# ECE 578 - Project 2

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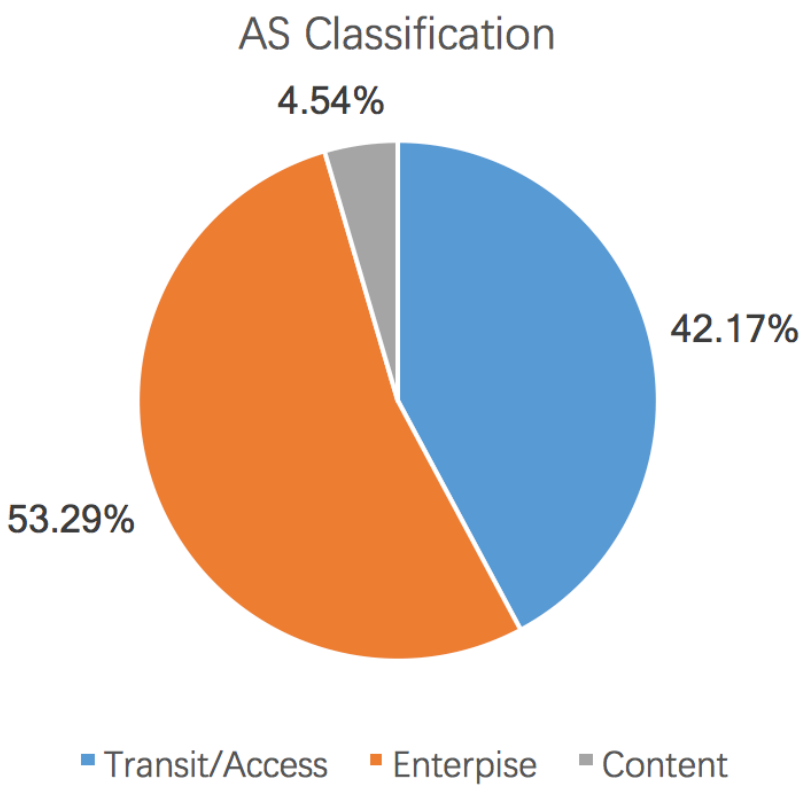
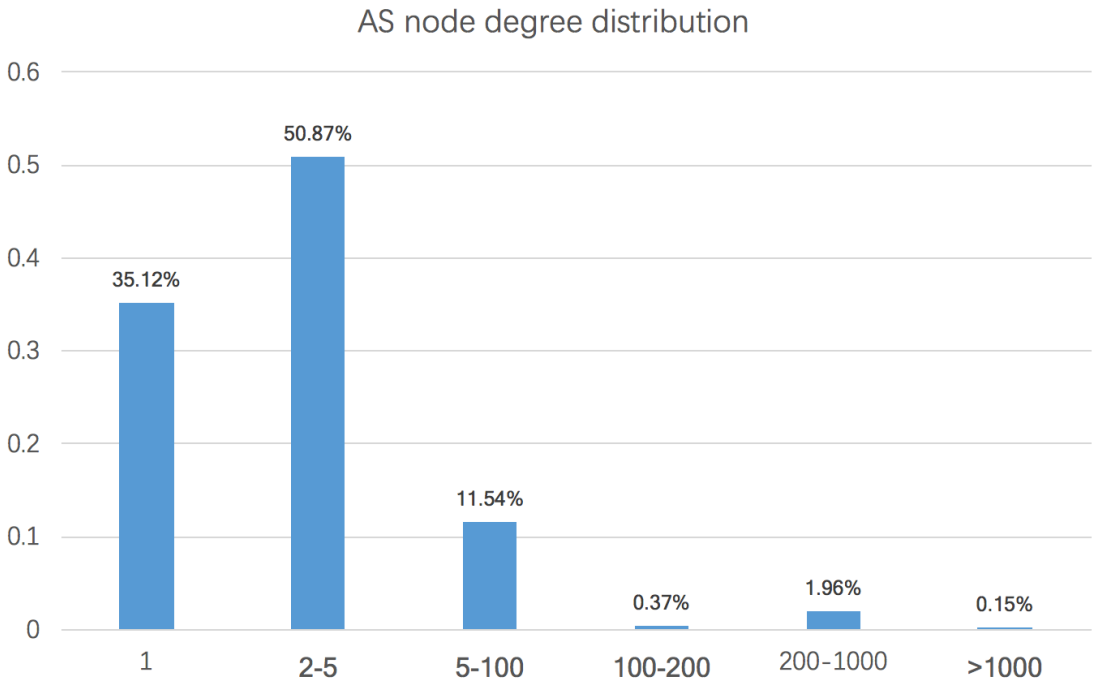
## 2.1 AS Classification



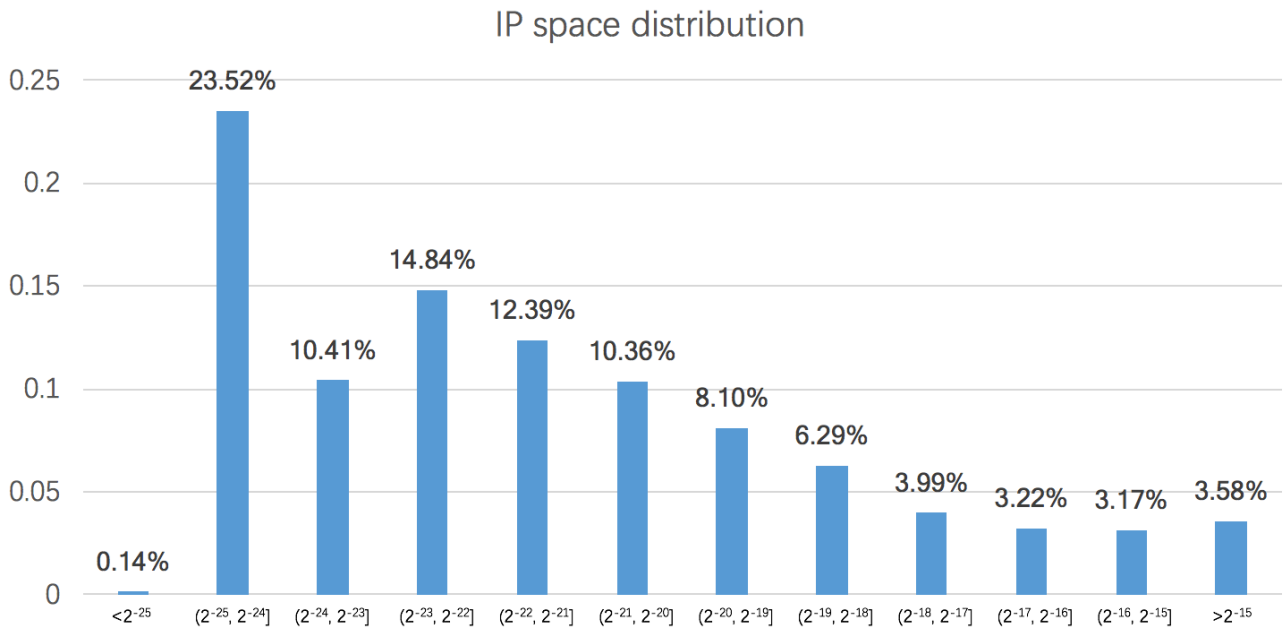

Graph 1

## 2.2 Topology Inference Through AS links




Graph 2

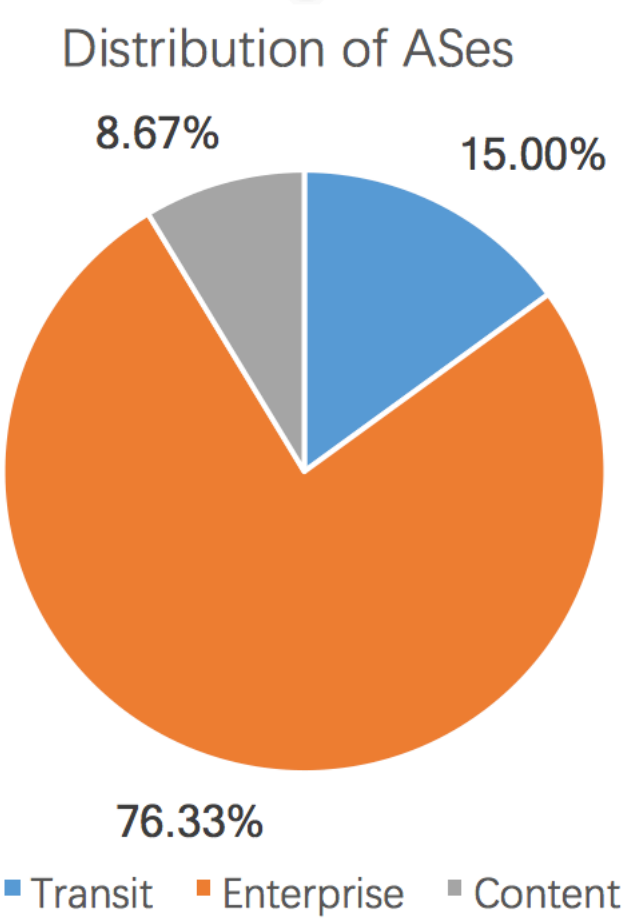
In the graph 2, We can see that almost 90% of the AS nodes have the degree less than or equal to 5. And there are a little nodes who have the degree more than 100. Consider the large amount of AS nodes, the number of providers is much less than the number of customers. Usually, one peer is connected to no more than 5 other peers.




Graph 3

In graph 3, generally speaking, If the AS nodes have more IP space, then the number of such nodes is less. More IP space means shorter Prefix IP length, In the previous lecture, we know that there are 3 classes of IP address, Class A, Class B, and Class C. And Class A has the least number of networks, Class C has the most number of networks.

In another word, we can deem that the IP address with different length prefix has different rank, which means the shorter prefix an IP has, the higher rank it will be in. Recall the 3 Classes, we can regard Class A has higher rank than Class B and C. By analogy, we can say that the AS node with shorter average prefix length has higher rank, so that the number of such AS node is less.




Graph 4

In graph 4, the distribution of ASes is basically the same as graph1. Enterprise ASes take the largest part, Transit ASes take the second largest part, and Content ASes take the smallest. As for the percentage of each kind of ASes vary a lot, we think that's because these two graphs were drawn from different data file.

## 2.3 Inference of T1 ASes

We finished this part by using the document of '20161001as-rel2.txt', '20161001.as-org2info.txt', the data got from Graph2 and following the algorithm showed below.

• Rank all the ASes according to their degree and place them to set R = {AS1, AS2, ...}, where degree(ASi) > degree(ASi+1).
• Initialize the clique S = {AS1}.
• If AS2 is connected to AS1, add it to S. That is S = {AS1, AS2}.
• If AS3 is connected to AS1 and AS2, add it to S. That is S = {AS1, AS2, AS3}.
• Terminate when you find the first AS that is not connected to all ASes in S.

As the table 1 showed below, we only got 4 ASes belonging to T1 list. We tried the experiment as you

posted on Piazza, we ignored these ASes and checked the rest of ASes, but we still got these 4 ASes. In addition, if we change the algorithm that we can add the ASi to S if ASi is connected with one of AS in S at least, then we would get 1334 ASes in S.

Table 1

| Rank | AS # | Organization |
|---|---|---|
| 1 | 6939 | HURRICANE |
| 2 | 174 | COGENT-174 |
| 3 | 3356 | LEVEL3 |
| 4 | 3549 | LVLT-3549 |

## 2.4 Customer Cones and AS Rank

At first, there are three things we need to mention here.

1. Total number of IP prefixes.
Instructor posted an answer that IP prefix means the total number of different IP prefixes. Since there doesn't have the case that two or more same ASes have the same IP prefixes, I got the total number of prefixes from Graph2 directly and computed the percentage of IP prefixes. The total number is 667610.

2. Total number of ASes.
Since the ASes used here are all connected with others through p2c link, the total number of ASes would be the sum of different ASes linked by p2c, whatever providers or customers. The total number is 55390.

3. Total number of IP spaces.
Since there wouldn't have the customer cone with more than 2^32 IP spaces, 2^32would be the total IP spaces.

We used the data that utilized by Graph2, and found out all of connections with p2c links. We got the sets of every AS customer cone and stored these data according to the definition of the customer cone. After that, we got ASes numbers, IP prefixes and IPs based on this data and some other data came from Graph2 and Graph3, then we got the table 2.

Table 2: The top 15 ASes ranked by the customer cone in number of ASes

| AS rank | AS# | AS name | AS degree | Customer cone | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Number of | | | percentage of | | |
| | | | | Ases | IP prefix | IPs | Ases | IP prefix | IPs |
| 1 | 3356 | LEVEL3 | 4627 | 47542 | 585416 | 3148441803 | 85.83% | 87.69% | 73.31% |
| 2 | 174 | COGENT-174 | 5137 | 47110 | 579855 | 2996395347 | 85.05% | 86.86% | 69.77% |
| 3 | 1299 | TELIANET | 1362 | 47059 | 582464 | 3069671486 | 84.96% | 87.25% | 71.47% |
| 4 | 2914 | NTT-COMMUNICATIONS-2914 | 1534 | 43948 | 554728 | 2873181579 | 79.34% | 83.09% | 66.90% |
| 5 | 3257 | GTT-BACKBONE | 1388 | 43821 | 557368 | 2917784809 | 79.11% | 83.49% | 67.93% |
| 6 | 6453 | AS6453 | 845 | 42902 | 551743 | 2929140065 | 77.45% | 82.64% | 68.20% |
| 7 | 2828 | XO-AS15 | 1115 | 42526 | 547672 | 2932005991 | 76.78% | 82.03% | 68.27% |
| 8 | 4436 | AS-GTT-4436 | 859 | 42492 | 546150 | 2884266967 | 76.71% | 81.81% | 67.15% |
| 9 | 6939 | HURRICANE | 6059 | 42402 | 546236 | 2831219301 | 76.55% | 81.82% | 65.92% |
| 10 | 209 | CENTURYLINK-US-LEGACY-QWEST | 1832 | 41435 | 534380 | 2901209083 | 74.81% | 80.04% | 67.55% |
| 11 | 4826 | VOCUS-BACKBONE-AS | 1113 | 40398 | 528104 | 2791660482 | 72.93% | 79.10% | 65.00% |
| 12 | 3491 | BTN-ASN | 696 | 40193 | 526565 | 2789594794 | 72.56% | 78.87% | 64.95% |
| 13 | 1239 | SPRINTLINK | 532 | 40001 | 522260 | 2730980137 | 72.22% | 78.23% | 63.59% |
| 14 | 3561 | CENTURYLINK-LEGACY-SAVVIS | 259 | 39544 | 510998 | 2687633218 | 71.39% | 76.54% | 62.58% |
| 15 | 4637 | ASN-TELSTRA-GLOBAL | 1003 | 39406 | 509571 | 2670204730 | 71.14% | 76.33% | 62.17% |

Table 3: The top 15 ASes ranked by the customer cone in percentage of IP addresses

| AS rank | AS# | AS name | AS degree | Customer cone | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Number of | | | percentage of | | |
| | | | | Ases | IP prefix | IPs | Ases | IP prefix | IPs |
| 1 | 3356 | LEVEL3 | 4627 | 47542 | 585416 | 3148441803 | 85.83% | 87.69% | 73.31% |
| 2 | 1299 | TELIANET | 1362 | 47059 | 582464 | 3069671486 | 84.96% | 87.25% | 71.47% |
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| 15 | 4637 | ASN-TELSTRA-GLOBAL | 1003 | 39406 | 509571 | 2670204730 | 71.14% | 76.33% | 62.17% |

Here, we just used the same data as showed in Table 2 and sorted it as the percentage of IPs. It's obvious that only a few ranks of ASes changed.