



# Google Summer of Code

Proposal - Google Summer of Code 2024

## Network Topology Overview



### Internet Health Report

Project Proposed  
By  
**Utkarsh Singh**

---

## ABOUT ME

<b>Name</b>	Utkarsh Singh
<b>Email</b>	f20220844@goa.bits-pilani.ac.in
<b>Github</b>	<a href="#">OxAnon0602</a>
<b>Linkedin</b>	<a href="#">linkedin.com/in/Oxanon0602</a>
<b>College</b>	Bits Pilani K.K. Birla Goa Campus
<b>Timezone</b>	India (+5:30 UTC)
<b>Resume</b>	<a href="#">Resume</a>

I am currently a sophomore studying **Chemical Engineering** at **BITS Pilani K.K. Birla Goa** Campus in India. For the past 2 years, I have been passionate about contributing to open-source projects. During this time, I have developed my skills and gained valuable experience through various hackathons and open-source programs. Coding has been a significant part of my life for the last 3 years, and I truly enjoy the process of writing code and making meaningful contributions through pull requests.

For the past couple of months, I have been actively involved in exploring and contributing to the Internet Health Report. This experience has been enriching, and I am now eager to take my contributions to the next level by participating in Google Summer of Code 2024. My goal is to delve deeper into this project and make a substantial impact.

---

## ABSTRACT

The project focuses on improving the visual representation of network connectivity for **Autonomous Systems (AS)**. It makes use of the extensive data available from the **Internet Yellow Pages (IYP)**. The goal is to provide a clearer and more detailed understanding of the complex connections and relationships within the network infrastructure. By incorporating IYP's comprehensive dataset, the project aims researchers, and other stakeholders, enabling better analysis and comprehension of the network. to offer valuable insights into the topology and behaviour of the internet's backbone. This information can be beneficial for network administrators. This information can be beneficial for network administrators, researchers, and other stakeholders, enabling better analysis and comprehension of the network.

The project size will be **175 hours**.

---

## TECHNICAL DETAILS

Technologies and libraries which will be used in the project are listed below

- a) [Vue-Flow](#) will be used to make customizable Vue 3 component to integrate graphs to the website.
- b) [Internet Yellow Pages](#) will be used to retrieve detailed data about the Autonomous Systems (AS).

For the next part of this proposal **AS 55836** will be the standard for all forthcoming demonstrations, providing a concrete example for the project's data visualization and interaction functionalities.

---

# IMPLEMENTATION

The implementation of the project is structured around two fundamental components:

- a) **Gathering Data from the Internet Yellow Pages (IYP):** The first step involves meticulously gathering accurate data regarding the connections between Autonomous Systems (AS) from the IYP. This phase focuses on identifying and extracting the necessary details that are critical for mapping out the network connectivity.
- b) **Visualization on the Website:** With the foundational data acquired, the second component is centered around the development and integration of visualization tools on the website. This stage aims to translate the complex AS connections data into intuitive, interactive, and informative visual representations. By employing advanced visualization techniques and technologies, the project seeks to enable users to explore and understand the network's structure and dynamics easily.

Together, these two components form the core of the project, each playing a crucial role in achieving the goal of enhancing the visibility and comprehension of network connectivity through sophisticated data analysis and visualization techniques.

## Gathering Data from the Internet Yellow Pages (IYP)

We will retrieve data from the Internet Yellow Pages (IYP)'s Neo4j database using **Cypher queries**. These queries are essential for accurately and efficiently gathering information on Autonomous Systems (AS) connections. Selecting and executing the right queries is crucial to securing a detailed dataset that will form the foundation for the project's visualization component.

Below, we outline the Cypher queries chosen for this project

## 1) Cypher Query for Identifying Dependency Relationships Among AS

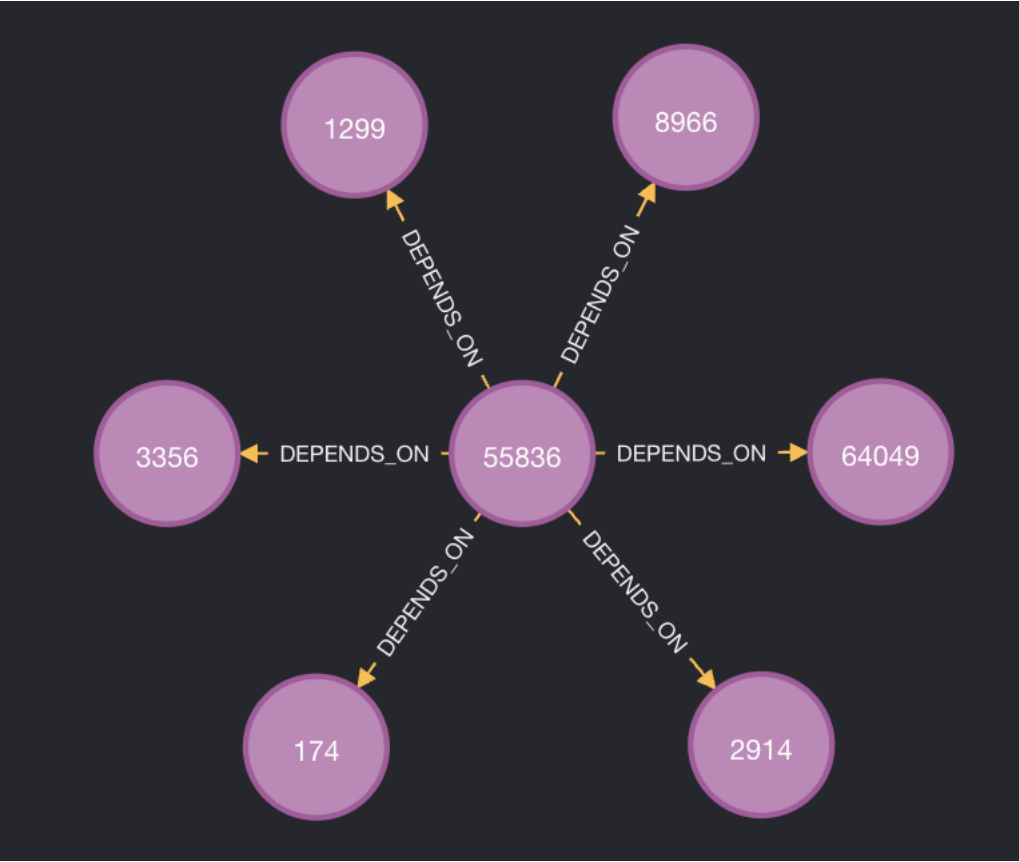
Query:

```
MATCH (a:AS {asn:55836})-[d:DEPENDS_ON {af:4}]-> (b:AS)
WHERE a < b
RETURN a.asn AS ASN1, d.hege*100 AS HEGE, b.asn AS ASN2
```

Result:

ASN1	HEGE	ASN2
55836	1.5888844229487002	2914
55836	100.0	64049
55836	0.00011908315497323001	8966
55836	7.17851431059908	1299
55836	5.12785917752129	3356
55836	13.9823029138933	174

**Graph :**



**Interpretation from above Result and Graph:**

The data analysis and graph generated from the query reveal the dependency relationships of AS 55836. It highlights the various AS entities that AS 55836 relies on to maintain connectivity. Moreover, the integration of hegemony percentages into the data provides understanding of the extent to which AS 55836 is reliant on each specific AS.

**AS 55836 Dependencies with their Hegemony -**

AS	Hegemony(%)
3356	5.127
1299	7.178
174	13.982
8966	0.0001
64049	100
2914	1.588

## 2) Cypher Query for Detailed Insights on Dependent AS

### Query:

```
MATCH (a:AS)
WHERE a.asn in [3356,1299,174,8966,64049,2914,55836]
OPTIONAL MATCH (a)-[:NAME {reference_org:'PeeringDB'}]-(pdbn:Name)
OPTIONAL MATCH (a)-[:NAME {reference_org:'BGP.Tools'}]-(btn:Name)
OPTIONAL MATCH (a)-[:NAME {reference_org:'RIPE NCC'}]-(ripen:Name)
OPTIONAL MATCH (a)-[:NAME]-(n:Name)
OPTIONAL MATCH (a)-[:MEMBER_OF]-(ixp:IXP)-[:COUNTRY]-(ixp_country:Country)
OPTIONAL MATCH (a)-[:COUNTRY {reference_name: 'nro.delegated_stats'}]-(c:Country)
RETURN a.asn AS ASN ,c.country_code AS CC, c.name AS Country, COALESCE(pdbn.name, btn.name, ripen.name) AS Name, count(DISTINCT ixp) as nb_ixp
```

### Result:

ASN	CC	Country	Name	nb_ixp
174	"US"	"United States of America"	"Cogent Communications"	7
1299	"SE"	"Sweden"	"Arelion (fka. Telia Carrier)"	5
2914	"US"	"United States of America"	"NTT Global IP Network"	17
3356	"US"	"United States of America"	"Lumen AS3356"	8
8966	"AE"	"United Arab Emirates"	"Etisalat"	29
55836	"IN"	"India"	"Reliance Jio Infocomm Limited"	3
64049	"SG"	"Singapore"	"Reliance Jio Infocomm Singapore"	17

### Interpretation from above Result:

The analysis derived from the query results provides an in-depth information of the AS on which AS 55836 is dependent. It furnishes detailed information about each dependent AS, encapsulating its name, the country of origin, and the corresponding country code (CC).

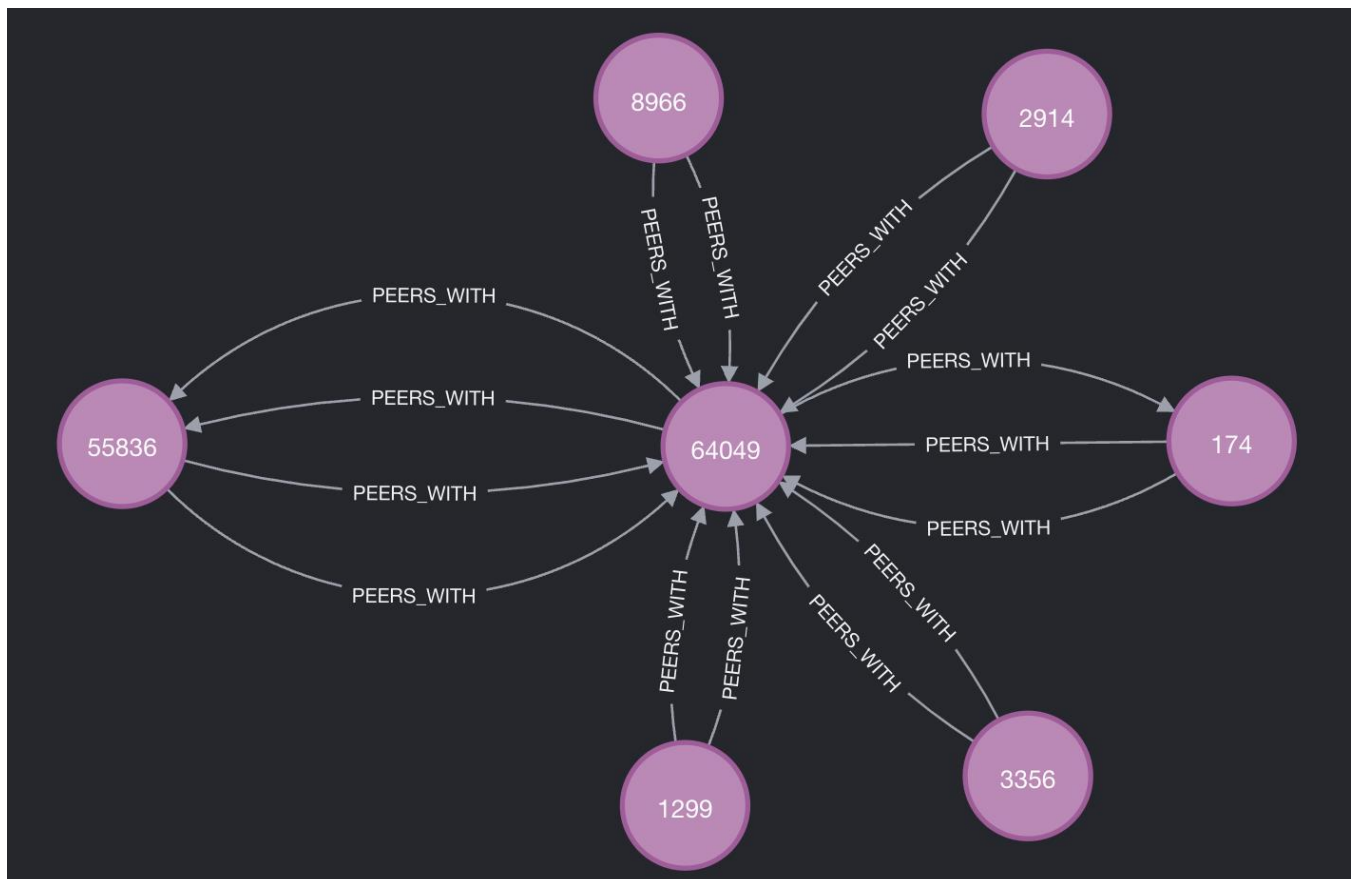
### 3) Cypher Query for Mapping Connections to the Target AS

Query:

```
MATCH (a:AS {asn:55836})-[h:DEPENDS_ON {af:4}]->(d:AS)
WITH a, COLLECT(DISTINCT d) AS dependencies
UNWIND dependencies as d
MATCH p = allShortestPaths((a)-[:PEERS_WITH*]-(d))
WHERE a.asn <> d.asn AND all(r IN relationships(p) WHERE r.af = 4) AND all(n IN nodes(p) WHERE n IN dependencies)
RETURN p
```

Thanks to [Romain](#) for his invaluable assistance in addressing this query.

Graph:





## Interpretation from above Graph:

The interpretation of the graph indicates a detailed visualization of how the dependent AS interconnect among themselves and ultimately link to the primary AS, AS 55836, through the "PEER\_WITH" relationship within the Neo4j database. The visual analysis reveals not only the direct dependencies but also the complex web of inter-AS relationships that ensure network robustness and redundancy. Such insights are invaluable for understanding the network's operational dynamics, facilitating strategic planning for network expansion, resilience enhancement, and optimization of data flow paths to ensure efficient and reliable connectivity.

## Visualization on the website

In this section, we will leverage the data retrieved from the IYP Neo4j database above to present it to users in a more accessible and visually appealing format. The objective is to transform the complex and detailed information about AS and their connections into intuitive, interactive visual representations that can be easily understood by both technical and non-technical audiences.

### 1) Getting the data on the website

For this part, the **IYP API** plugin from our existing codebase will be used, facilitating precise querying and the retrieval of network data.

```
/// Base url for api
const IYP_API_BASE = 'https://iyp.iijlab.net/iyp/db/neo4j/tx/'
/// default timeout before api call are considered failed
const DEFAULT_TIMEOUT = 180000

const IypApi = {
  install: (app, options) => {
    const axios_base = axios.create({
      baseURL: IYP_API_BASE,
      timeout: DEFAULT_TIMEOUT,
    })

    const run = async (queries) => {
      const storageAllowed = JSON.parse(localStorage.getItem('storage-allowed'))
      let response = await cache(JSON.stringify(queries), () => {
        return axios_base.post('', {
          statements: queries
        })
      })
      const rows = response.data.results
      const res = []
      for (let i=0; i<rows.length; i++) {
        res.push(formatResponse(rows[i]))
      }
      return res
    }

    const formatResponse = (results) => {
    }

    const iyp_api = {
      run,
    }

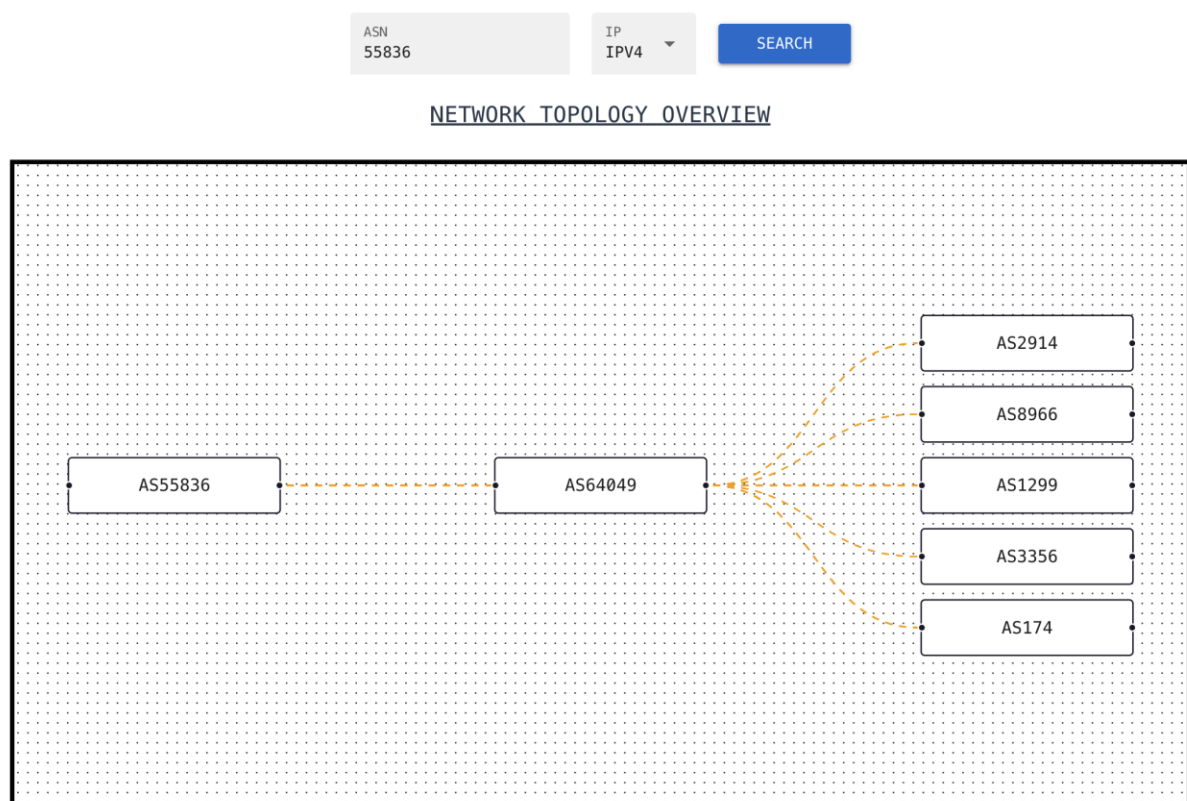
    app.provide('iyp_api', iyp_api)
  }
}
```

## 2) Creating a Vue3 component using Vue-Flow for visualization

For this segment , I have created a prototype using Vue3 in conjunction with the Vue-Flow library . Using this prototype, I will provide a comprehensive demonstration of the Vue-Flow library's capabilities. This practical example will serve as a foundation for a detailed exploration into the application of Vue-Flow within our project, focusing on its ability to facilitate dynamic and interactive visualizations of complex network data.

The prototype is live and available [here](#).  
Github Repo for the code is available [here](#).

### Basic overview of the prototype:



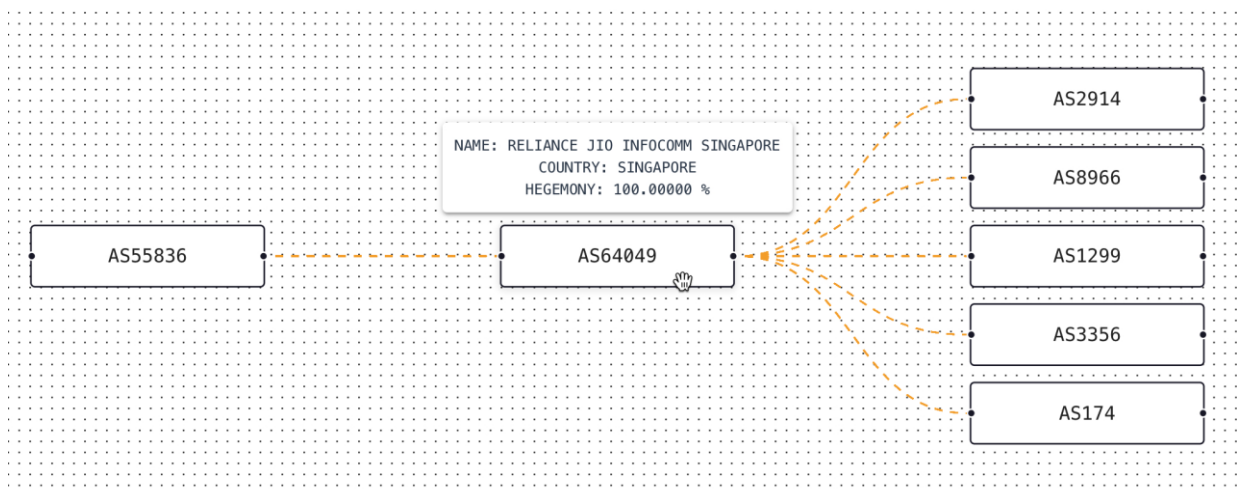
This is the basic version of the project designed to offer users the capability to select an ASN and its corresponding IP version. Upon selection, the system generates a visualization, albeit in a rudimentary form, to depict the network's structure and connections.

## Nodes and Edges in Vue-Flow Library:



In the image provided above , the ASNs are represented as nodes within the Vue-Flow library framework. The connection, or relationship, between these ASNs is articulated through the connecting edge, demonstrating the interactive capacity of Vue-Flow to map and display network linkages.

## Hover effects on the Nodes to show detailed information



The interactive design of the Vue-Flow library is exemplified by the hover effects on the nodes, which are used to reveal detailed information about the ASNs which include its **Name**, **Country of Origin** And **Hegemony** ( Inter-dependence on main ASN ).

```

✓ onNodeMouseEnter(({ node }) => {
  |   node.data.toolbarVisible = true;
  | }
  | )

✓ onNodeMouseLeave(({ node }) => {
  |   node.data.toolbarVisible = false;
  | }
  | )

```

The hover functionality demonstrated above is made possible through the integration of two specific libraries within the Vue-Flow framework:

### 1) NodeToolbar from @vue-flow/node-toolbar:

This library provides a set of tools that enable the addition of a toolbar or other custom overlays to nodes.

### 2) onNodeMouseEnter and onNodeMouseLeave functions from @vue-flow/core:

These functions are essential for creating responsive interactions within the flow diagram. They allow for the customization of node behaviour on mouse events, such as displaying detailed information when a user hovers over a node (onNodeMouseEnter) and hiding this information when the mouse leaves the node (onNodeMouseLeave).

## Click effects on the Nodes

```

onNodeClick(({ node }) => {
  |   asn.value = node.id
  |   searchASN()
  | })

```

The click functionality within the Vue-Flow visualization adds a layer of interactivity to the user experience. Upon clicking on a node that represents an ASN, the user is seamlessly redirected to the same graph of that specific ASN.

## Customization

As this is currently a prototype version of the main project, customization has been kept to a minimum. However, the Vue-Flow library offers extensive functionalities to tailor each element, including nodes and edges, to meet specific requirements and integrate seamlessly with the website's design.

A prime example of such customization is the ability to modify node sizes based on their Hegemony percentage. Nodes with lower Hegemony can be made smaller, visually representing their lesser degree of dependence within the network. Conversely, nodes with higher hierarchy scores are displayed as larger, highlighting their critical role and greater level of dependence. This visual differentiation not only enhances the user experience by making the data more accessible and intuitive but also adds a layer of analytical depth to the visualization, allowing users to quickly ascertain the relative importance and interdependence of nodes within the network.

Further enhancing this customization, we can also differentiate the main AS as well as those ASes that are one hop or two hops away, using distinct colour schemes. This approach allows for a clearer visual distinction of the network's hierarchy and connectivity layers. By assigning specific colours to represent the main AS, and varying shades or entirely different colours for ASes one hop and two hops away, we significantly improve the visual comprehension of the network's structure.

---

## EXTENDED GOALS

Once the project's primary goals are met, I plan to create a visualization to explore the connections between countries, single prefixes, and ASNs. This visualization will aim to present these relationships clearly and concisely.

For example we can use the following query to get the country's top 10 ASes-

Query:

```
MATCH (a)-[c:COUNTRY {reference_org:'RIPE NCC'}]-(:Country {country_code:'JP'})
MATCH (a:AS)-[ra:RANK {reference_name:"ihr.country_dependency"}]->(r:Ranking)-(:Country {country_code:'JP'})
WHERE ra.rank < 10
OPTIONAL MATCH (a)-[:NAME {reference_org:"BGP.Tools"}]-(:Name)
RETURN DISTINCT a.asn as ASN, n.name AS AS_Name
ORDER BY a.asn
```

Result:

ASN	AS_Name
2497	"Internet Initiative Japan Inc."
2516	"KDDI CORPORATION"
2907	"Science Information Network"
4713	"NTT Communications Corporation"
9605	"NTT DOCOMO, INC."
9824	"JCOM Co., Ltd."
17676	"SoftBank Corp."

## Interpretation from above Result:

This analysis gives a comprehensive look at the top 10 Autonomous Systems (ASes) that handle internet traffic in Japan. This data is crucial for comprehending the foundation of Japan's internet infrastructure. It reveals the major players controlling most of the data movement inside the nation.

---

## DOCUMENTATION

Once the project is finished, I will concentrate on creating thorough documentation. This documentation will cover key technical aspects like Cypher queries and the Vue-flow library in detail, ensuring a thorough understanding of the project's technical implementation.

---

## TIMELINE

### Community Bonding period ( May 1 – May 26 ):

- a) Get familiar with the codebase.
- b) Fix any issues encountered in the codebase during this period.
- c) Collaborate with mentors and optimize the Cypher query for improved performance.

### Coding Period ( May 27 – Jun 16 ):

- a) Create the foundational Vue 3 component for basic visualization.
- b) Implement data retrieval from the IYP database using Cypher queries.
- c) Begin integration of the Vue-Flow library.

### **Coding Period ( June 17 – July 7):**

- a) Refine and format the data from IYP to use it with Vue-Flow.
- b) Using the formatted data to create basic visualization
- c) Start preliminary testing and take review of the component from mentors.

### **Midterm Evaluation ( July 8 – July 12 )**

### **Coding Period ( July 13 – August 6 ):**

- a) Take review from the mentors about the customization needed to be added.
- b) Start with adding customization to the nodes and edges.
- c) Solving for any bugs that may occur.

### **Coding Period ( August 7 – August 18 ):**

- a) Finalizing the Vue3 component and take reviews from mentors.
- b) Making sure everything works and solving all the bugs.
- c) Creating a detailed documentation about this project.

### **Final Evaluation ( August 19 – August 26):**

- a) Generate the pull requests for the newly implemented features.
- b) Hand over all the observation, report and code to the mentors for the final evaluation.



---

## OPEN SOURCE CONTRIBUTIONS

Organization	PR	Issue
Internet Health Report	<a href="#">#775</a>	Peeringdb Fix
Internet Health Report	<a href="#">#769</a>	User Info UI Added
Internet Health Report	<a href="#">#755</a>	Loading Page Fix
Internet Health Report	<a href="#">#598</a>	Added Hover Effect
Internet Health Report	<a href="#">#592</a>	Pre-commit Git Hook Added

---

## PERSONAL INSPIRATION

Google Summer of Code (GSoC) presents an exceptional chance for me to delve into real-life networking implementations, a field that captivates me. This program transcends mere technical skill development; it immerses me in a professional environment that fosters innovation and collective problem-solving. GSoC bridges theory and practice, empowering me to apply my academic knowledge to practical challenges. It also offers a platform to contribute to open-source projects under the guidance of experts worldwide. This experience will propel my growth as a developer, granting me insights into the challenges faced in the industry.

I have a huge personal inspiration to work on this project, and you can assured of my motivation to complete this project.

---

## OTHER COMMITMENTS

From May 4th to May 16th, I'll be taking my final exams, which will take up most of my time. Once I finish my exams, I'll have all my time free from other commitments and will be able to focus completely on the project and can give **30-35 hours/week**.

---

## POST GSoC AND FUTURE WORKS

After GSoC, I will maintain my involvement with the Internet Health Report, offering guidance to new members during their onboarding process. I plan to actively participate in discussions and contribute by creating and resolving issues, as well as implementing enhancements to the website.

---

## GSoC

a) **Have you previously participated in GSoC?**

-> I haven't participated in GSoC before.

b) **Are you applying to other projects?**

-> NO