facebook

The Road To IPv6

Bumpy

Paul Saab
Infrastructure
2014/03/20

Agenda

Motivation

Motivation

- We're out of RFC1918
  - More on this later.
- Why maintain two stacks in your entire network?
  - Much easier to handle two stacks at the edge and one internally.
- It needs to be done someday, why not now while we're motivated?
- Stop engineers from continually writing IPv4 only code that will need to be fixed later.
- Push the industry to move faster and re-prioritize IPv6.

Running out of RFC1918

16,777,216 addresses isn’t enough

/24 for every rack – Genius!

- Math is easy
- Subnet mask is easy to remember
- Wastes a lot of space
  - 254 usable addresses
  - 80 addresses in a rack
- /25 is what we could re-number into
  - Not enough savings
- Do it if you want to get to IPv6 faster

Solutions

- re-number/re-subnet IPv4
  - Too much code assumed racks are /24
  - Too much code assumed clusters are /n (where n < 24)
  - /25 doesn't save us much
- IPv6
  - Easier to overlay IPv6 on top of the network than re-subnet
  - Can be done without taking datacenters/clusters offline
  - Most importantly, you can test incrementally and iterate

IPv6 @ face:booc

79,228,162,514,264,337,593,543,950,336 addresses enough?

The Network

- Each rack is a /64
- Each cluster is a /n (where n < 64)
- Layer 3
  - Core should not handle Neighbor Discovery
  - fping6 –g xxx::/64 confined to a rack
  - Just Do It

The Problems - Switches

- Vendors do not QA IPv6 like they do IPv4
- Started seeing multi-second latency to hosts over IPv6
  - Occurred when host eth link goes up and down
  - Suspected Linux
- Turns out vendor batch updated to the hardware table
  - Add and Delete occurred in the same batch
  - Ended up software switching
- Set us back about 6 months
  - Thousands of racks had to be upgraded

The Problems – Switches (cont)

- Hardware ASIC has a separate ECMP table for /65 - /128 routes
  - Total of 127 entries
  - Forced us to use /64 for route all route injection
  - Required us to renumber
- Dual BGP sessions
  - Cluster switches could not support that many BGP sessions
  - Forced to run IPv4 and IPv6 over a single BGP session
- Turning on IPv6 Address Family on BGP sessions to rack switches that did not have IPv6 enabled crashed all of the rack switches. Awesome!

The Problems – Switches (cont)

- Multi-second latency returned again!
  - Issue was between the rack switch and the cluster switch
  - No rebuild was needed, just a one line configuration change
- Uneven traffic across multiple links
  - Issue between the rack switch and cluster switch
  - BGP comes up before Neighbor Discovery
  - Traffic goes only over links where ND happened before BGP

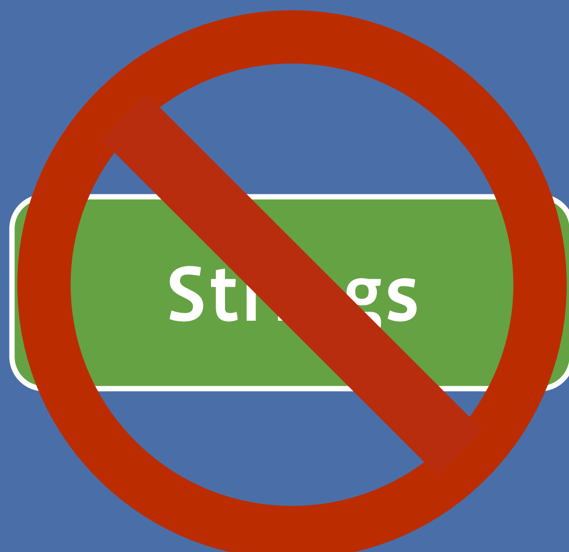
The Problems - PHP

- ip2long is the devil
  - IP addresses are not integers (or strings!)
- Inconsistent API's to use IPv6 addresses.
  - Some functions expect a URL (must enclose with brackets for IPv6)
  - Some functions expect just an IP (no bracket)

The Problems – Strings

- Java's InetAddress produces different zero compressed string than glibc, FreeBSD, and MacOS X
  - pick a format and normalize all input
  - regex matching (10000000 different ways to match an IPv6 address)
- "host:port".split(':'), explode(':', "host:port")
  - everyone assumes you can split on a ':' to extract a host port
  - IPv6 addresses must be enclosed in '[]', adds complexity
- strcmp(ip1, ip2) == 0
  - "2a03:2880::1" != "2a03:2880:0000:0000:0000:0000:0000:0001"

The Problems – Storage



Store all in binary format

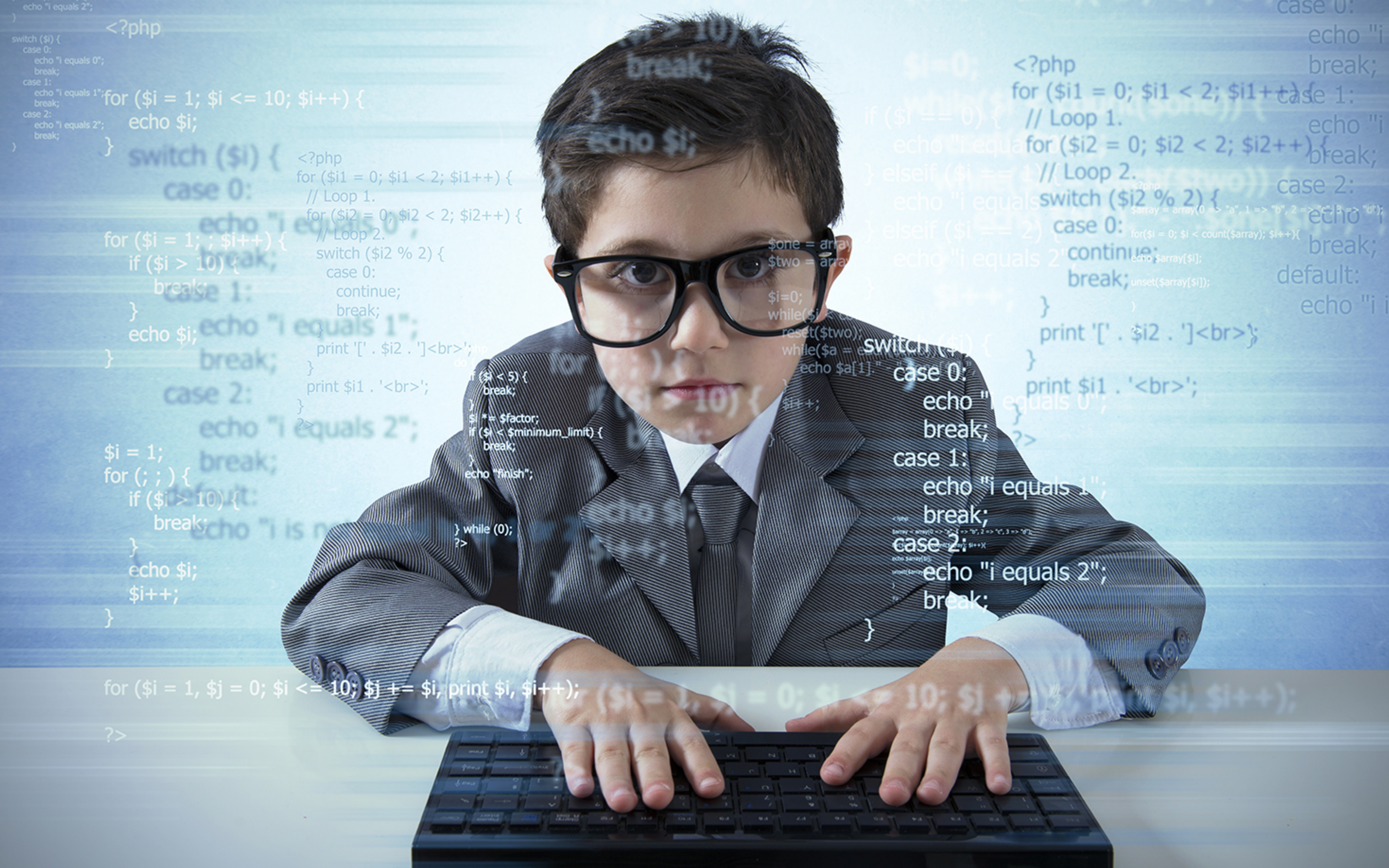
- In MySQL use VARBINARY(16)

The Problems – < glibc-2.17

- getaddrinfo(ipv6-ip-address) failed with EAI_FAMILY
  - Happens once, and continues until process is restarted
  - Single netlink socket failure inside glibc causes this
  - Not fixed until glibc-2.17

The Problems – Engineers & AF_INET

- GRRRRRRRRRRR
- Engineers have been trained to write IPv4 only code
  - Must educate the usage of getaddrinfo(3)
  - Teach engineers about how to use the hints to getaddrinfo(3)
    - AF_UNSPEC
    - AI_ADDRCONFIG | AI_PASSIVE
- New code constantly being written IPv4 only
- Solution
  - Take away IPv4 on development systems in 2014



<?php
for ($i = 1; $i <= 10; $i++) {
echo $i;
}
switch ($i) {
case 0:
for ($i = 1; ; $i++) {
if ($i > 10) {
break;
}
echo $i;
}
$i = 1;
for (; ;) {
if ($i > 10) {
break;
}
echo $i;
$i++;
}
for ($i = 1, $j = 0; $i <= 10; $j += $i, print $i, $i++);
?>
<?php
for ($i1 = 0; $i1 < 2; $i1++) {
// Loop 1.
for ($i2 = 0; $i2 < 2; $i2++) {
// Loop 2.
switch ($i2 % 2) {
case 0:
continue;
break;
}
print '[' . $i2 . ']
';
}
print $i1 . '
';
}
?>
switch ($i) {
case 0:
echo "i equals 0";
break;
case 1:
echo "i equals 1";
break;
case 2:
echo "i equals 2";
break;
}
} while (0);
?>

The Problems – SLAAC vs Static Assignment

- SLAAC
  - Great idea
  - Terrible for datacenter deployment
  - NIC changes, IP address changes
- Static Assignment
  - Avoid encoding IPv4 address in the IPv6 address
    - But it makes mapping back and forth easy!
    - What happens when you stop using IPv4?
    - Take the opportunity to have a clean slate with no dependencies

The Problems – Linux

- Routing table
  - Max size defaults to 4096
  - Runs garbage collection when there are more than 512 entries
  - *ALL* connections are cached in the routing table
    - Default TTL is 30 seconds
    - Lots of churn happens
    - ip -6 route show can take forever or even duplicate output
    - /proc/net/ipv6_route returns ENOMEM with 1000s of connections (netstat)

The Problems – Linux

- non-eth0 addresses unusable on network restart
- options ipv6 disable=1
  - Requires a reboot to enable IPv6
  - blacklist ipv6 allows you to load IPv6 on a running system
- options ipv6 autoconf=0
  - SLAAC is terrible for datacenter deployments
  - Do not want multiple addresses on eth0

The Problems – AAAA records

- Can break applications which were not expecting an IPv6 address
- IPv4 hosts can "fallback" to IPv6 if IPv4 fails to connect
  - Get back EAFNOSUPPORT
  - Engineers complain
  - getaddrinfo(3) returns a list of addresses that applications walk connecting to until one succeeds
- No need with adequate service discovery
- Turn on selectively

The Problems – Applications

- MySQL 5.6 is required for IPv6 client and server
- Curl
  - Very hostile to the format of the IPv6 address
  - Wants everything bracket enclosed
  - Many IPv6 bugs that only recently were fixed
- Understand operational behavior of app on IPv4
  - Engineers don't monitor under IPv4
    - All of a sudden they are interested in monitoring when turning on IPv6
  - Busted code is agnostic to IP protocols

The good stuff

It wasn't all bad

The Good

- We were able to get rid of a lot of technical debt
- IPAddress class
  - Death to strings and integers
- Rollout of traffic
  - Most services were able to slowly roll out IPv6 from 0-100%
  - Instantaneous rollback if needed
  - Problems may not show up at 1%, 5% or 10%, but they do at 100%
- Iterate Iterate Iterate
  - Don’t make IPv6 an all or nothing proposition. You will fail.

The Good – Neteng @ Facebook

- Backbone was upgraded a couple of years ago
- Clusters were converted to Layer 3
- IPv6 native to all cluster and rack switches after World IPv6 Day
- The real heroes

The Good

- APIs to detect if host supported IPv6 and it had *working* IPv6
  - Not all hosts had working IPv6 until recently
- IPv6 became a native component of our service discovery framework
  - all services to be dual stacked
  - ip:port no longer a reasonable way to identify a service
- Thrift already supported IPv6
  - Most of our non-memcache traffic is thrift
  - Initially supported IPv6 with V4MAPPED
  - Separate AF_INET and AF_INET6 sockets today

The Good

- Automation built to handle rack switch upgrades
  - It could never be done
  - Empowered engineers to do their own maintenance
  - We finished it

Where are we now?

Where are we now?

100%

of our hosts we care about respond on IPv6

- Hosts that are not IPv6 ready are going away

75%

of our internal traffic is now IPv6

- 100% Q3 2014 (or earlier)

98%

of traffic in & out of HHVM is IPv6

100%

of our memcache traffic is IPv6

100%

IPv6 only (no RFC1918) in 2-3 years

Where are we now? (cont)

- New IPv6 traffic showing up daily
  - Engineers asking if they can start writing IPv6-only code today
- Latency and other metrics show IPv6 to be the same as IPv4
- Plans for first IPv6 only cluster (no RFC1918) by end of 2014
- We will not remove RFC1918 from existing clusters