CS 168 Introduction to the Internet
Fall 2017 Scott Shenker

Discussion 6: IP and Forwarding

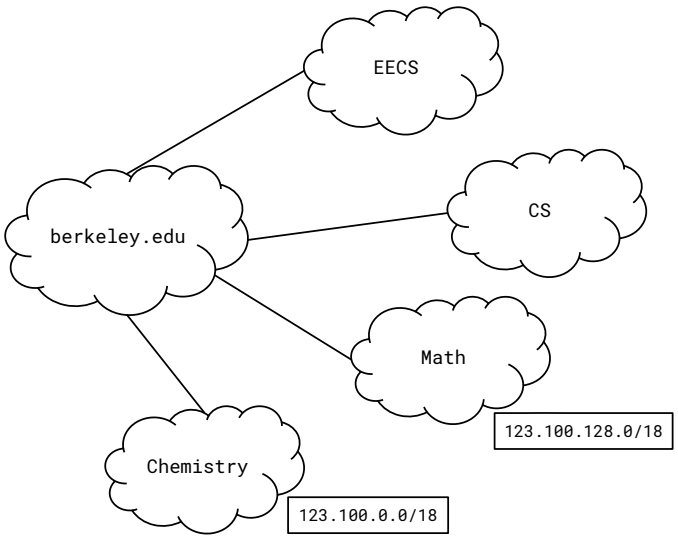
1 Warm Up

Find the binary representation, subnet mask, and address range of `192.168.0.0/13`.

Solution: Binary representation: `11000000 10101000 00000000 00000000`
Subnet Mask: `255.248.0.0`
Address Range: `[192.168.0.0, 192.175.255.255]`

2 IP Addressing

berkeley.edu is the Provider AS for EECS, CS, Math, and Chemistry. Assume that the CIDR (Classless InterDomain Routing) addressing scheme is used.



(1) What range of addresses does Math hold? How many addresses are in this range?

Solution: `[123.100.128.0, 123.100.191.255]`. This contains 2^{14} addresses.

(2) `123.100.192.0/18` is reserved for EECS and CS. Assign equal halves of this address space to the two departments.
Solution: EECS:
`01111011 . 01100100 . 11000000 . 00000000`
`123.100.192.0/19`
CS:
`01111011 . 01100100 . 11100000 . 00000000`
`123.100.224.0/19`
(or vice versa)

(3) What is the longest prefix for berkeley.edu that encompasses all of Chemistry, Math, EECS and CS?

Solution: Take the first N bits common to all three prefixes, and take this as the network portion for berkeley.edu:
`01111011 . 01100100 . 11000000 . 00000000`: EECS & CS
`01111011 . 01100100 . 10000000 . 00000000`: Math
`01111011 . 01100100 . 00000000 . 00000000`: Chemistry

The first diverging bit is the 17th bit. Thus, the answer is `123.100.0.0/16`.

(Alternatively, observe that the total size of the Berkeley AS must be at least $(3 \times 2^{14}) > 2^{15}$, so you need at least 16 bits for the host portion. Taking the first 16 bits of any of the prefixes, you have `123.100.0.0/16`)

(4) You want to start a new department Floriology, but you foresee that no more than 50 people will enroll. Assuming one address per person, what prefix would you assign to it?

Solution: Floriology: Needs 64 addresses
Must allocate from unclaimed chunk: `123.100.64.0/18`
`123.100.64.0/26`

(5) Your friend came up with the brilliant idea of starting yet another (slightly redundant) department, Mathematical Floriology (`123.100.64.0/29`), which is multi-homed from the existing Math and Floriology departments. Why might it be a good idea for Mathematical Floriology to be multi-homed, instead of directly attached to only Math or Floriology?

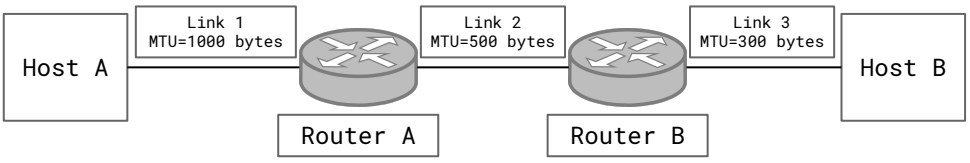
Solution: In case one of Math or Floriology goes down (but not both).

(6) How does this affect Berkeley.edu?

Solution: Berkeley.edu must now remember that `123.100.64.0/29` is attached to both Math and Floriology (i.e. one extra route to keep track of). This makes the forwarding tables of the routers in Berkeley.edu bigger. Breaks aggregation!

3 IP Fragmentation

Maximum Transmission Unit (MTU) is the size of the largest packet that a link can carry. Host A sends an **600 byte** IP packet (including header) to Host B, which is fragmented along the way. Assume the typical IP header length of 20 bytes.



(1) The packet fits within the MTU of Link 1 and arrives at Router A. What are the resulting fragments that traverse Link 2? For each fragment, identify the total length (including header), flags, and offset.

Solution: Original payload = 600 byte total length 20 byte header = 580 bytes
F1: total length = (20 byte header + 480 byte payload) = 500 bytes, flags = 001, offset = 0
F2: total length = (20 byte header + 100 byte payload) = 120 bytes, flags = 000, offset = 480/8 = 60

(2) The fragments arrive at Router B. What are the resulting fragments that traverse Link 3?

Solution: F1a: total length = (20 byte header + 280 byte payload) = 300 bytes, flags = 001, offset = 0
F1b: total length = (20 byte header + 200 byte payload) = 220 bytes, flags = 001, offset = 280/8 = 35
F2: total length = (20 byte header + 100 byte payload) = 120 bytes, flags = 000, offset = 480/8 = 60
Observe that fragmentation offsets in F2 stays the same.

(3) Why is the MF flag needed?

Solution: Packets can arrive out of order; MF flag tells the end host which fragment is the last one.

(4) Why cant we just number our fragments instead of keeping track of fragmentation offsets?

Solution: How else would you order fragments of fragments? (Consider the further fragmentation of F1)

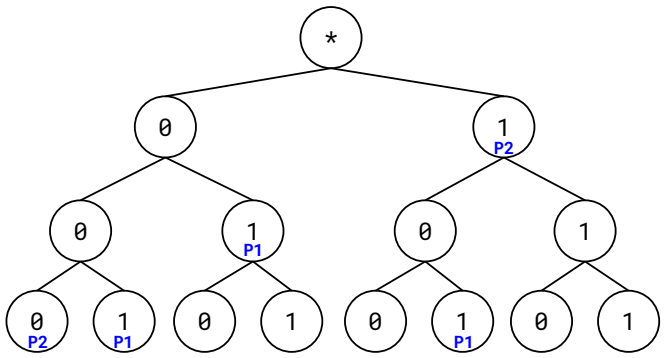
4 Longest Prefix Matching

Your routing table contains the following entries:

Address	Port
01*	Port 1
000	Port 2
001	Port 1
1**	Port 2
101	Port 1

Mark the entries on the following tree. Then, find a more concise representation of the table.

Solution:



Address	Port
***	Port 1 (or 0** Port 1)
000	Port 2
1**	Port 2
101	Port 1