A quick introduction to networks

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What you should learn

- Understand an IPv4 address
- See how networks packets travel
- Understand a netmask and a broadcast address
- What a gateway is
- What is a nameserver?
- What is a time (ntp) server
- What a protocol is, and the difference between “network” and “protocol”

IPv4 and IPv6

IPv4 network was designed in the 1970's

4 billion (4*1024*1024*1024) possible addresses

That seemed a **ridiculously** large number at the time (a computer cost millions of dollars)

(Other networks, e.g. DECNet, had only 65536 (256*256) addresses)

Today, where everyone uses multiple IP addresses (laptop, iPad, smartphone), we are running out of IPv4 addresses quickly

No more IPv4 addresses in Latin America and the Caribbean

Latin America and the Caribbean have entered the IPv4 exhaustion phase; the delay in deploying Internet Protocol version 6 in our region is cause for concern.

La Casa de Internet de Latinoamérica y el Caribe, 10 June.- Today, the Internet Address Registry for Latin America and the Caribbean (LACNIC), the organization responsible for assigning Internet resources in the region, announced the exhaustion of its IPv4 address pool and expressed its concern regarding the fact that operators and governments throughout the region are delaying the deployment of Internet Protocol version 6 (IPv6).

Also, the address space is very inefficiently used

For example my institution: has 65536 addresses 15500 in use

IPv6

IPv6 network protocol was des

18446744073709551616 possible addresses (“one for each sandcorn at the beaches”)

The roll-out for the new IPv6 has been **very** slow

It is a new technology, one needs to learn

Cyber security tools (network scanners, firewalls, etc) need development

It takes a lot of infrastructure upgrades to go to IPv6 – switches, routers, manpower

Brookhaven Lab: estimated $8million

You will almost always still get a IPv4 address today.

IPv4

The Address you get is a 32bit number

Usually written as the “4-dot” notation

Eg. 192.168.2.13 (is what my Laptop has now)

Each network has a netmask and a broadcast address

inet 192.168.2.13 netmask 0xffffff00 broadcast 192.168.2.255

The broadcast and the netwmask define the ”**Subnet**”

An IPv4 subnet

A subnet is the collection of all addresses which can be reached “directly”

Subnet = all addresses where this is true:

Bit-wise “and”

Address & broadcast== broadcast

192 . 168. 2. 13

C 0 . A 8 . 0 2 . 0 D

1100 0000 1010 1000 0000 0010 0000 1101

&

1100 0000 1010 1000 0000 0010 1111 1111

=

1100 0000 1010 1000 0000 0010 0000 1101 = 192.168.2.13 ✓

Bit-wise and:

1 0 0 1 0 0 1 1
&
0 0 0 1 1 1 1 1
=
0 0 0 1 1 0 1 1

That means that ALL addresses which start with 192.168.2 fullfill that requirement

192.168.2.78

192.168.2.199 -> 256 Addresses

Netmask and broadcast

Bit-wise "or" **Bit-wise "xor"**

broadcast = address | (netmask ^ 0xffffffff)

```
1111 1111 1111 1111 1111 1111 0000 0000
                     ^
1111 1111 1111 1111 1111 1111 1111 1111
                    =>
0000 0000 0000 0000 0000 0000 1111 1111
                     |
1100 0000 1010 1000 0000 0010 0000 1101
                    =>
1100 0000 1010 1000 0000 0010 1111 1111 = 192.168.2.255
```

Bit-wise xor:
("1 when they are different")

1 ^ 1 = 0
0 ^ 0 = 0
1 ^ 0 = 1
0 ^ 1 = 1

Netmask notation

netmask 0xffffff00 --- how many “leading one’s?”

`1111 1111 1111 1111 1111 1111 0000 0000`

(24) This is called a “/24” network

so you can say much shorter:

I am on a 192.168.2.0/24 network

What happens if I add one more “0” to my netmask? /23?

The broadcast gets “one more 1” 192.168.2.255 -> 192.168.3.255

Now I have doubled the size of my subnet!

Now everything that starts with 192.168.2 is in the subnet as before

But now also all addresses 192.168.3.X

➔ 512 addresses

Address & broadcast== broadcast

192 . 168. 2. 13

C 0 . A 8 . 0 2 . 0 D

1100 0000 1010 1000 0000 0010 0000 1101

&

1100 0000 1010 1000 0000 0011 1111 1111

=

1100 0000 1010 1000 0000 0010 0000 1101 = 192.168.2.13 ✓

Gateways

You can reach everything that is on the same subnet directly

So everything that starts with 192.168.2.X we can get to directly

But what is with www.bnl.gov (130.199.3.21)

For that you go through a **gateway**

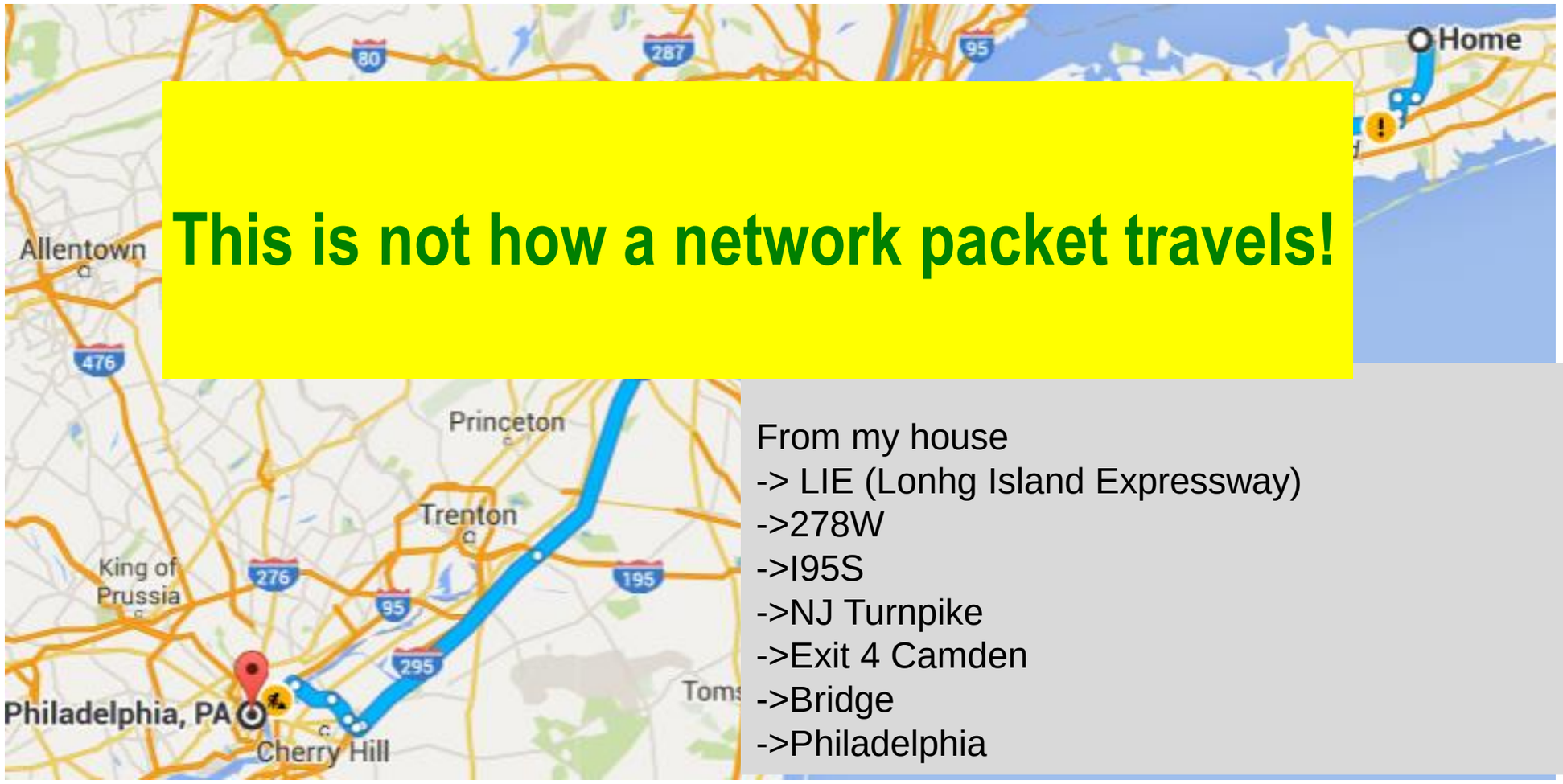
```
$ netstat -rn
Routing tables

Internet:
Destination        Gateway            Flags   Refs      Use   Netif Expire
default            192.168.2.1        UGSc    30        0     en1
```

How network packets travel

If you are a car driver and want to go from one place to another, you usually have some idea how to get to your destination.

When I drive from my home to Philadelphia, I know how to get there.

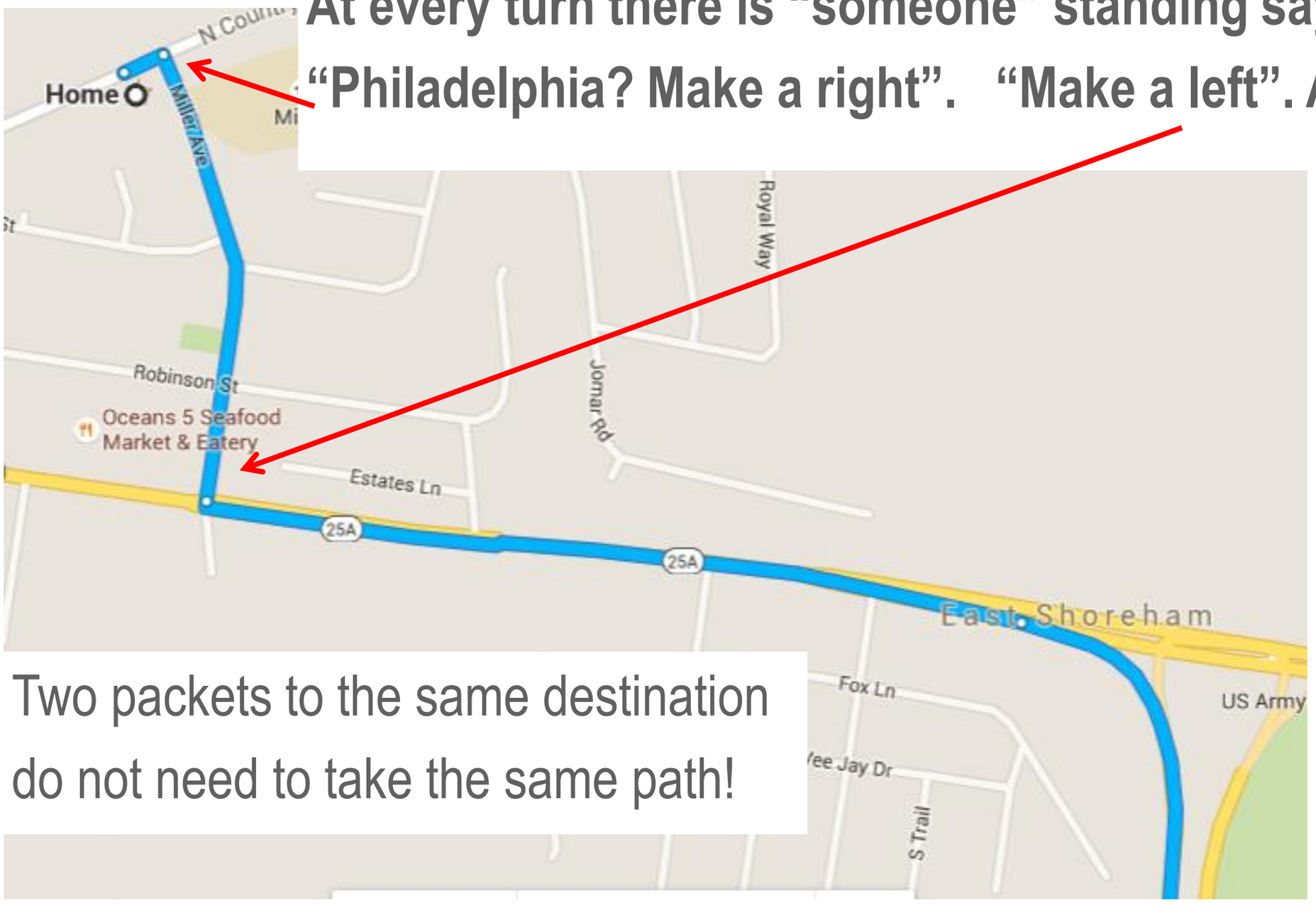


From my house
-> LIE (Lonhg Island Expressway)
->278W
->I95S
->NJ Turnpike
->Exit 4 Camden
->Bridge
->Philadelphia

How network packets travel

The network packet has NO IDEA how to get to Philadelphia

At every turn there is “someone” standing saying “Philadelphia? Make a right”. “Make a left”. And so on



Two packets to the same destination do not need to take the same path!

Going from Vietnam -> www.bnl.gov

But what is with www.bnl.gov (130.199.3.21)

Traceroute will show you the path

```
$ traceroute www.bnl.gov
traceroute to cache3.bnl.gov (130.199.3.21), 64 hops max, 52 byte packets
 1  vigor.router (192.168.2.1)  1.291 ms  0.752 ms  1.758 ms
 2  192.168.93.253 (192.168.93.253)  21.509 ms  9.787 ms  7.499 ms
 3  123.21.240.1 (123.21.240.1)  17.003 ms  21.830 ms  19.799 ms
 4  172.17.32.66 (172.17.32.66)  11.929 ms  6.681 ms  3.333 ms
 5  localhost (113.171.17.121)  2.688 ms  3.019 ms
    localhost (113.171.31.105)  14.617 ms
 6  * * *
 7  localhost (113.171.14.130)  10.099 ms
    vdc.vn (123.29.10.238)  9.953 ms
    localhost (113.171.14.62)  7.262 ms
 8  203.131.252.21 (203.131.252.21)  31.731 ms  29.689 ms  49.016 ms
 9  ae-9.r22.tkokhk01.hk.bb.gin.ntt.net (129.250.2.122)  169.338 ms  31.765 ms  36.917 ms
10  ae-16.r30.tokyjp05.jp.bb.gin.ntt.net (129.250.5.133)  81.544 ms  83.560 ms  92.222 ms
11  ae-4.r23.snjsca04.us.bb.gin.ntt.net (129.250.5.78)  176.699 ms  173.570 ms  173.948 ms
12  ae-41.r02.snjsca04.us.bb.gin.ntt.net (129.250.6.119)  183.971 ms  179.105 ms  185.893 ms
13  eqx-sj.es.net (206.223.116.137)  194.576 ms  201.395 ms  193.408 ms
```