# Some Predictions about IPv4, IPv6, and Your Boss

Lee Howard

Retevia

# The Peter Principle

Managers rise to the level of their incompetence.

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# IPv6 Business Case

- GOAL:
  To help you
  build a business case in ten minutes,
  supported by metrics,
  to convince management
  to work on an IPv6 plan.

  - Secondary Goal: Provide all of the metrics in one place.

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# Motivation

- What motivates you?
  - Autonomy. Choosing how to do your work.
  - Mastery. Learning new technologies.
  - Purpose. Feeling like your work matters.
    - Dan Pink, Drive https://youtu.be/u6XAPnuFjJc

- What motivates your boss?
  - Risk aversion
  - Competition
  - Cost reduction
  - New capabilities/New revenue

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# Motivation: Risk

- Risk
  - Running out of IPv4 addresses
  - Risk of something being IPv6-only too soon
- Competition
  - Growth rate in your country
  - Latency

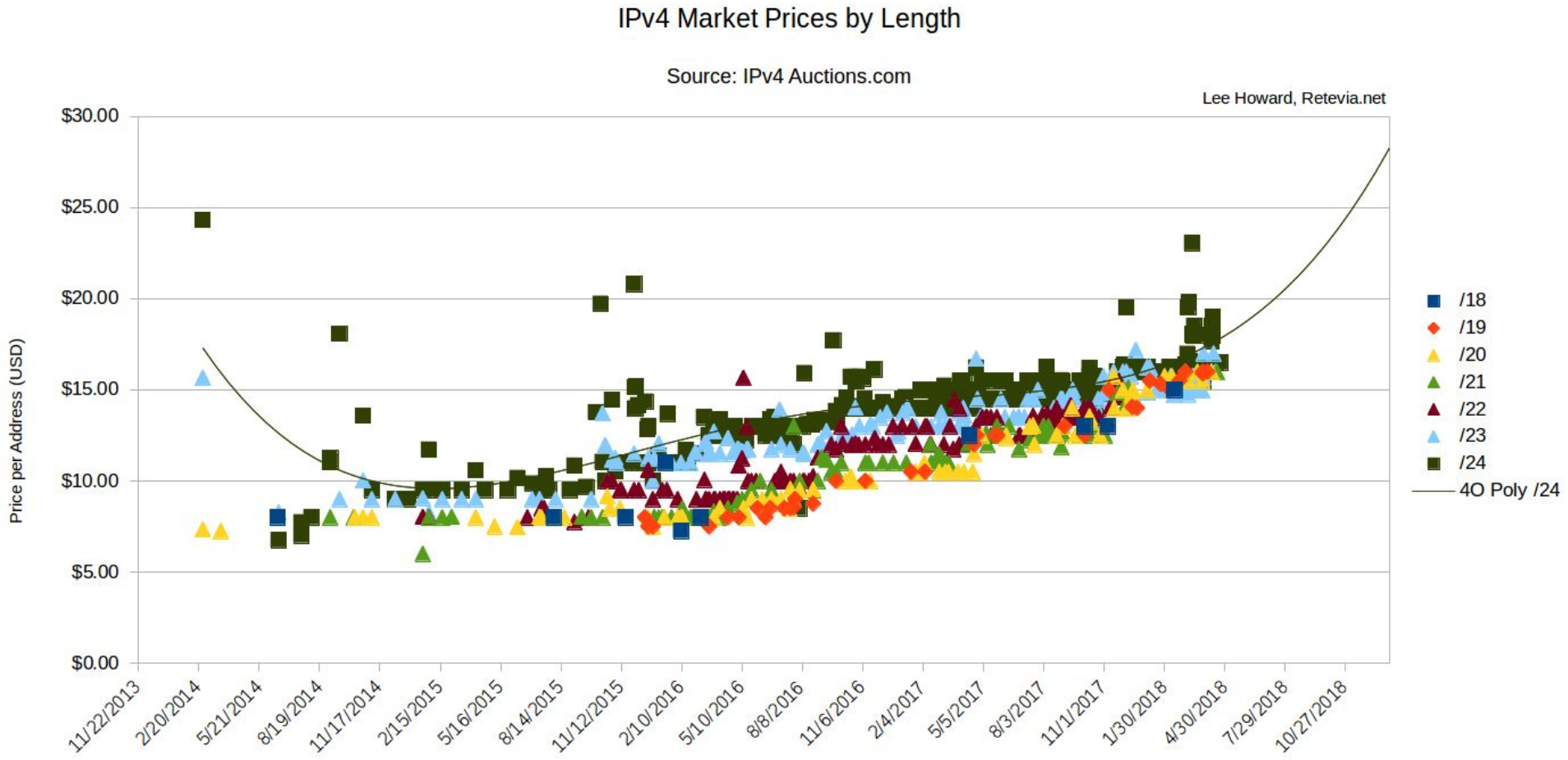
# Motivation: Risk

- Running out of IPv4 addresses

*At our current growth rate, we will run out of IPv4 addresses by D date. We have three choices:*

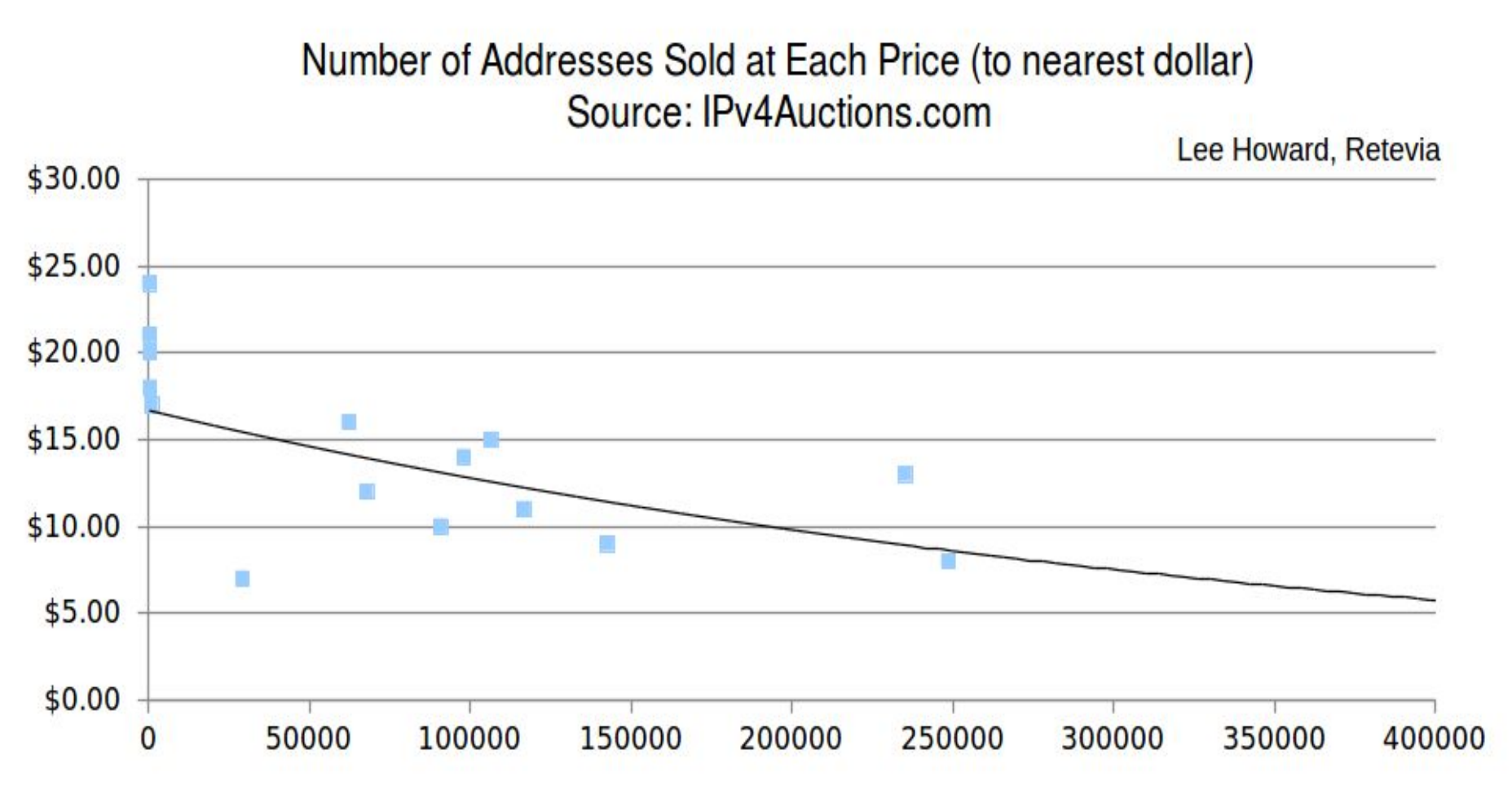
1) *Deploy CGN. All traffic for all new and some current customers will go through it.*
2) *Buy IPv4 addresses. At our current rate, a two year supply will then be X addresses. Looking at the current IPv4 market, that will cost Y.*
3) *Deploy IPv6+IPv4aaS. We need to do a full assessment to see if we can do it in time. IPv4aaS means a fraction of traffic will use NAT.*

# Cost Reduction / New Revenue




Remember TCO of CGN? At what price is it more expensive to buy addresses than to deploy IPv6? http://ipv6.nanog.org/meetings/abstract?id=2025

# Cost Reduction / New Revenue



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# Motivation: Risk

- Risk of something being IPv6-only before you're ready

*At the current growth rate, 80% of the world will have IPv6 in four years. Most of them will use translation (IPv4aaS), so IPv4 performance will suffer.*
https://docs.google.com/spreadsheets/d/1ksOoWOaRdRyjZnjLSikHf4O5L1OUTNOO_7NK9vcVApc/edit#gid=0

*There is a significant risk that in the next 4-10 years, something we need will be IPv6-only. Or something our customers need. Or maybe not IPv6-only, but IPv6-cheaper.*

# Risk: IPv6-only


https://www.vyncke.org/ipv6status/project.php

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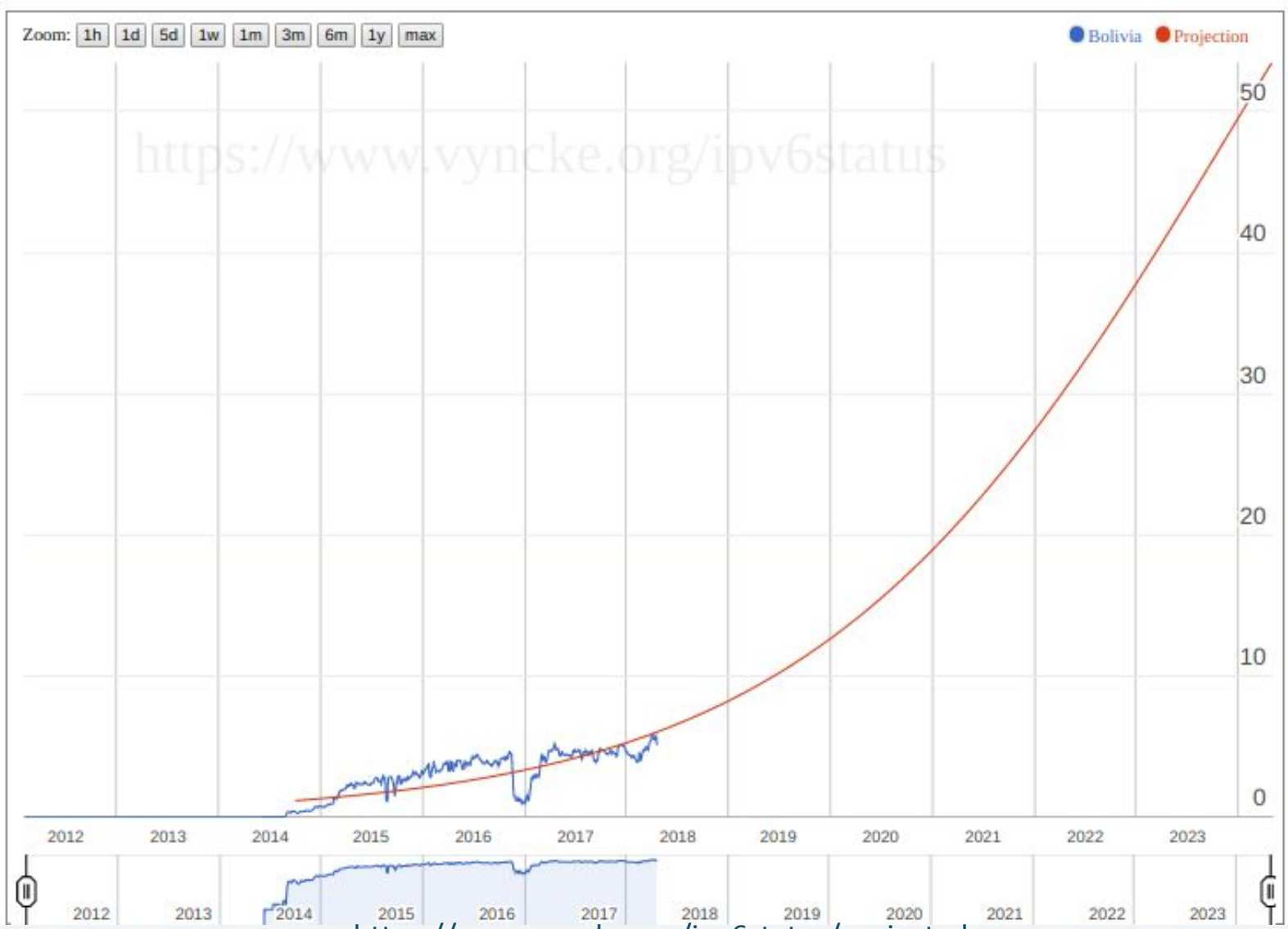


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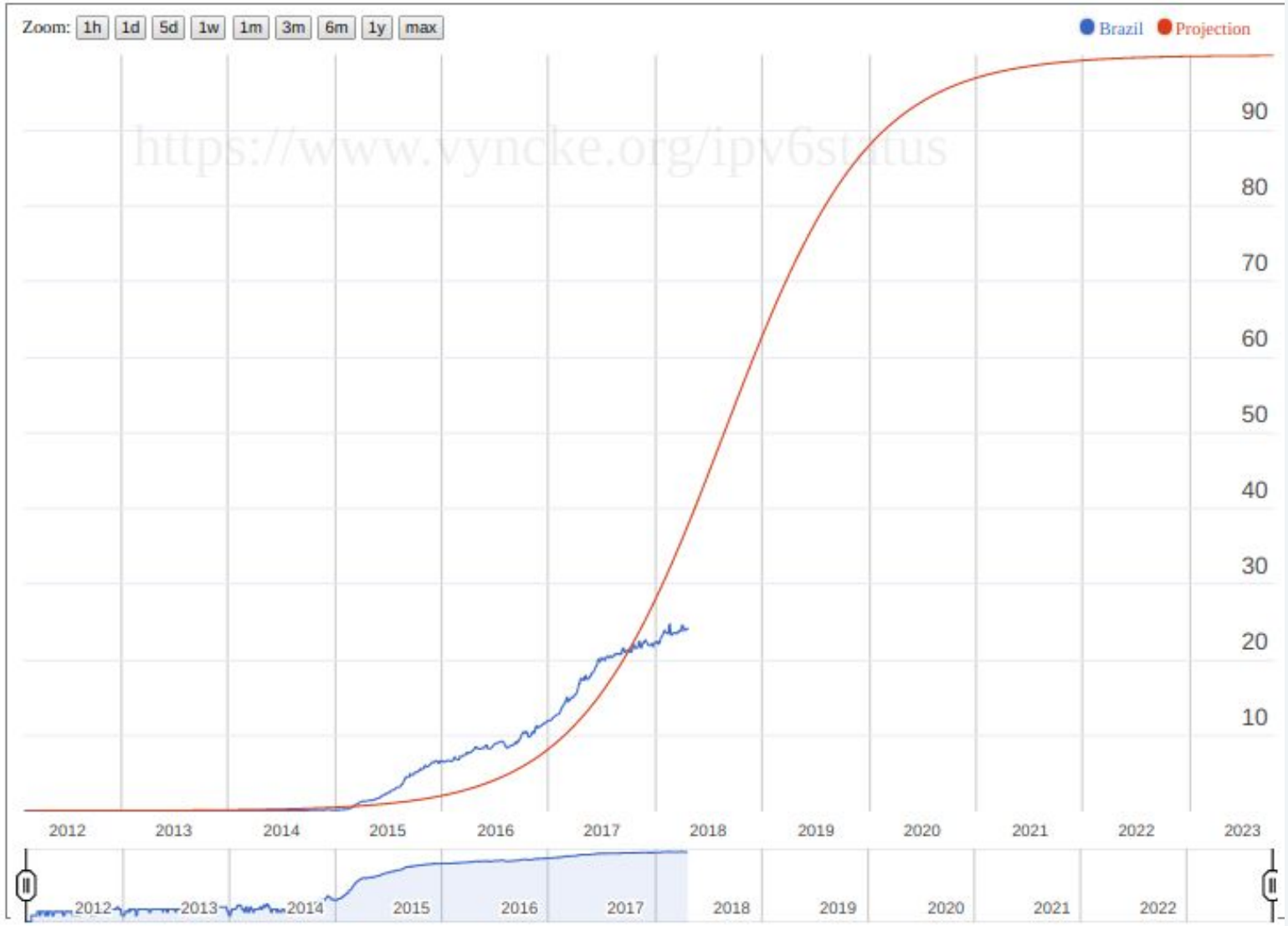


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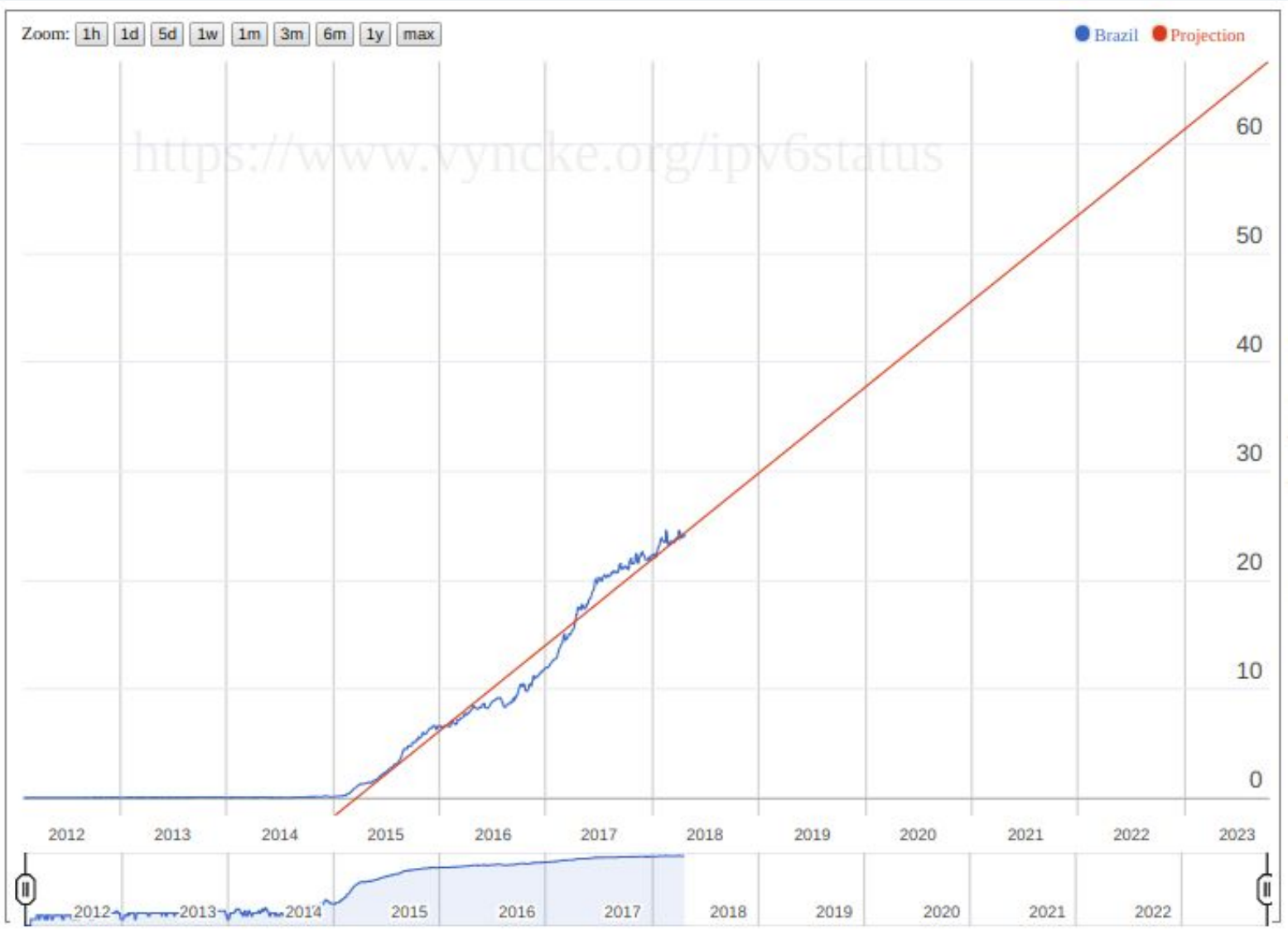


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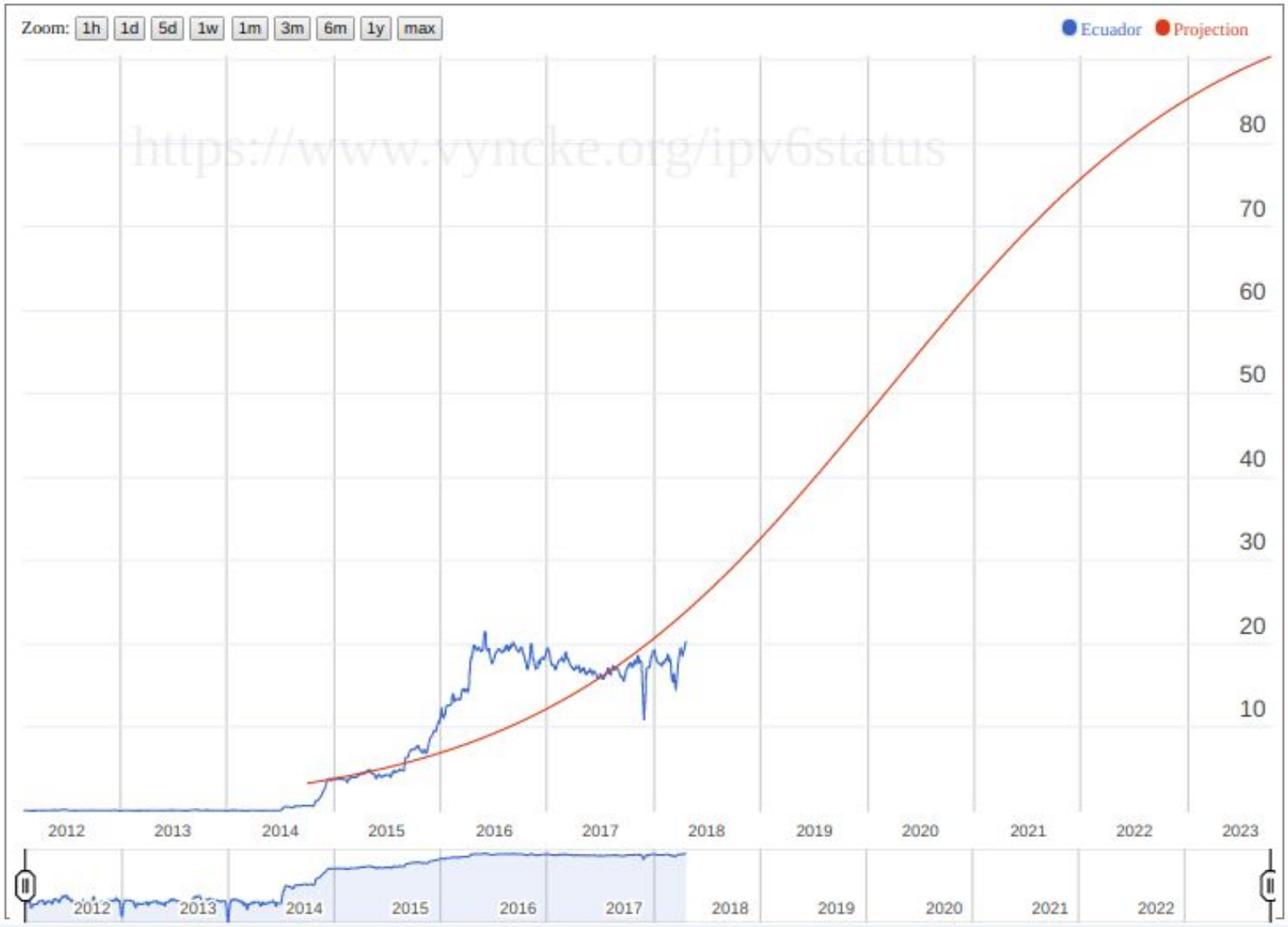


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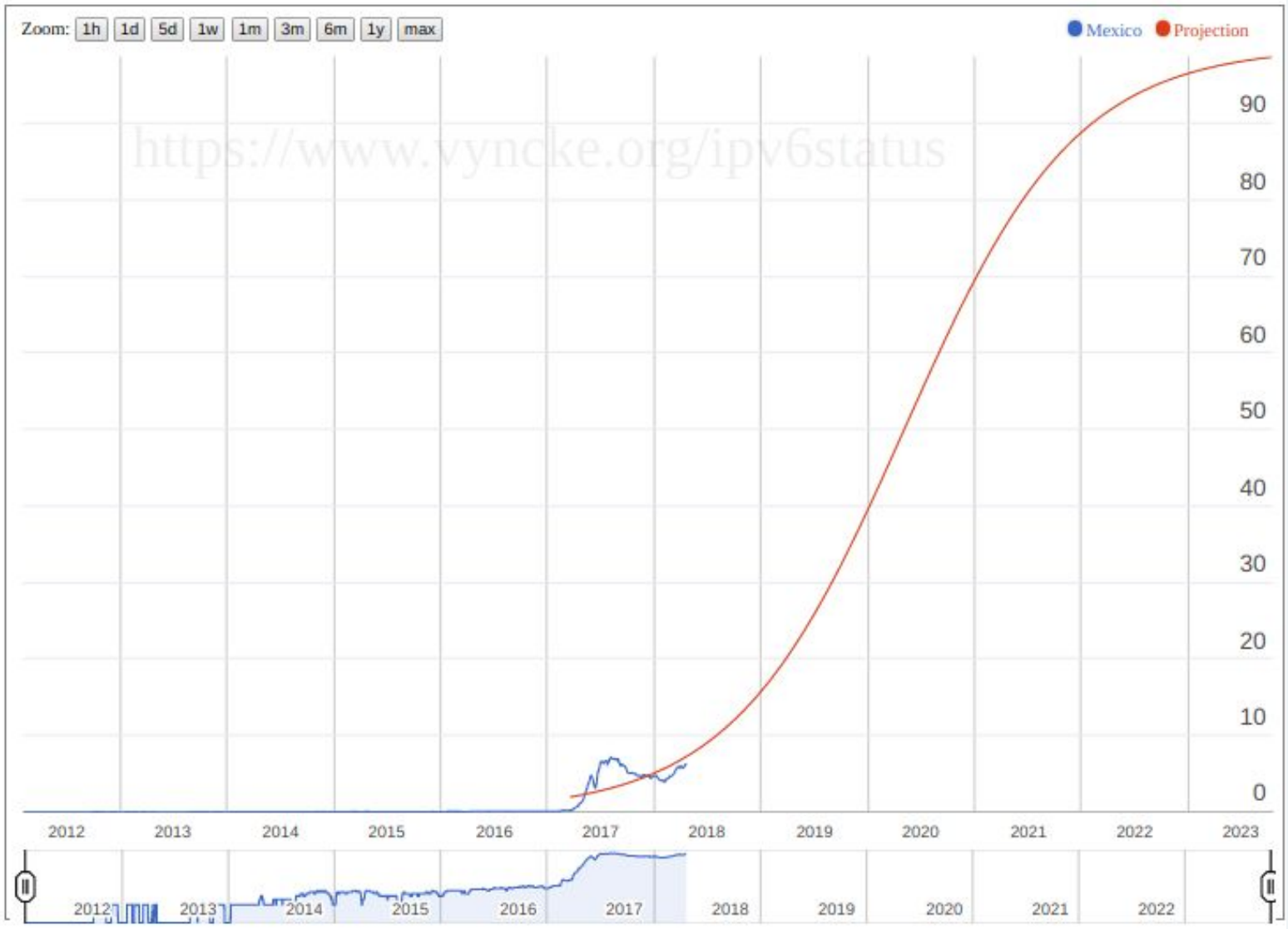


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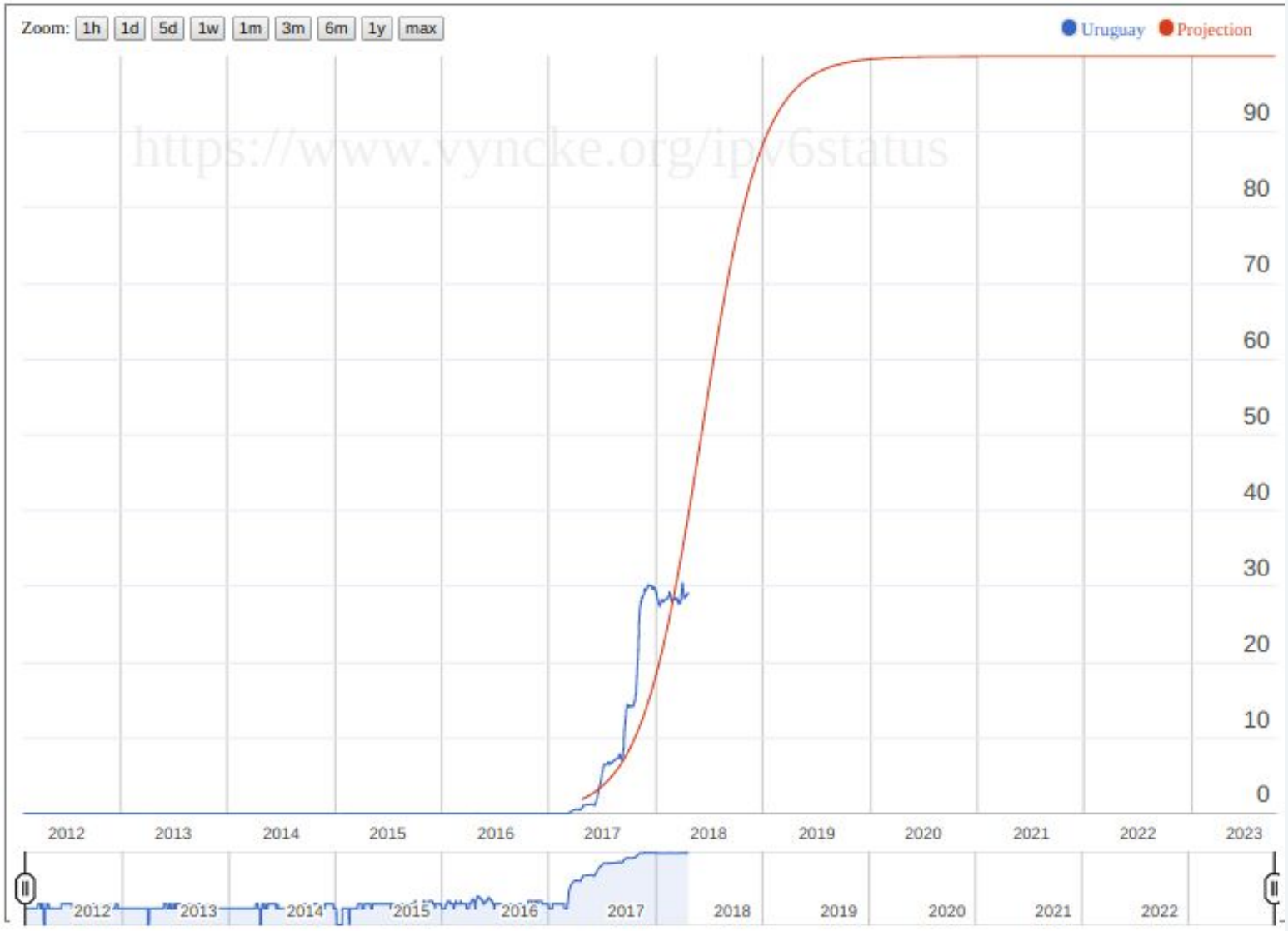


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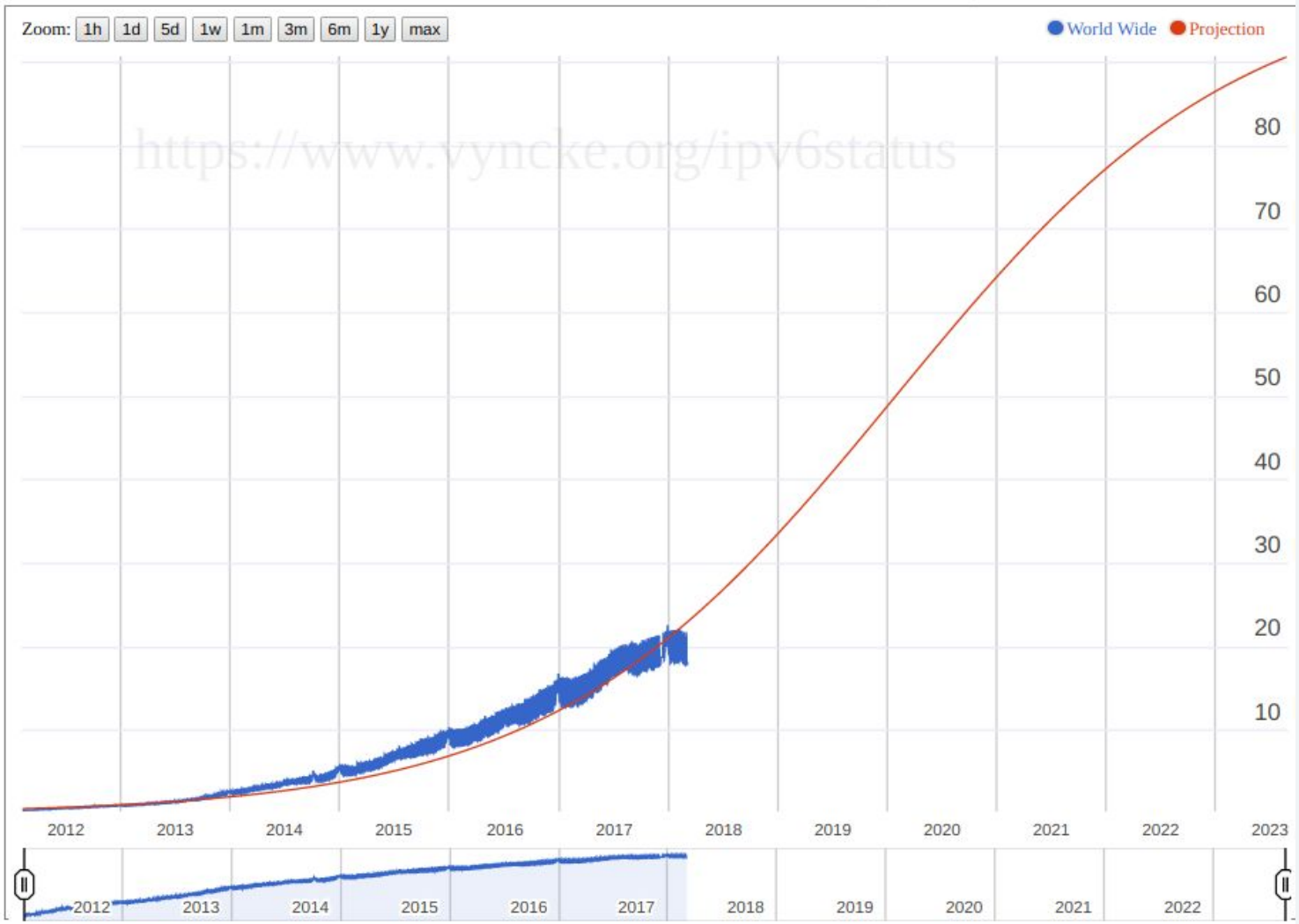



https://www.vyncke.org/ipv6status/project.php

# Risk: IPv6-only

| ASN | AS Name | IPv6 Capable | IPv6 Preferred | Samples |
|---|---|---|---|---|
| AS21951 | STOLAF - St. Olaf College | 99.38% | 96.23% | 1,778 |
| AS36384 | GOOGLE-IT - Google LLC | 99.37% | 98.63% | 18,201 |
| AS62023 | NYNEX | 99.22% | 97.00% | 1,402 |
| AS54115 | FACEBOOK-CORP - Facebook Inc | 98.18% | 87.32% | 2,200 |
| AS393869 | CMC - COLORADO MOUNTAIN COLLEGE | 98.18% | 95.11% | 879 |
| AS3598 | MICROSOFT-CORP-AS - Microsoft Corporation | 97.86% | 96.88% | 143,175 |
| AS393475 | AS-DYNATRACE-01 - Dynatrace | 97.51% | 97.26% | 402 |
| AS3676 | UIOWA-AS - University of Iowa | 97.36% | 95.65% | 15,018 |
| AS30013 | PIXAR-AS - Pixar | 96.88% | 96.88% | 64 |
| AS13953 | SVCC-EDU - Sauk Valley Community College | 95.19% | 93.05% | 187 |
| AS1312 | VA-TECH-AS - Virginia Polytechnic Institute and State Univ. | 94.88% | 93.01% | 23,400 |
| AS63056 | HOOPESTON-AREA-SCHOOLS - Hoopeston Area Schools | 94.12% | 90.20% | 51 |
| AS29848 | WCU - West Chester University of Pennsylvania | 93.57% | 91.26% | 4,155 |
| AS41264 | GOOGLE-IT-RO-ISP | 93.45% | 92.12% | 977 |
| AS21928 | T-MOBILE-AS21928 - T-Mobile USA, Inc. | 93.15% | 92.23% | 8,511,804 |
| AS3685 | BUFFALO-ASN - State University of New York at Buffalo | 92.41% | 91.07% | 12,379 |
| AS2698 | IASTATE-AS - Iowa State University | 92.04% | 89.69% | 42,209 |
| AS26462 | AS-GENESEO - SUNY Geneseo Computer Center | 92.02% | 89.24% | 3,998 |
| AS22418 | COLOG - Cologuard | 90.91% | 27.27% | 66 |
| AS6124 | MARIST - Marist College | 90.52% | 87.42% | 3,091 |
| AS6167 | CELLCO-PART - Cellco Partnership DBA Verizon Wireless | 89.25% | 73.79% | 763 |
| AS14298 | EPA-NET - Environmental Protection Agency | 88.63% | 86.88% | 1,319 |
| AS36444 | NEXCESS-NET - NEXCESS.NET L.L.C. | 88.24% | 88.24% | 102 |
| AS17234 | GAC - Gustavus Adolphus College | 87.97% | 84.96% | 2,294 |
| AS16591 | GOOGLE-FIBER - Google Fiber Inc. | 87.01% | 84.35% | 381,734 |
| AS25 | UCB - University of California at Berkeley | 86.87% | 83.28% | 9,458 |
| AS22394 | CELLCO - Cellco Partnership DBA Verizon Wireless | 86.66% | 84.05% | 10,259,416 |
| AS55 | UPENN - University of Pennsylvania | 84.82% | 79.96% | 3,268 |
| AS17244 | MCNEESE - McNeese State University | 83.10% | 81.69% | 284 |
| AS20130 | DEPAUL - Depaul University | 82.65% | 81.13% | 3,100 |
| AS7233 | YAHOO-US - Yahoo | 82.65% | 81.63% | 196 |
| AS7018 | ATT-INTERNET4 - ATT Services, Inc. | 81.66% | 75.67% | 17,284,758 |

https://stats.labs.apnic.net/ipv6/US

U.S. Mobile Carriers combined: >75%

# Risk: IPv6-only

| | |
|---|---|
| IPv4 ASes | 54577 |
| IPv6 ASes | 13985 |
| ASes using only IPv4 | 40858 |
| ASes using only IPv6 | 266 0.5% |
| ASes using IPv4 and IPv6 | 13719 |
| ASes using IPv4 or IPv6 | 54843 |

http://bgp.he.net/ipv6-progress-report.cgi

# Motivation: Competition

- Growth rate in your country

*At the current growth rate, 80% of people in our country will have IPv6 by X date. Our competitors are deploying at a high rate. There is a risk that one of our competitors will have an advantage in service.*

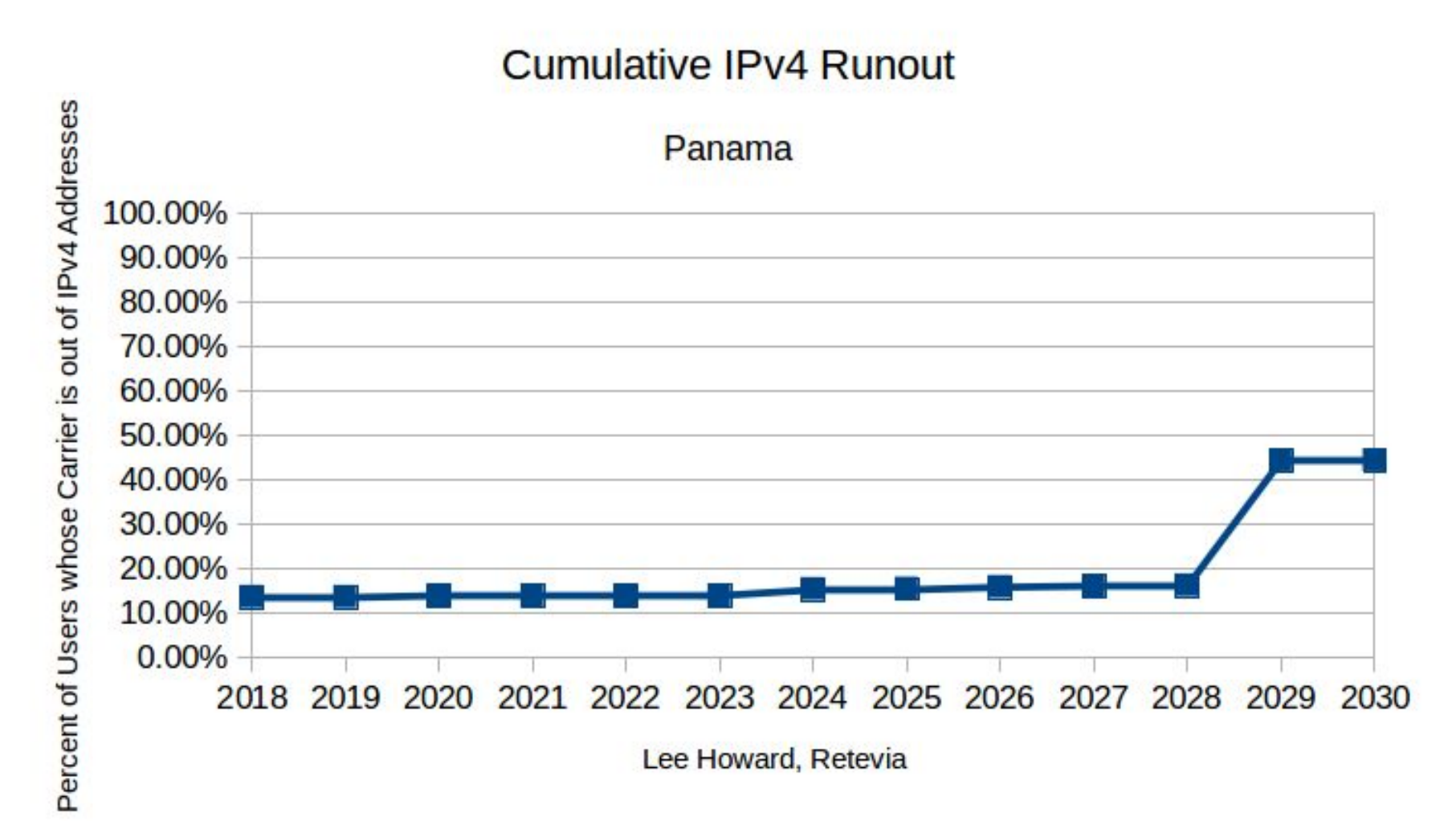
To see your competitors' growth rates, click on them at https://stats.labs.apnic.net/ipv6/CC (where CC is your Country Code)

# Methodology

## Warning: The next few slides are a work in progress!

- For #users, used Samples from APNIC's statistics
  - https://stats.labs.apnic.net/ipv6/EC
  - Correlates pretty closely with number of users.
- Took growth rate for Internet penetration for the country. Assumed growth is evenly distributed.
- #Users / $IPv4 addresses announced in BGP = percent utilization.
- When utilization > 100%, that ASN's percent of the country has run out.

# Motivation: Competition



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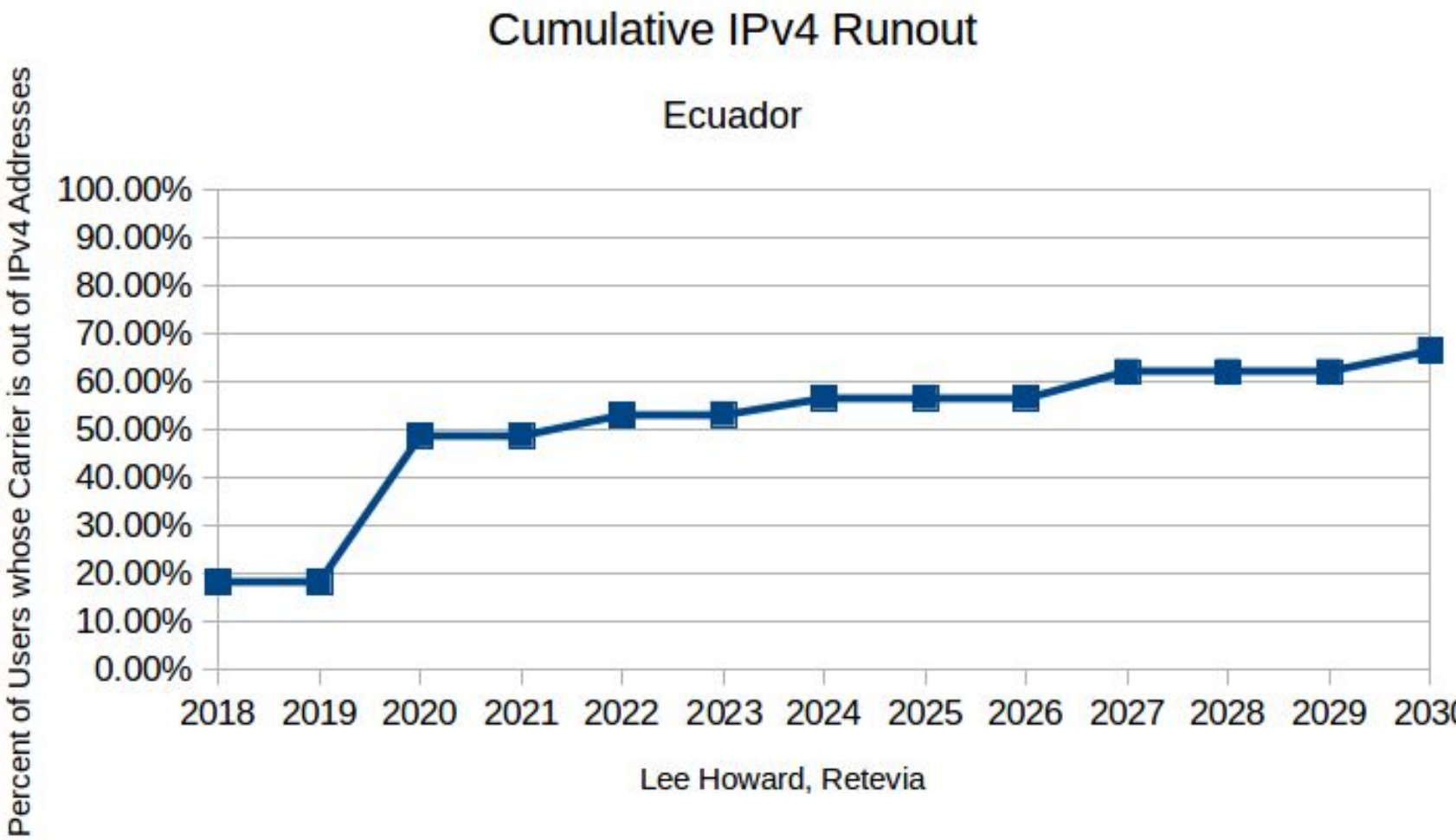

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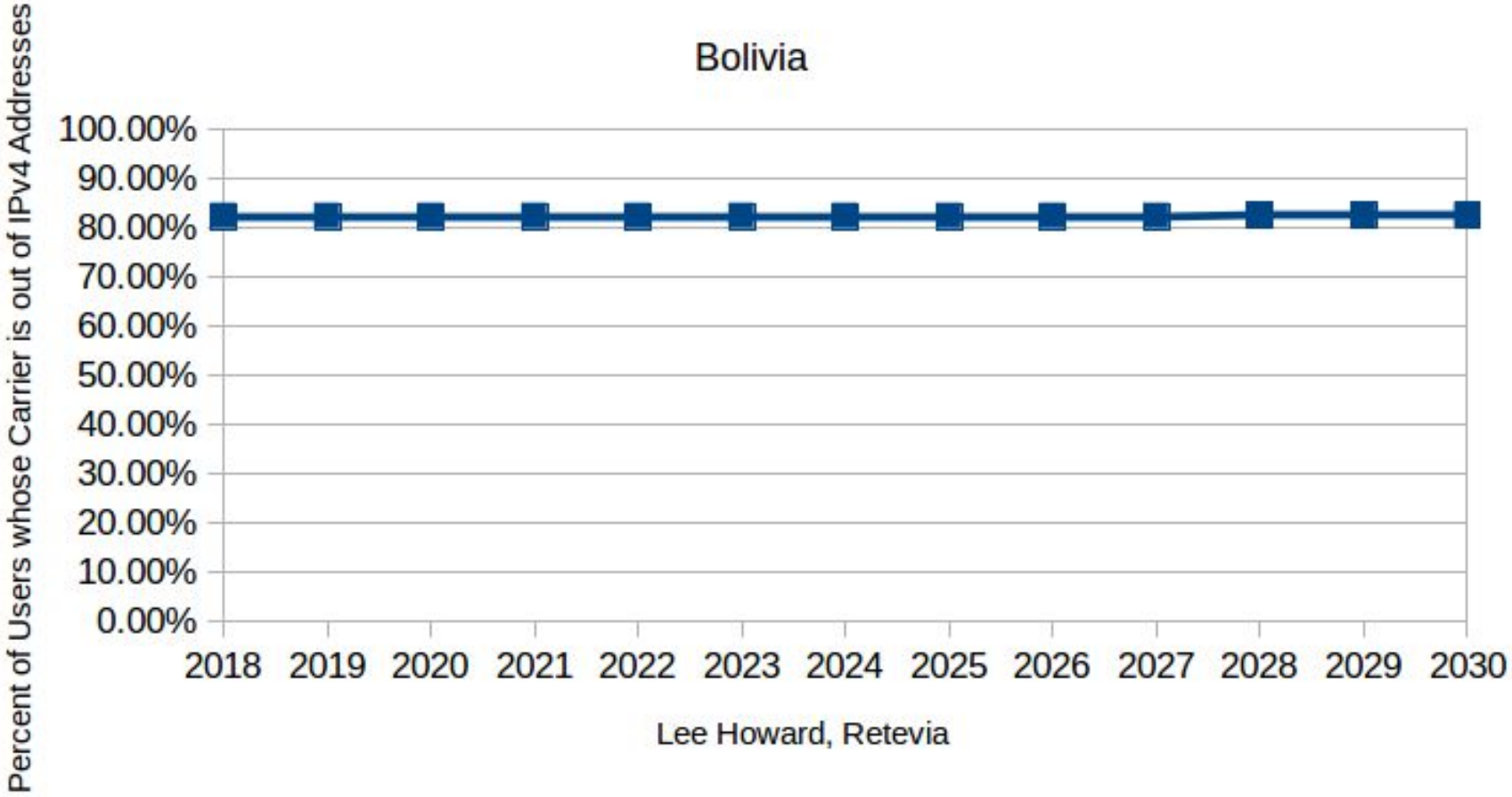


# Motivation: Competition

Latency

## Where is latency important to us?

*Mobile providers are 5-30% faster with IPv6.*

*We need to plan to deploy IPv6 before our competition advertises their advantage.*

- Consider both Internet-facing servers and user experience
- IPv6 is 15% faster on average
- IPv6 is 40% faster in some mobile networks

Really?

# Competition: Latency

We performed such an experiment looking at one specific site (URL) on one specific device (**iPhone**) on one network (**Verizon**), and we saw that the selected sites load **5% faster in median** and **15% faster for the 95% percentile** on IPv6 compared to IPv4.

https://blogs.akamai.com/2016/06/preparing-for-ipv6-only-mobile-networks-why-and-how.html

*Measurements using Akamai's RUM system have also shown measurable performance improvements for US mobile users from dual stacking content.*

*https://blogs.akamai.com/2016/10/ipv6-at-akamai-edge-2016.html*

# Competition: Latency

Data Center ▸ Networks

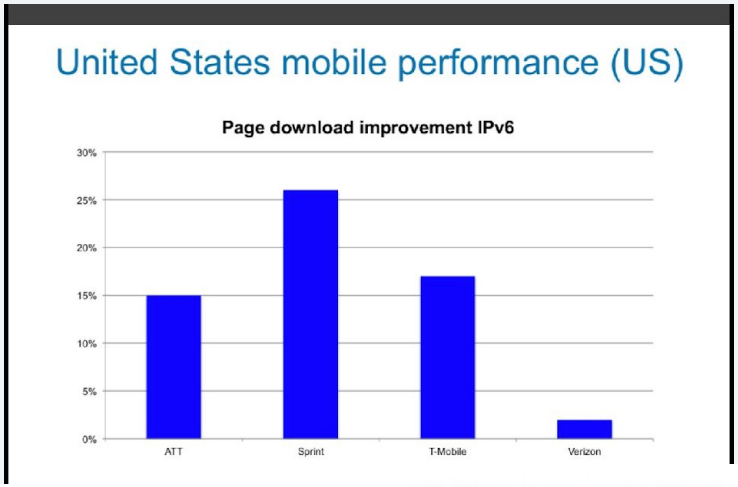
## IPv6 now faster than IPv4 when visiting 20% of top websites – and just as fast for the rest

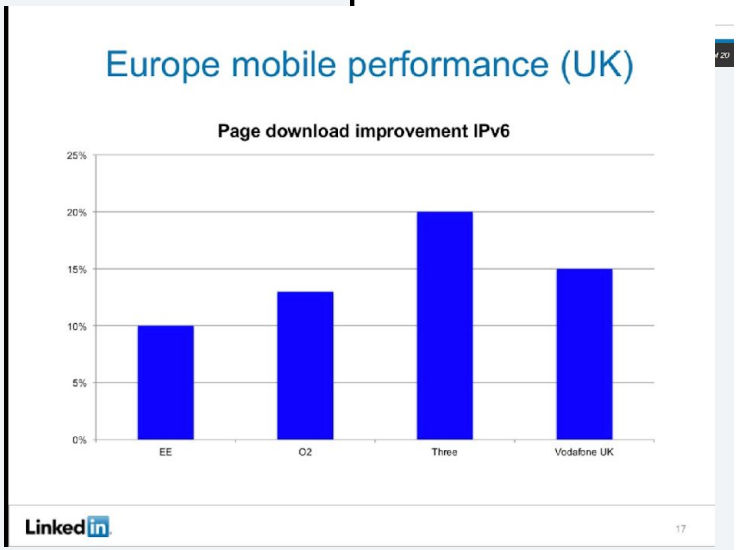
The long and painful transition is getting there

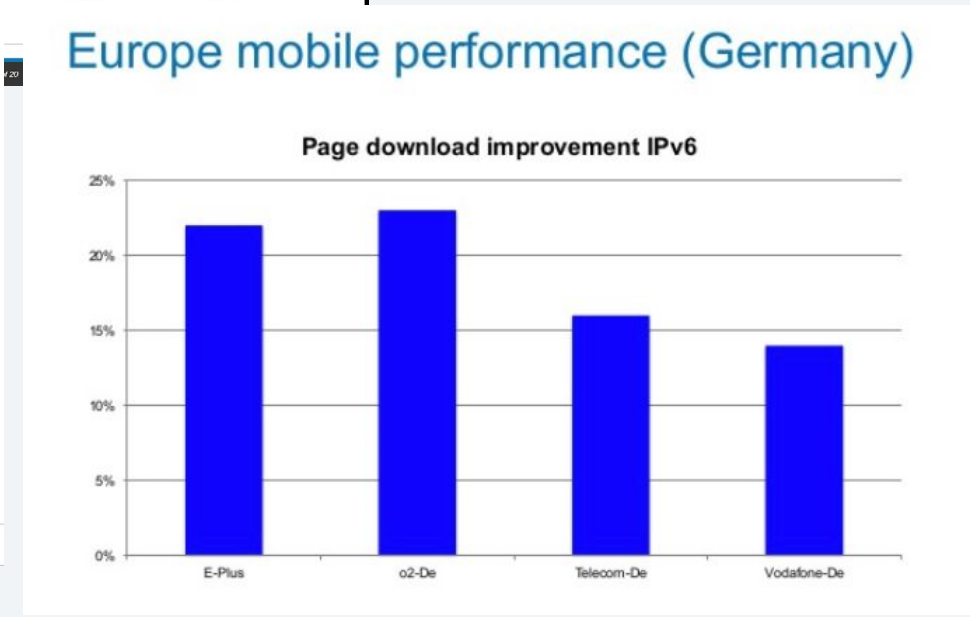
By Kieren McCarthy in San Francisco 28 Jul 2016 at 19:29 99 SHARE ▾

https://www.theregister.co.uk/2016/07/28/ipv6_now_faster_a_fifth_of_the_time cites
http://dl.acm.org/citation.cfm?doid=2959424.2959429 Vaibhav Bajpai and Jürgen Schönwälder

# Competition: Latency




https://www.linkedin.com/pulse/ipv6-measurements-zaid-ali-kahn/

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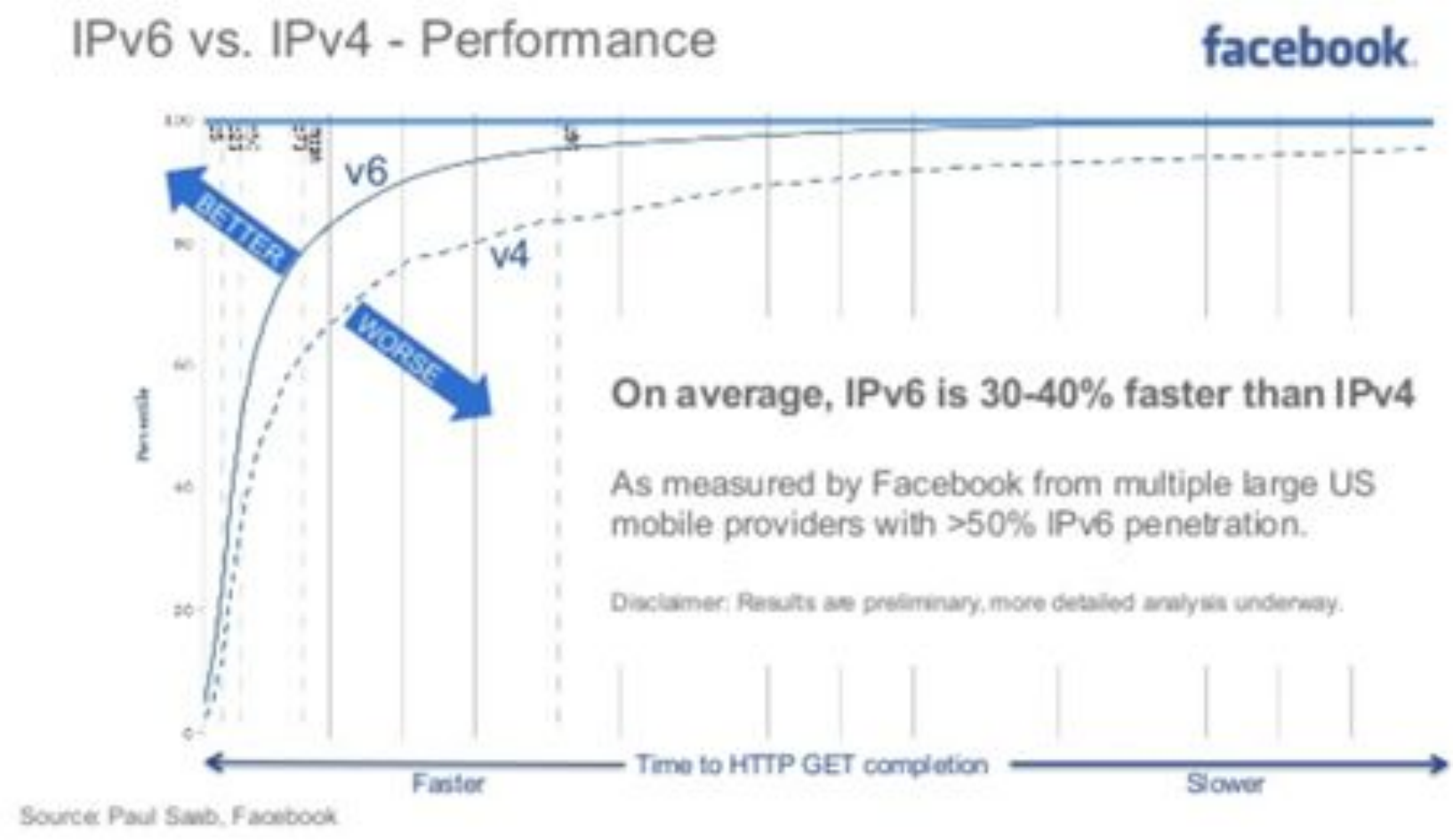


https://community.infoblox.com/t5/IPv6-CoE-Blog/Can-IPv6-Rally-Be-Faster-than-IPv4-Part-1/ba-p/6419

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# Motivation: Greed

- Cost reduction
  - Avoiding buying IPv4 addresses
  - Minimizing translation
- New Revenue, New Capabilities
  - Sell addresses
  - Service Bits
  - IPv6 Segment Routing
  - Process IDs in IP
  - Containerization

# Motivation: Cost Reduction

What cost for IPv4 addresses would make deployment worthwhile?

*At current deployment rates, our current growth rate, we will run out of IPv4 addresses by D date.*
*If the IPv4 market continues as it has been, by that time the price per address will be Z.*

- *A two year supply will then be X addresses. X*Z=$$*
- *A five year supply will then be Y addresses. Y*Z=$$*

# Motivation: Reducing Costs

- Reduce need for NAT with Native IPv6
- Simplify network

*NAT44 may cost us X per year in increased calls and upset customers. IPv4 address prices could exceed $30 each next year. We ran a report on the outages for the last six months, and we estimate simplifying our network with (SRv6 or Containers with IPv6) would reduce Y hours of down time (# customers times # hours).*
*Simplifying the network this way would reduce engineering and operations time by Z hours.*

TCO of CGN: https://ripe67.ripe.net/presentations/188-The_Cost_of_IPv4-IPv6_Transition.pdf

# Motivation: Revenue

- Sell addresses

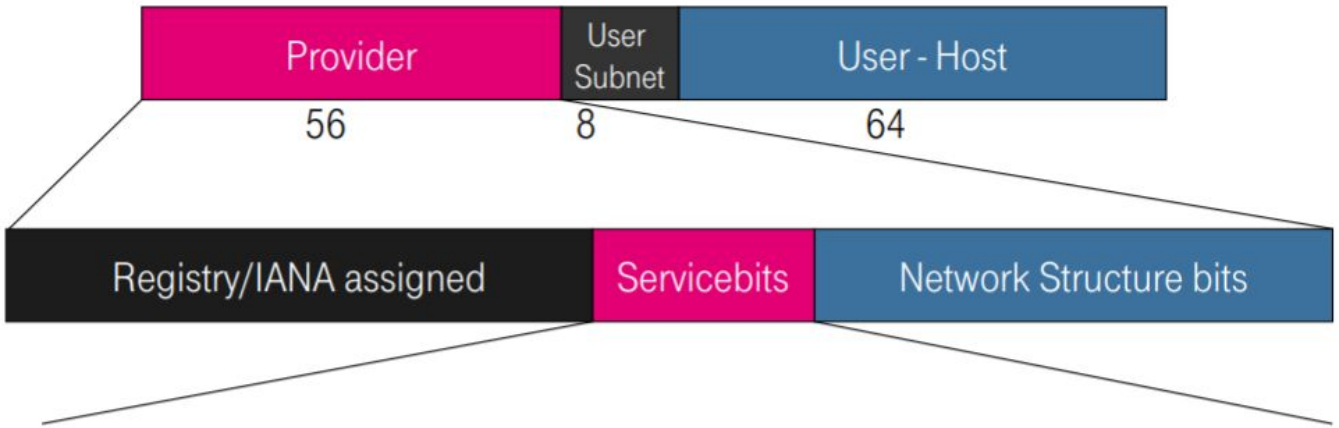
*Prices for IPv4 are rising. If we renumber into IPv6 and use translation (IPv4aaS), we can sell $X$ IPv4 addresses for an estimated $Y$. We have to move before the market falls.*

- Additional services and policy: Service bits

*I saw a neat thing at LACNIC, let me send you some URLs.*

# New Capabilities: Service Bits

## USING IPv6 ADDRESS SPACE AS LABELS




| | | |
|---|---|---|
| P Public | 0=SP-intern, 1=extern | |
| I Infrastructure | 0=end user, 1=infrastructure packet | |
| E Endpoint/Service | 0=endpoint, 1=service | |
| SSS Logical Nw (int. ISP)# | 0=res, 1=internet, 4=video, 5=L2, 6=voice, 7=mgmt | |
| Examples: | Source PIESSS | Destination PIESSS |
| User -> Voice | 000110 | 011110 |
| Voice -> User | 011110 | 000110 |
| User -> User (best effort) | X00001 | X00001 |
| User -> Internet (best effort) | 100001 | XXXXXX |
| Internet -> User (best effort) | XXXXXX | 100001 |
| Lan-Lan service | 010101 | 010101 |

 14-Oct-2013 6 6

https://ripe67.ripe.net/presentations/251-ripe2-4.pdf

# Motivation: New Capabilities

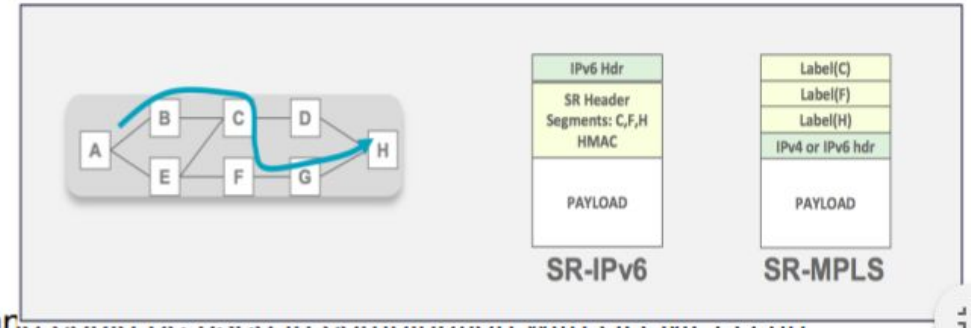
- No more NAT!
- IPv6 Segment Routing
- Terastream “Service Bits”
- Process ID, related processes
- Containerization with unique addresses

*Everybody at LACNIC was talking about these cool new technologies we can only do if we use IPv6. Do you want to look into them, or do you want me to?*

# New Capabilities: Segment Routing IPv6

## Segment Routing for IPv6 Dataplane

- SR-IPv6 allows Segment Routing do be deployed over non-MPLS networks and/or in areas of the network where MPLS is not present (e.g.: datacenters)
- Segment Routing for IPv6 Dataplane
  - Defines SID as 128 bit IPv6 addresses (no label or MPLS Data Plane)
  - Much simpler from a signaling perspective: no need to advertise anything else than IPv6 prefixes (the prefix is the SID)
  - draft-psenak-ospf-segment-routing-ospfv3-extension-02
- Segments are coded at Header of IPv6 Packet
  - Define a new Routing Extensions Header type
    - > Segment Routing Header (SRH)
    - > Contains Segment List
    - > VERY close to what already specified in RFC2460
    - > draft-previdi-6man-segment-routing-header-00

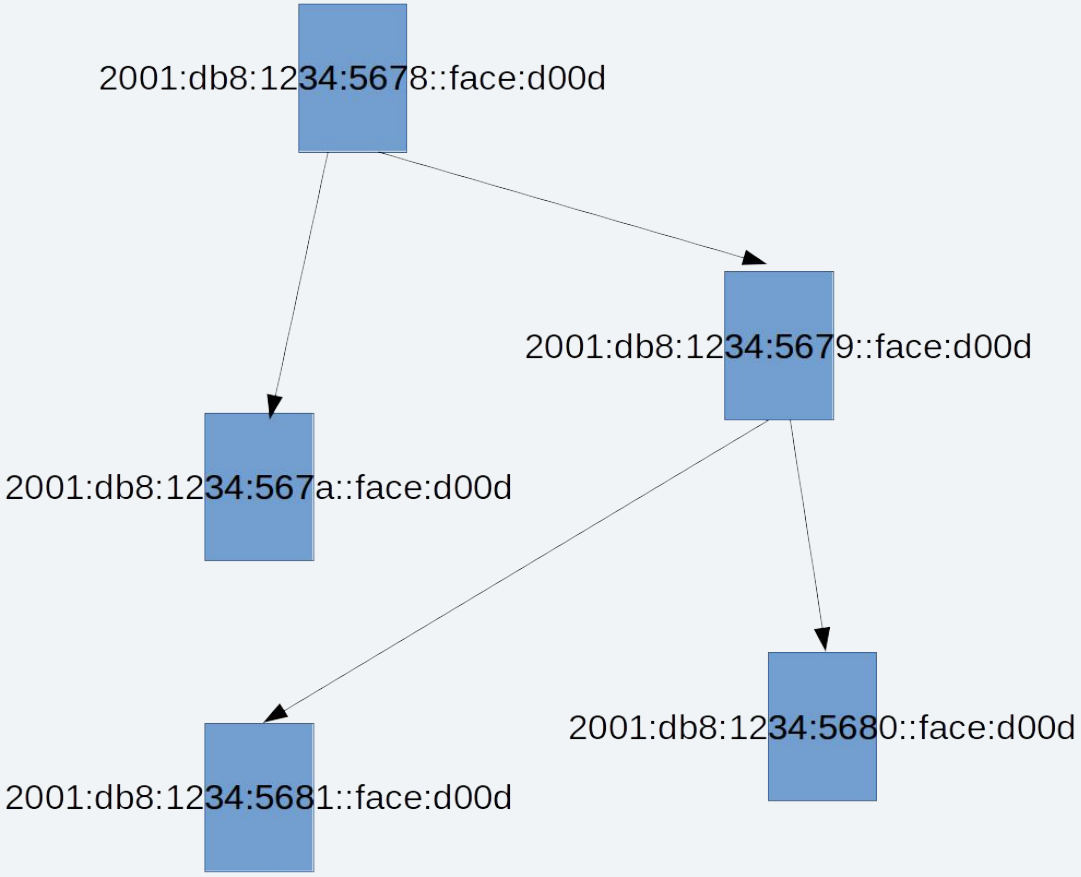



- SR nodes fully interoperate with non-SR nodes and could be used in combination with SR-MPLS (in networks where MPLS is used in the core and IPv6 is used at the edge, like home networks and datacenters).



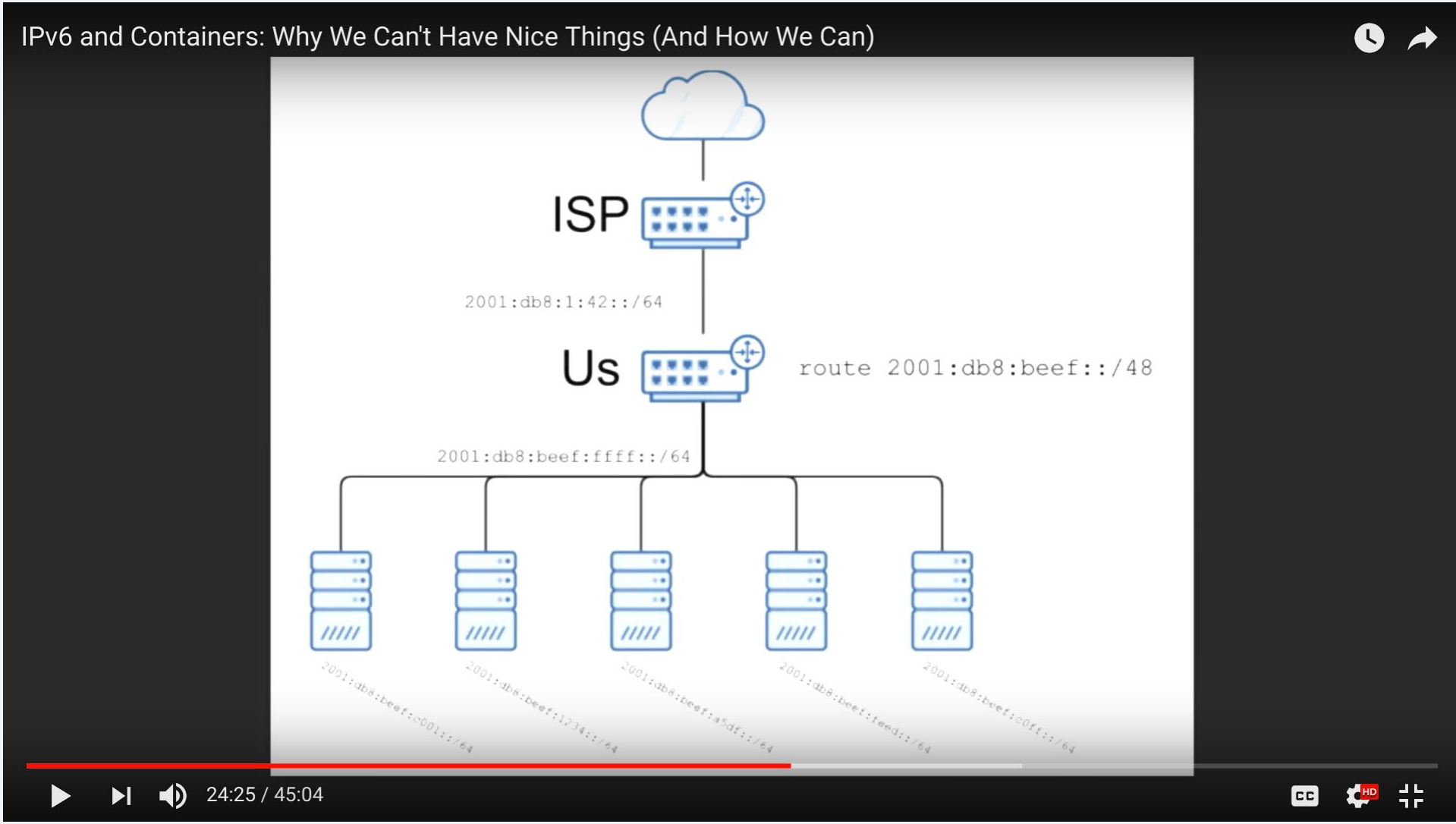
http://www3.lacnic.net/eventos/lacnic23/jueves/gianpietro-cisco-segmentrouting-ipv6-flip6.pdf
https://blogs.cisco.com/sp/bringing-segment-routing-and-ipv6-together

# New Capabilities: Process IDs




```
$ grep face:d00d /var/log
Cxn from 2000:db8:db8:db8:58ab:87ff:fe4e:49cd to 2001:db8:1234:5678::443 pid
face:d00d
Cxn from 2001:db8:1234:5678::face:d00d to 2001:db8:1234:5679::face:d00d
Cxn from 2001:db8:1234:5678::face:d00d to 2001:db8:1234:567a::face:d00d
Cxn from 2001:db8:1234:5679::face:d00d to 2001:db8:1234:5680::face:d00d
Cxn from 2001:db8:1234:5679::face:d00d to 2001:db8:1234:5681::face:d00d
```

# New Capabilities: Containerization




Matt Palmer https://youtu.be/eF50OxZ5u4o?t=11m44s

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# What is Management's Priority?

- Risk
  - Date you'll run out of IPv4 addresses
  - Risk of something being IPv6-only too soon
- Competition
  - Growth rate in your country
  - Latency
- Reducing Costs
  - Reduce need for NAT with Native
  - Avoid buying IPv4
  - Simplify network
- New Capabilities/Revenue
  - Sell addresses
  - Service bits, process bits
  - Segment Routing
  - Containers

# Closing thoughts. . .

- Dual-stack offers little
  - Opportunity for lower latency
  - Access to IPv6-only content
- IPv6+ IPv4aaS gets you out of the legacy network business
  - Sell addresses
  - Access to IPv6-only tools
  - New architectures


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