

ANALYSIS OF THE IMPLEMENTATION OF INTERNET AUTONOMOUS SYSTEMS: TOPOLOGY CLASSIFICATION FOR INTERNET AUTONOMOUS SYSTEMS.

Cao Yuanqing^{1*}, Midhun Chakkaravarthy¹

¹Lincoln University College, Petaling Jaya, Malaysia.

*Corresponding author: Cao Yuanqing, Lincoln University College, Petaling Jaya, Malaysia.

ABSTRACT

The exponential growth of the internet is making data management and data routing across global networks increasingly difficult. Because getting online is so simple now, this is the current situation. Under the watchful eye of several institutions, autonomous systems (AS) on the Internet function as decentralised networks that follow conventional routing protocols. This layout is made feasible by distributed networks, or AS. These auxiliary pieces are the most important ones for the system. The study delves further into the effects of various topological topologies on the functionality and efficiency of Internet Autonomous Systems. By analysing each of the many topological structures, this research delves deeply into the problem of topology categorisation inside these systems. The operational characteristics, fault tolerance, scalability, and routing efficiency of the presently utilised AS topologies will be used to categorise them in this research. Hybrid, ring, star, mesh, and many more topologies are all a part of this vast group. Three key performance characteristics are data transfer rates, network dependability, and routing stability that should be considered while establishing an AS. Experts take into account each of these separate factors. More successful implementation procedures may be executed with the help of such topologies. Network engineers and lawmakers will have more data to work with when deciding on dependable and scalable alternative service deployment topologies thanks to this research. Increased connection, speed, and resilience may be achieved by integrating this kind of research and categorisation into the design of the internet's infrastructure. This program will be priceless in a future when all processes are being done digitally. The internet's architecture is one area that can be improved using this technique.

Keywords: Topology, Networking, Autonomous Systems, Border Gateway Protocol, System.

INTRODUCTION

Network engineers and academics find studying the Internet to be an interesting subject. It is not the individual networks that make up the Internet that determine its topology. This is why researcher are still lacking a complete Internet map from any source. This information would be helpful for many individuals working on network protocols; hence, it presents a significant challenge. It would be a remarkable accomplishment to capture only one part of the Internet's design more readily than the others. This architecture was built by the Intelligent Systems that run the Internet. These network components are used by the Internet to route data across

various domains. Researcher may find a wealth of information on cross-domain routing at the National Laboratory for Applied Network Research. Researchers provide a review of related work, and this information is used to conduct further studies. Investigators have calculated several average AS network properties using distributions relating to degree, distance, number of shortest routes, trees, etc., using six samples of BGP data (from November 1997 to May 2000). According to researcher's results, power laws provide a concise definition for several of them. In addition to studying how these typical attributes have changed throughout time, researchers have established specific empirical guidelines. Thanks to the Internet, many AS may be connected, including thousands of cases administered by various administrative authorities. When ASes communicate with one another, the BGP protocol controls how they operate. With BGP, each AS may decide for itself the routes to utilise for incoming and outgoing traffic from nearby systems. The network managers decide on the constraints based on AS relationships, which may be seen as a kind of business contract between ASes. Although there are other varieties of P2P relationships, P2P and P2C partnerships are by far the most common. The onus for payment for the service of facilitating data transfer between the Internet and other networks is on the customer. While it is possible for ASes and their customers to exchange traffic without restriction, it is not possible for ASes and their suppliers or other recognised businesses to share traffic with one another. According to the standard economic model, ASs shouldn't trade provider or peer routes with one another. Their efforts to shift the economic paradigm will inevitably lead to such a setup. To fully comprehend the architecture, dynamics of inter-domain routing, and growth of the Internet, one must be familiar with the commercial connections between application servers (ASes) (Matcharashvili et al., 2020).

BACKGROUND OF THE STUDY

Domain prefix theft is a persistent problem on the internet, however it's hard to determine. Intentional or accidental BGP route setting is one of the potential causes of prefix hijacking. Problems including service disruptions, invasions of privacy, and substantial financial losses might result from the latter. If these hijackings impact even a handful of ASes in a particular area, it may be because they impact all ASes on researcher's planet. The BGP update that was put in place in reaction to PCCW Global has finally made its way to the whole internet, according to ASC 4391 (AS3491). This was a ploy by Pakistan Communications Corporation to trick YouTube viewers in a number of nations. This turn of events extended the siege by two hours. As of its 2010 publication of all unassigned prefixes, China Net (AS23724) was almost as large as the whole global routing database. Typically, forty distinct prefixes are produced and distributed by China Telecom's network, which is known as China Net. Thankfully, only a few of networks outside of China have access to these prefixes. A China Telecom AS hijacked over 50,000 prefixes in April 2010, diverting 15% of Internet traffic for fifteen minutes to the incorrect destination (Witono & Yazid, 2021). Companhia de Telecomunicadores do Brasil Central AS16735 (CDTDBC) was the target of similar assaults for around five minutes while it displayed its whole prefix database to its upstream providers. Public key infrastructure (PKI) is notoriously difficult to set up due to the high processing and storage expenses involved. A novel approach

to preventing routing issues is to do nothing when routes seem suspect. Developing strategies to deal with outliers might prove to be a challenging task. Peers in the same or distinct ASes may exchange reachability information using BGP. With this data, researchers may draw up a network topology illustrating the interconnections between AS, which is a kind of Internet topology. Every possible route and the prefixes of networks that may be reached over any path or AS path are shown in a database of routing tables that a BGP peer creates. The "best path" is represented by the symbol ">" in this BGP table example. The topology of the Internet will seem differently to different BGP routers since each BGP router only shares its optimal path with other BGP peers. Since a broader view of the Internet's architecture is necessary, researchers investigate ways to merge several BGP tables from various places. Once every two hours, Oregon Route Views stores the BGP tables of all the ASs that are linked to the BGP route repository. A fresh method for describing intricate networks has been investigated by many writers. A highly functional network may be shown by its configuration. This research examines three primary topological models: the scale-free model, which displays power-law degree distributions; the small-world model, which relies on short pathways between two nodes and high clustering coefficients; and the conventional Erdős-Renyi model for random networks (Leyba et al., 2022).

PURPOSE OF THE RESEARCH

The goals of this study are to recognise and classify the topologies that are used in Internet AS and get an understanding of the influence that various topologies have on the installation and performance of AS. The effectiveness, dependability, and scalability of AS are becoming more important as the internet continues to gain more and more users. The fundamental objective of this research is to get an understanding of the implications that topologies have on routing algorithms, data transmission, fault tolerance, and the structural integrity of networks. On the basis of this comprehension, the research is constructed. A few examples of the many different topologies that are available are hybrid, star, mesh, and ring topologies. The results of this research may be useful to network designers, engineers, and decision-makers since they may provide information on which topological frameworks are most effective for meeting the specific operational needs of their organisations. In order to achieve this goal, research will be conducted to investigate the benefits and drawbacks of each design in actual AS configurations. In conclusion, researcher's objective is to enhance the infrastructure of the internet by promoting the use of AS in a manner that is both more prudent and more practical. The realisation of this improvement is going to be made possible by the aid that researcher provide in the implementation of autonomous systems. This implies that connection, efficiency, and resilience will all be increased on a global scale.

LITERATURE REVIEW

The entries in the BGP routing table are the most important item to consider when trying to establish the topology of an ASN. Using the routing details of a nearby VPN and an IP address

prefix block, one may determine an AS route connecting two sites. They looked to the AS Graph to help them make sense of what was happening. The set of AS is linked together with the use of nodes and edges. Researchers are able to create new types of AS graphs by linking AS nodes along the edges of annotated AS graphs. Results from the P2P and P2C connections lend credence to this idea. Passing BGP routes is not a big deal. Several groups support IXPs, including Packet Clearing House. This strategy might be used to track IXPs throughout the world after that. In order to analyse the whole network, data is stored in interconnected databases called Internet Routing Registries (IRRs). Internet Routing Registries (IRRs) are far less common than the linkages in researcher's database. To keep the RADb databases up-to-date, a number of groups and people collaborate, including Merit Network and RIPE. It is feasible for AS to establish several connections to various IP addresses at the same time. Researchers may use traceroute and tracer to identify problems with researcher's network. In order to respond to an ICMP inquiry, a router must provide a comprehensive inventory of all the IPv4 addresses it is linked to. The CAIDA Archipelago (Ark) monitoring system produced IPv4 routed /24 AS connection statistics using traceroute data. Connecting to ASes and giving them IP addresses allows researchers to do these things. A lot more traffic may be monitored by a network using Traceroute. There are three ways that researchers might look at each AS connection: BGP routes, Traceroute, or IRR. The researcher has to be tech-savvy and able to use ASes and the internet to study all the region transit firms. One good measure of an AS's customer base is the number of persons it carries. The AS classifies customers whose journeys are become less frequent as part of the Customer Cone (CC). Since customers aren't buying anything right now, researcher should definitely contact out to them. Additionally, this data might be used for a variety of purposes. When deciding how to link clients to other networks, administrators of internet exchange points may consider the size of the client's cone (Bakhshaliyev, 2020). The size of the consumer cone changes when AS-to-AS communication is taking place. This is a problem for peering networks. The bigger an AS's client cone, the lower its CAIDA rating will be. Due to the large variation in site sizes, the consumer cone does not represent the AS's real customer connection correctly. In contrast to Europe, Level 3 is rather popular in America. In order to better understand AS's state, researchers might use the consumer cone. None of the two can be compared. A possible metaphor for the web is a system of interdependent AS that work together to complete tasks. Although AS may operate independently in terms of traffic routing, the networks connecting them play a vital role. The impact of various topological designs on data routing speed, efficiency, and reliability has been the subject of much study by network engineers and researchers. The models were made using rings, meshes, and hybrids. Network connectivity, data exchange, and communication processes may be better understood with the help of AS topologies. A single weak point in star topologies might allow a problem to go undetected. Although mesh topologies are known to be notoriously difficult to construct, they provide fault tolerance and redundancy that is second to none. Getting a handle on mesh topologies could be tough. The goal of hybrid topologies is to strike a balance between the ease of adaptability and the possible pace of change. Research indicates that routing algorithm

performance may be affected by the topology of big, multihomed, extensively peering networks (Yuan & Song, 2023).

RESEARCH QUESTION

What is the Impact of Scalability Requirements on Implementation of Internet Autonomous Systems?

RESEARCH METHODOLOGY

Research Design

The quantitative investigation used the most recent version of SPSS, 25. The odds ratio and 95% confidence interval were used to evaluate the strength and direction of the statistical association. The researchers established a statistically significant threshold of $p < 0.05$. An analytical assessment was conducted to ascertain the principal elements of the data. Quantitative approaches are often used to evaluate data obtained from surveys, polls, and questionnaires, as well as data examined using computing tools for statistical assessment.

Sampling

Research participants filled out questionnaires to provide data for the research. Utilising the Rao-soft approach, researchers identified a cohort of 1,260 individuals, resulting in a total of 1,416 enquiries. The researchers received 1358 responses, excluding 43 for incompleteness, resulting in a final sample size of 1315.

Data and Measurement

This research used a questionnaire as the primary instrument for data collection. Section A of the survey solicited fundamental demographic information, while Section B used a 5-point Likert scale to gather responses about attributes associated with online and offline channels. The secondary data was acquired from many sources, mostly internet databases.

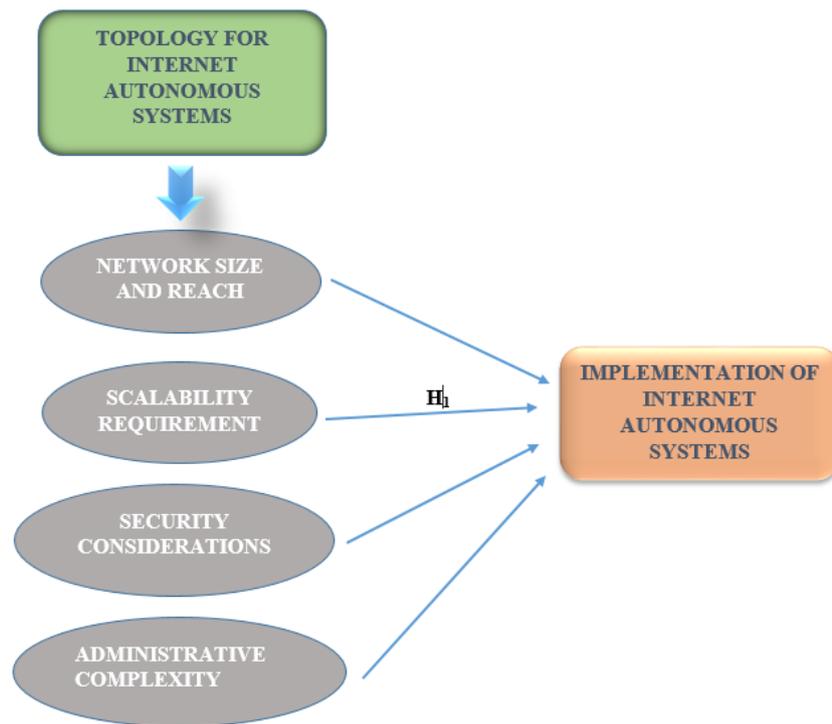
Statistical Software

The statistical study was conducted with SPSS version 25 and Microsoft Excel.

Statistical Tools

The statistical analysis method was used to comprehend the fundamental characteristics of the data under examination. The researcher must do a data analysis using ANOVA.

CONCEPTUAL FRAMEWORK



RESULT

Factor Analysis: Factor Analysis (FA) is often used to discern hidden variables within visible data. Employing regression coefficients for assessment is a standard procedure in the absence of clear visual or diagnostic indicators. Models are essential for success in financial analysis. Modelling naturally involves errors, interferences, and identifiable linkages. The Kaiser-Meyer-Olkin (KMO) Test may assess datasets produced by multiple regression studies. Researchers contend that the model and the variables in the sample are indicative. The data demonstrates redundancy. Information is more comprehensible when presented in smaller quantities. Any number ranging from 0 to 1 may serve as the KMO output. A KMO value between 0.8 and 1 is deemed adequate for sample size. Kaiser thinks that these are the permissible ranges: Kaiser has specified further entrance standards.

An insufficient range of 0.050 to 0.059 and a mediocre range of 0.60 to 0.69

The standard range for middle grades is 0.70 to 0.79.

The quality point score varies between 0.80 and 0.89.

The interval from 0.90 to 1.00 astonishes them.

The results of Bartlett's sphericity test are as follows: The chi-square statistic is around 190, with a significance level of 0.000.

This verifies that assertions made for sampling purposes are authentic. The researchers used Bartlett's Test of Sphericity to assess the significance of the correlation matrices. A Kaiser-Meyer-Olkin measure score of 0.869 indicates an adequate sample. Bartlett's sphericity test yields a p-value of 0.00. The association matrix lacks a unique value, hence fulfilling Bartlett's circularity test.

Table 1. The evaluation of sampling adequacy by KMO and Bartlett's Test reveals a Kaiser-Meyer-Olkin measure of 0.869.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.869
Bartlett's Test of Sphericity	Approx. Chi-Square	3252.968
	df	190
	Sig.	.000

Bartlett's Test of Sphericity further established the relevance of the association criterion. The Kaiser-Meyer-Olkin measure of sampling adequacy is 0.869. Researchers achieved a p-value of 0.00 using Bartlett's sphericity test. Bartlett's sphericity test findings suggested that the correlation matrix is invalid.

INDEPENDENT VARIABLE

Topology for Internet Autonomous Systems: The phrase "internet topology" describes how nodes and connections are set up in a data network. This may be as simple as basic or as complicated as highly complicated. The Internet Topology Zoo is one of several well-known initiatives that collect data from networks for research and analysis. An autonomous system (AS) is a group of Internet Protocol (IP) routing prefixes that work together to provide a clear and consistent policy to the Internet. One or more network operators handle these prefixes. They are all part of the same administrative body or domain. To make Border Gateway Protocol (BGP) routing easier, each AS that is being looked at is given an autonomous system number (ASN). The Internet Assigned Numbers Authority (IANA) gives blocks of Autonomous System Numbers (ASNs) to regional Internet registries (RIRs) so that they may be reassigned. After that, these blocks are sent to end-user organisations and local Internet registries (LIRs). The Internet Assigned Numbers Authority (IANA) also keeps track of ASNs that are meant for private use and shouldn't be made public on the Internet. The term "topology" is used to describe the general structure of the connections that make up the network when talking about autonomous systems (ASes) that are linked to the internet. When thinking about scalability, fault tolerance, network speed, and an efficient routing system, this is very important. There are many different types of topologies for AS, including as hybrid, multihomed, ring, star, and mesh. For example, larger ASes commonly deploy hybrid and mesh topologies to make sure that their systems are

always available and have backups. Smaller ASes, on the other hand, could select star topologies since they are easier to operate and demand less maintenance. Choosing the right topology is an important part of constructing and running an AS since the size, reach, and operational needs of the network all affect the decision-making process (Rahmatov & Baek, 2024).

DEPENDENT VARIABLE

Implementation of Internet Autonomous Systems: The creation, improvement, and operation of networks that are managed autonomously and that assist in the routing of traffic throughout the world are the primary focusses of Internet AS. In some manner, these networks contribute to the routing of the internet. One Autonomous System Number (ASN) is assigned to each autonomous system (AS) by a Regional Internet Registry (RIR), which is a kind of Internet registry. An entirely distinct organisation is in charge of each AS. One of these organisations might be an Internet service provider (ISP), a company, a school, or a government entity. In the event that the AS has this number, it may make use of the Border Gateway Protocol (BGP) in order to establish connections with other information systems and share routing information with them.

In order to effectively set up an AS, the first thing that needs to be done is to create a comprehensive routing policy. This policy determines the flow of traffic to and from other ASes, including traffic that is entering and traffic that is departing. As part of this, travelling to and from several ASes is included. In order to ensure that there is redundancy, that pathways are picked promptly, and that there is a high level of security, it is the responsibility of experienced networking professionals to configure routers in accordance with these criteria. An extra step that must be taken in terms of technology is the establishment of transit arrangements in order to connect to upstream providers or peering agreements with other advanced services. This particular component of the strategy, however, is contingent upon the business model that is being put into action (Dadauto et al., 2024).

FACTOR

Scalability Requirements: How well the buyer and seller watermarking approach handles changes in the number of participants (i.e., buyers, sellers, TTP) and the kind and quantity of devices is dependent on a scalability requirement. A "Scalability Requirement" in computer science is a system's capacity to grow and adjust to the evolving size and requirements of the client, even after the original installation. Project management and quality assurance methods are used to guarantee that the system can handle growing needs after commissioning. Before researcher set up researcher's Sterling™ Order Management System Software for production, it's crucial to assess researcher's workload, the nature of researcher's company's operations, and researcher's performance needs. When an environment is scalable, it can reliably handle a rising number of users and external services without compromising performance. The ability to

add servers to the cluster in order to accommodate more users (simultaneously or not) is the primary factor in scalability. Make note of if more cluster components may be included into the design at a later stage. Although database servers are often designed to grow, it could be more complicated to upgrade or install redundant load balancers than to increase the capacity of the shared repository. The two concepts generally go hand in hand, scalability and high availability. Researcher's availability criteria may be violated if the system operates normally under normal conditions but stops working under load. Researcher need to think about if researcher's availability needs will alter as the number of users increases. When an example, the need of a highly available cluster grows when the cluster-based BI solution is made available to an increasing number of customers. To secure future availability, researcher may have to update components or install redundant load-balancers. This growth should have been anticipated and accommodated in researcher's original cluster design (Hoeschele et al., 2021).

Relationship between Scalability Requirements and Implementation of Internet Autonomous Systems: In the realm of Internet AS, scalability is an essential factor to take into mind. If an AS is worth its salt, it will be able to expand to meet the growing demands of a network without compromising speed, stability, or security. This is true regardless of whether the expectations are a result of an increase in the number of users, an increase in geographic coverage, or an increase in the amount of data sent. In order for an AS to allow for scalability, the network architecture has to be carefully considered. This comprises the use of effective IP address management, adaptable topologies such as hybrid or multihomed architectures, and flexible routing technologies such as BGP. When it comes to building a system that has to be scalable, some of the more challenging features include having redundant lines, having a large number of upstream providers, and having dynamic routing patterns. The ability of an AS to scale implies that it is able to readily include more nodes, clients, and services. This is an essential feature for large Internet service providers and global service providers. In the other direction, ASes that have less rigorous scaling requirements could choose for implementations that are simpler. Therefore, the amount of technical intricacy, the resources that need to be committed, and the practicality of implementing AS in the long term are all impacted by the scalability criteria that are imposed (Wang et al., 2019).

Taking into consideration the discussion that was presented earlier, the researcher came up with the following hypothesis: to investigate the connection between Scalability Requirements and the implementation of Internet autonomous systems.

“H₀₁: There is no significant relationship between Scalability Requirements and Implementation of Internet Autonomous Systems.”

“H₁: There is a significant relationship between Scalability Requirements and Implementation of Internet Autonomous Systems.”

Table 2. H1 ANOVA Test.

ANOVA					
Sum					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	39588.620	363	5635.514	1052.187	.000
Within Groups	492.770	951	5.356		
Total	40081.390	1314			

This inquiry will provide significant results. The F statistic is 1052.187, with a p-value of .000, which is below the .05 alpha level. The hypothesis asserts that “*H₁: There is a significant relationship between Scalability Requirements and Implementation of Internet Autonomous Systems.*” The alternative hypothesis is affirmed, whereas the null hypothesis is dismissed.

DISCUSSION

The internet as researcher know it today is based on a network of computers, which is the basic structure that makes it up. Some of the people and groups who are in charge of keeping ASs running include internet service providers (ISPs), schools, and multinational organisations and organisations. ASs are the systems that let people utilise the internet. The way a system's nodes and connections are set up, known as its topology, is an important factor in how well the system works. The topology reveals how the system is set up, which is why this is the case. The aim of this study was to create a categorisation system for AS topologies and to determine the extent to which different topologies influence technology utilisation. Further analysis has shown that topology is not universally applicable. Many big ASes that cover a lot of ground throughout the globe employ more complex topologies, such mesh or hybrid, to provide their clients considerable advantages in terms of availability, performance, and redundancy. The design makes sure that the flow of data will not be disrupted if there is a mistake, which is a big plus. On the other hand, smaller ASes generally adopted star and stub topologies since they were easier to handle. Star and stub topologies are simpler to manage and cost less than other topologies. However, their designs are not flexible, and they don't have any programs that may be employed in an emergency. There are a lot of things to think about while choosing the best architecture for an AS deployment. The budget, the routing strategy, the growth of the network, and the many security needs are all factors that should be thought about. This list, however, is not complete. Choosing the right topology for a network is very important when it is growing and demand is increasing. This is the condition that has come about because the topology affects performance, error handling, and routing. Network engineers and legislators may find this categorisation useful in their attempts to build a more dependable, efficient, and resilient internet infrastructure in the future.

CONCLUSION

The expansion of the internet has given rise to an ecology of AS, the details of which are becoming murkier and complex with the passage of time. At stake here are AS that can handle

a wide range of situations, users, and goals all on their own, while also operating independently and according to their own set of rules. Network topology is relevant, according to this study's results, since it may predict an AS's routing, scalability, fault tolerance, and overall efficiency performance. This article provides an analysis of many different AS topologies that have been put into practice in actual situations. Multiple homes, hybrid, star, mesh, and ring topologies are some ways to categorise these kinds of setups. Here researcher see the strong correlation between network size, network reach, and topology selection. The findings imply that larger and more globally connected ASes use more intricate topologies to guarantee the speed and reliability of data transfer. But smaller and less costly ASes often go for cheaper, simpler designs. This is because there are options for more basic designs. Topology, as the hypothesis demonstrated, is not an arbitrary design choice but rather a purposeful one that impacts the network's performance and longevity. The very fact that the theory was put out proved this.

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