

The Internet Topology

Lewis Koplon and Ramon Driesen

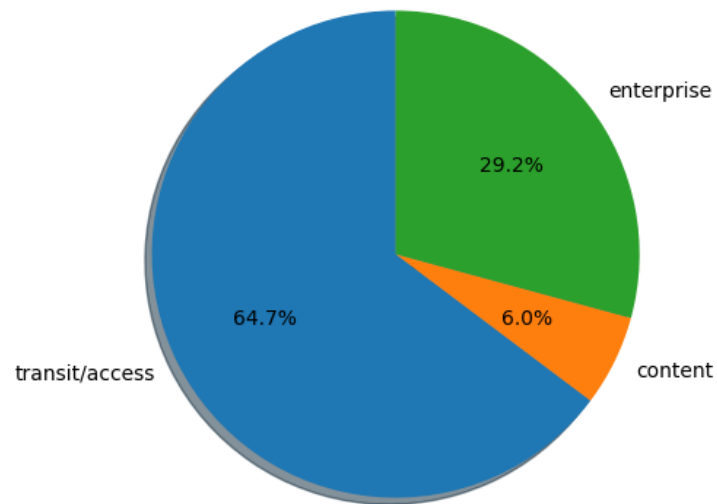
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ECE578 - Dr. Loukas Lazos

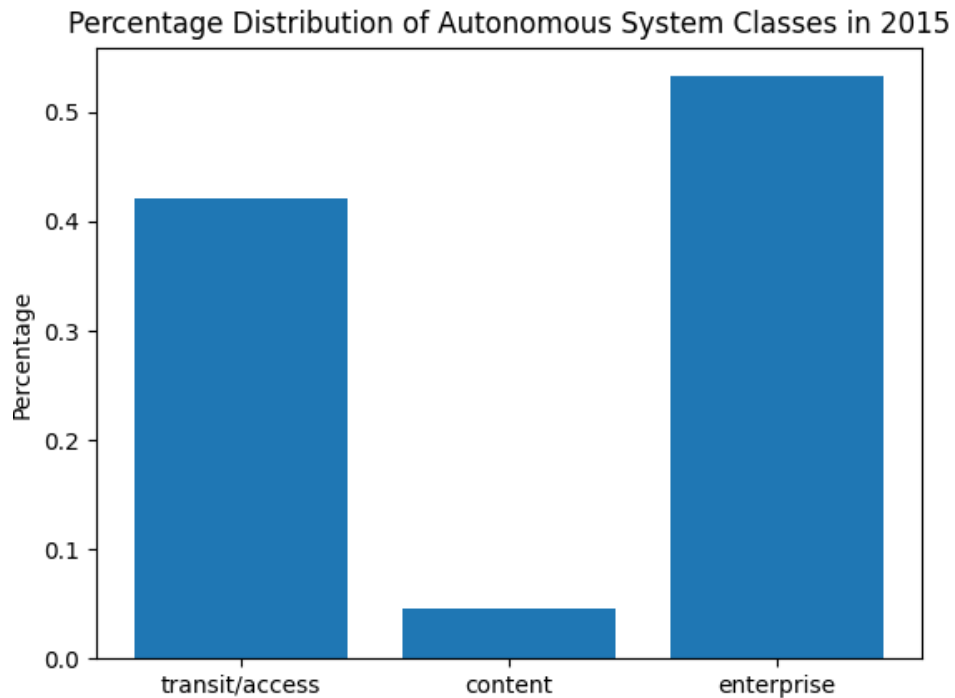
2.1 - AS Classification

Graph 1a

Percentage Distribution of Autonomous System Classes in 2021



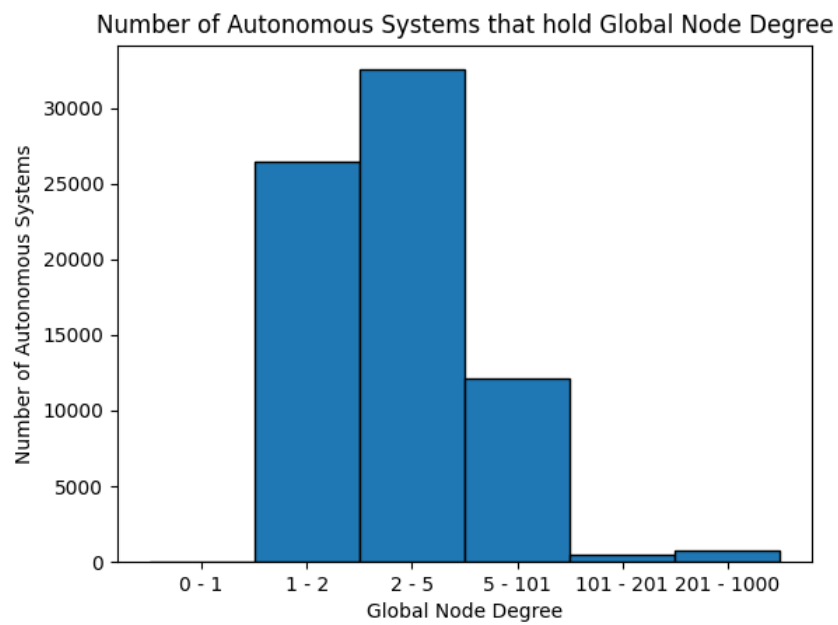
Graph 1b



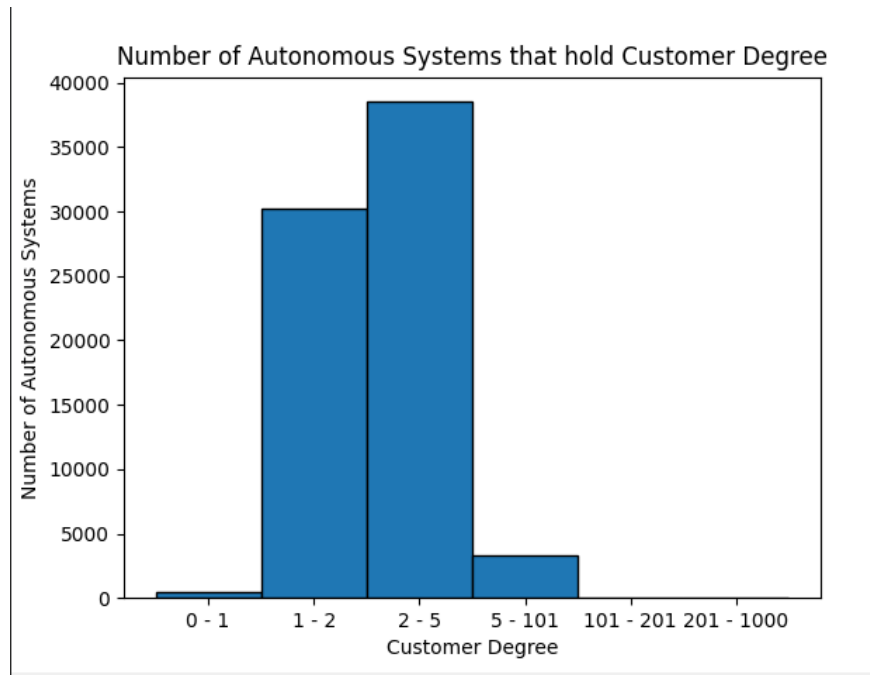
Graph 1a provides a visualization of the percentage of the distribution of AS classes in 2021. In the file used for our visualization there were three types of classes: Transit/access, Content, and Enterprise. In 2021, there was an overwhelming majority of Transit/Access ASes over the other two classes. The number of transit/access ASes grew to dominate the AS class as compared to in 2015. In 2021, the transit/access class made up 64.7% of the AS classes, whereas in 2015 it only made up roughly 40%. In 2015 enterprise ASes consisted the greatest percentage of AS classes with over 50% of the total distribution.

2.2 - Topology Inference Through AS Link

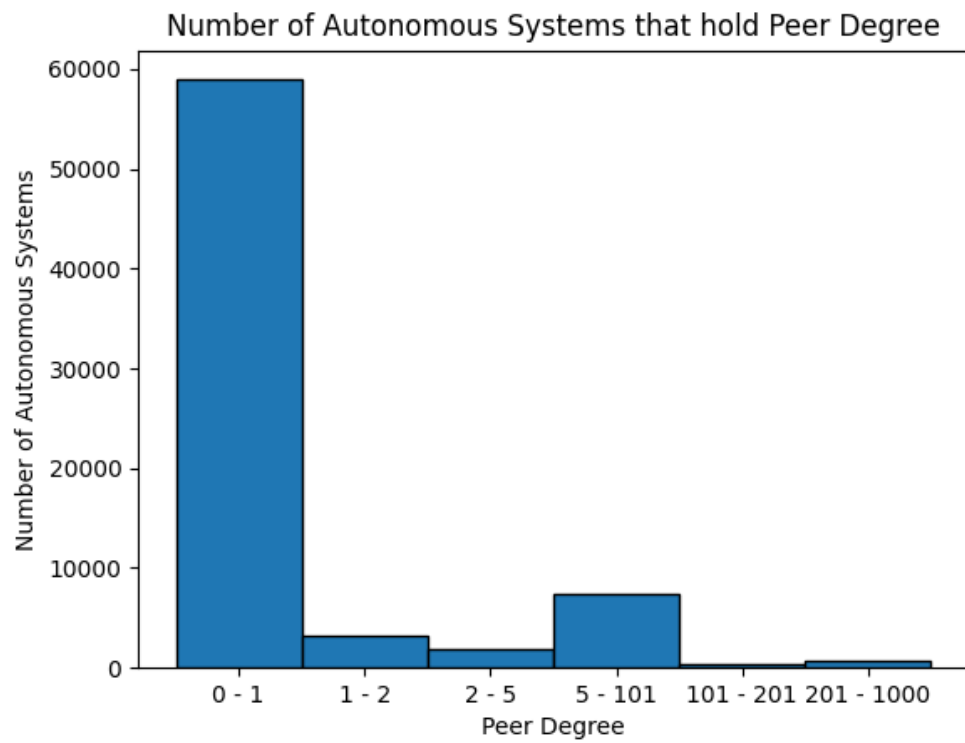
Graph 2a



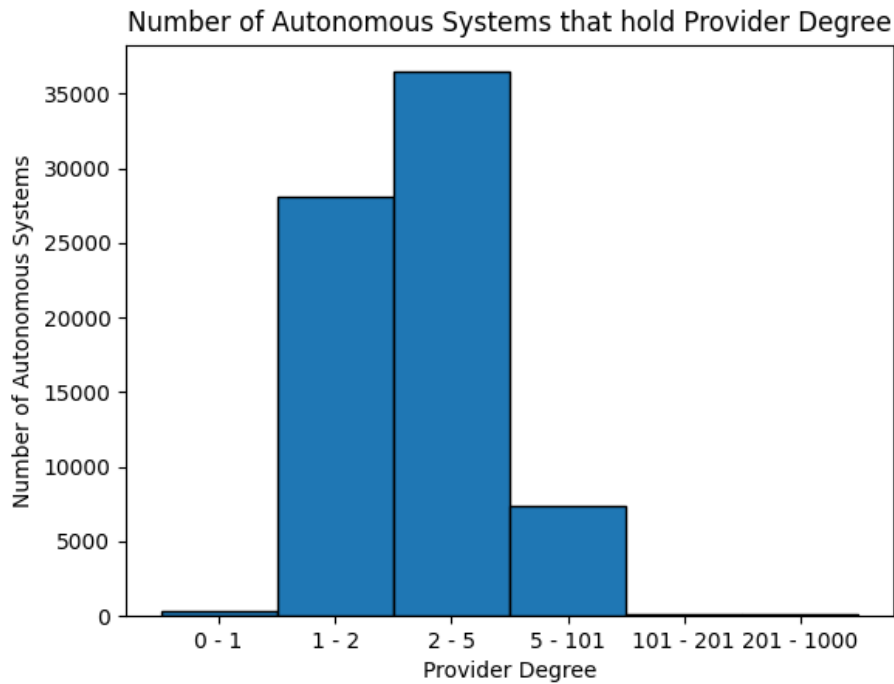
Graph 2b



Graph 2c



Graph 2d



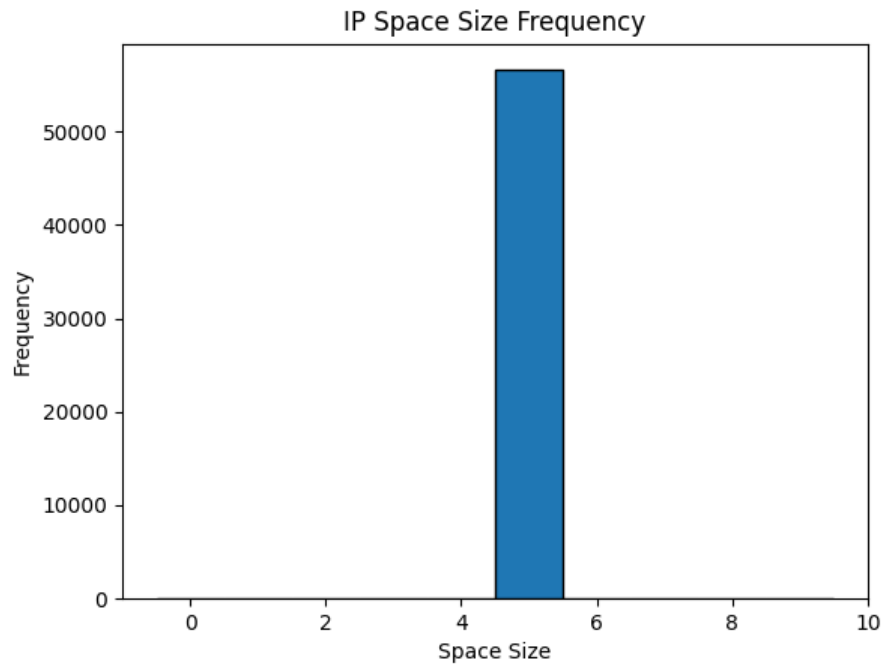
Global degree is the sum of the Customer, Peer, and Provider degrees. Graph 2a describes the Number of ASes with varying Global Node degrees. In the first graph, there are not any ASes with a Global degree from 0 to 1. This is because at least each AS has at least one link and therefore at least one degree. Most ASes have smaller Global degrees with most of the ASes having Global degrees of less than 5 and nearly all ASes have Global degrees of less than 101.

Graph 2b describes the distribution of AS Customer degrees. While some ASes are within the bin 0 to 1, nearly all ASes have at least one customer. This indicates that most of the observed ASes in 2021, are of the Transit class. This would make sense as the transit class carries both transit and local traffic.

Graph 2c describes the distribution of AS Peer degrees. While most ASes have no peers (by an overwhelming margin), some have Peer degrees between 1 to 101. Degree size 5 to 101 has the greatest number of ASes with degree size greater than 1. This tells us that if an AS has a peer, it is likely that it has more than just 1.

Graph 2d describes the distribution of AS Provider degrees. Its distribution is similar to that of the customer degree distribution. This is because each provider degree indicates that a node is a customer of another provider. This would follow what we are expecting to see since most nodes are customers of other nodes and each node has at least one customer themselves.

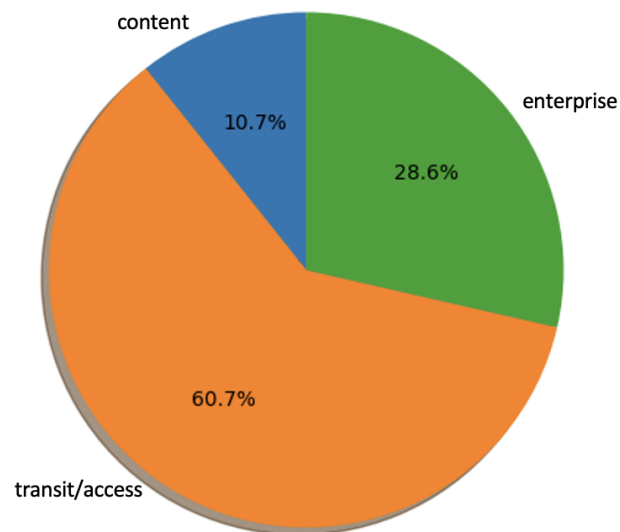
Graph 3



We chose each of our bins to be $2^{(32-\text{prefix size})}$ in size, where the prefix size took on 32 different values. We did this to demonstrate how many different IP prefixes each autonomous system has. Unfortunately our model of calculating IP space size was incorrect and so we only see ASes with bin size of $2^{(32-5)}$ or $2^{(27)}$. We would expect to see more of a distribution across each bin size.

Graph 4

Percentage Distribution of Autonomous System Classes in 2021 According to Link Traversal



The distribution of AS classes is similar to what is seen in Graph 1a. When calculating the distribution of AS classes by classifying each class by the number of degrees each has, the number of content ASes increases while the number of transit/access and enterprise ASes decreases. The greatest decrease is seen in the transit AS class, dropping by only four percent. These small differences might indicate a potential error in our simulation or in the file documentation.

2.3 - Inference of Tier-1 ASes

Table 1: At Least 10 AS-to-Organization Mapping

AS Number 6939 belongs to Hurricane Electric LLC
 AS Number 3356 belongs to Level 3 Parent, LLC
 AS Number 1828 belongs to Uitas Global LLC
 AS Number 14840 belongs to BR Digital
 AS Number 28186 belongs to ITS TELECOMUNICACOES LTDA
 AS Number 35598 belongs to Inetcom LLC
 AS Number 25091 belongs to IP-Max SA
 AS Number 267613 belongs to ELETRONET S.A.
 AS Number 42473 belongs to ANEXIA Internetdienstleistungs GmbH
 AS Number 3216 belongs to PJSC "Vimpelcom"
 AS Number 20764 belongs to CJSC RASCOM
 AS Number 37468 belongs to Angola Cables
 AS Number 31133 belongs to PJSC MegaFon

2.4 - Customer Cones and AS Rank

Table 2: Top 15 ASes Ranked by the customer cone in the number of reachable ASes

Table 3: Top 15 Ases ranked by the customer cone in percentage of reachable IP addresses

AS Rank	AS Number	AS Name	AS Degree	ASes	IP Prefix	IPs	ASes	IP Prefix	IPs
1	174	Cogent Commu	6250	31695	549378	1244328919	29.5	53.6	37.9

		nications							
2	24482	SG.GS	6063	~341	~10014	6716018	0.3	1	0.21
3	14840	BR.Digital Provider	4754	649	12930	14938497	0.61	1.3	0.46
4	7713	Telekomunikasi Indonesia (PT)	2736	427	19740	29233421	0.4	1.93	0.89
5	7018	AT&T Services, Inc.	2544	3345	66150	326141248	3.1	6.4	9.9
6	8220	COLT Technology Services Group Limited	2384	1244	12201	20045975	1.1	1.19	0.6
7	13786	Seabras 1 USA, LLC	2418	1374	22458	26682450	1.24	2.2	0.81
8	1299	Telia Company AB	2244	36489	641690	1705614912	34.03	62.6	52.
9	6461	Zayo Bandwidth	2245	15897	315258	544879629	14.83	30.9	16.4
10	13237	euNetworks GmbH	1906	322	2557	3520689	0.3	0.2	0.1
11	3257	GTT Communications Inc.	2103	21625	448616	1845966786	20.18	43.8	56.3

12	12779	IT.Gate S.p.A.	2036	63	455	499232	0.06	0.03	0.02
13	22548	Núcleo de Inf. e Coord. do Ponto BR - NIC.BR	1906	26	382	302592	0.04	0.04	0.01
14	18106	Viewqw est Pte Ltd	2043	41	909	107097 6	0.04	0.09	0.03
15	28634	Life Tecnolo gia Ltda.	1458	8	85	40704	0.01	0.01	`0

*Tables 2 and 3 are combined into one table

*There was a sorting error in our code and so Table 2 and Table 3 are inaccurate