map API such as google map to visualise the AS and IXP on a digital map.

Part B – Visualising the logical and physical topology (Router level mesh)

1. Identify Target Routers.
2. Retrieve measurement data from the database and build router mesh.
3. Filter out private IP addresses

4. Geographically Locate the routers
5. Implement the graph representation of the interconnections between routers
6. Identify the type of links/cables connecting the routers.
7. Visualising the Router level Mesh on a digital map
8. Implement filtering per region and zoom feature.

7.6 Work Allocation

The allocation of work between project team members will be shown in the Gantt chart.

References

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Appendix

Rank	Risk	Likelihood	Impact	Mitigation	Control	Management
1	Load shedding leads to project delays	High	High	Ensure that allocated work is done before load shedding	Check the load shedding schedules frequently	Ensure that the incomplete work is done as soon as possible after load shedding
2	Communication issues between team members or supervisor	Medium	Medium	Schedule regular meetings every week to discuss the project	Check if the team members or supervisor are available for the meetings	Arrange another meeting to make up for the ones that we can't attend
3	User expectations not met regarding the resulting visualisation	Low	Medium	Write an unambiguous and a well-defined project proposal	Check if all the tasks are clearly listed in the project proposal	Make changes to the visualisations based on user feedback
4	Poor visualisations due to inexperience in respective fields	Low	Medium	Use well known visualisation tools to avoid poor visualisations	Check if the software that will be used for visualisation have all the necessary features	Consult supervisor and users for improvements
5	Scope creep leads to poor time management	Medium	Medium	Do not add new features to the project until the basic features are working correctly	Check if the deadlines can be met for the project	Revaluate the scope of the project and remove unnecessary features
6	Loss or corruption of datasets	Low	Medium	Ensure that there are copies of the datasets for backup	Check if the datasets can be opened	Use the backup datasets
7	Encountering bugs when coding	Low	Low	Debug and test the code frequently	Check the quality of the code	Edit or remove the problematic code to ensure that the programs can run successfully

Table 1: Risk assessment table

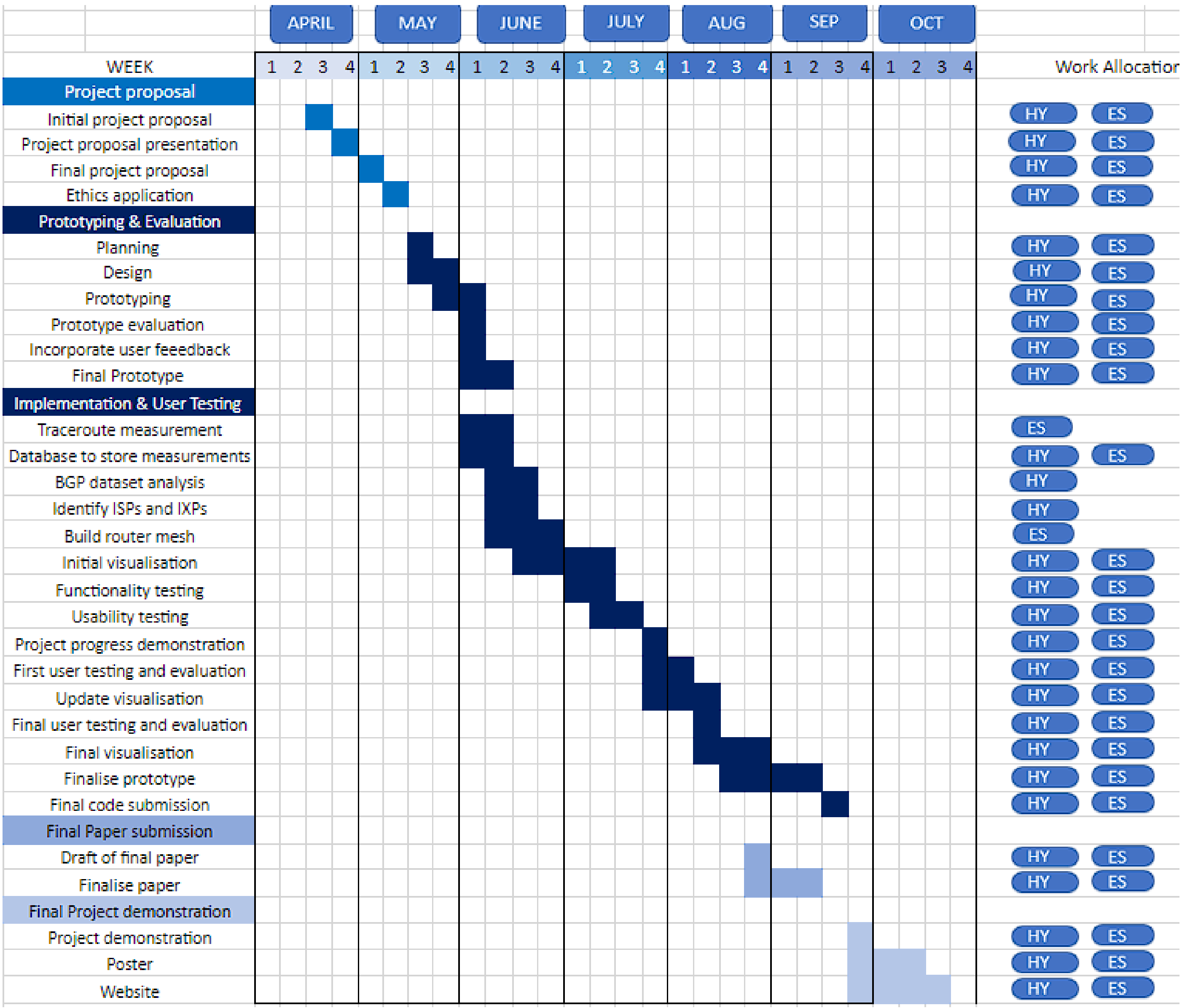

Figure 1. Gantt Chart showing project timeline

Deliverables	Due Date
Initial project proposal	24 April 2023
Project proposal presentation	28 April 2023
Revised project proposal	2 May 2023
Ethics application	12 May 2023
Initial Prototype	31 May 2023
Prototype evaluation	4 June 2023
Final Prototype	14 June 2023
System implementation	30 June 2023
Initial Visualisation tool	7 July 2023
User test plans	16 July 2023
Final Visualisation tool	25 August 2023
Draft of final paper	28 August 2023
Final paper submission	11 September 2023
Final code submission	15 September 2023
Final project demonstration	29 September 2023
Project poster	9 October 2023
Project website	16 October 2023

Table 2. Deliverables for MAIT project

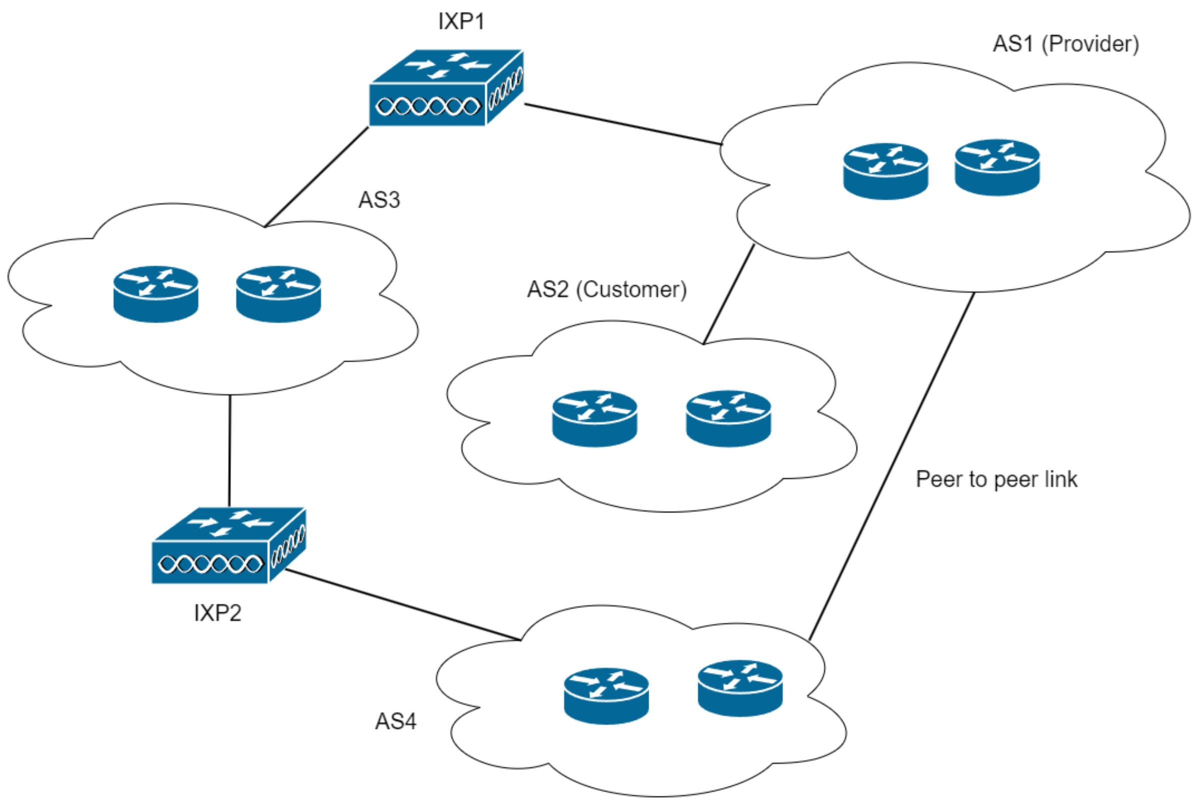

Figure 2. Relationships between ISPs at AS level

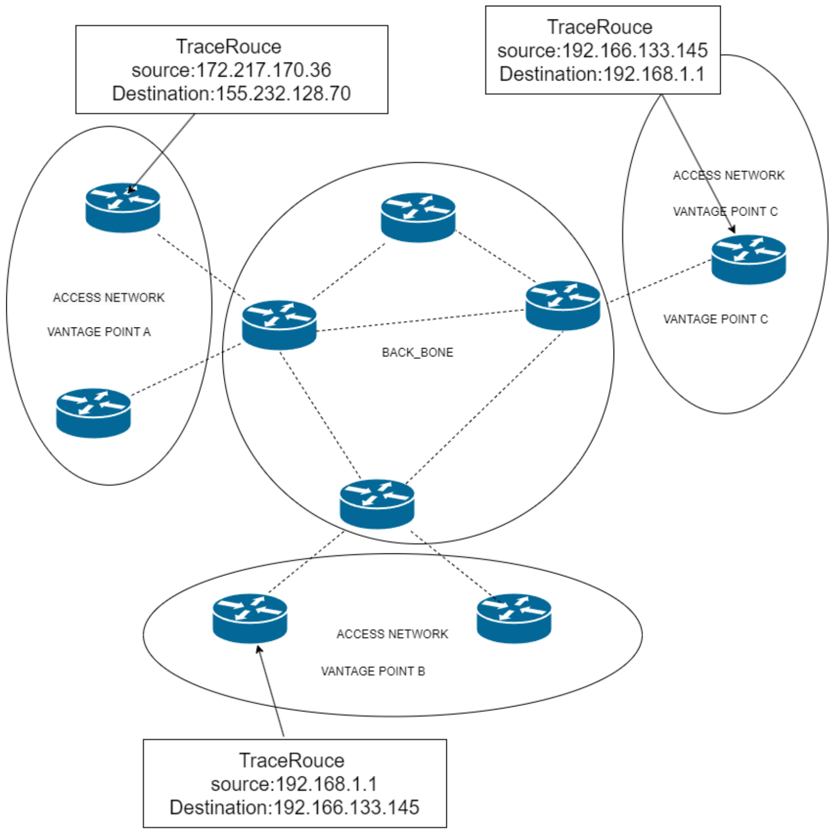

Figure 3. Traceroute Measurement