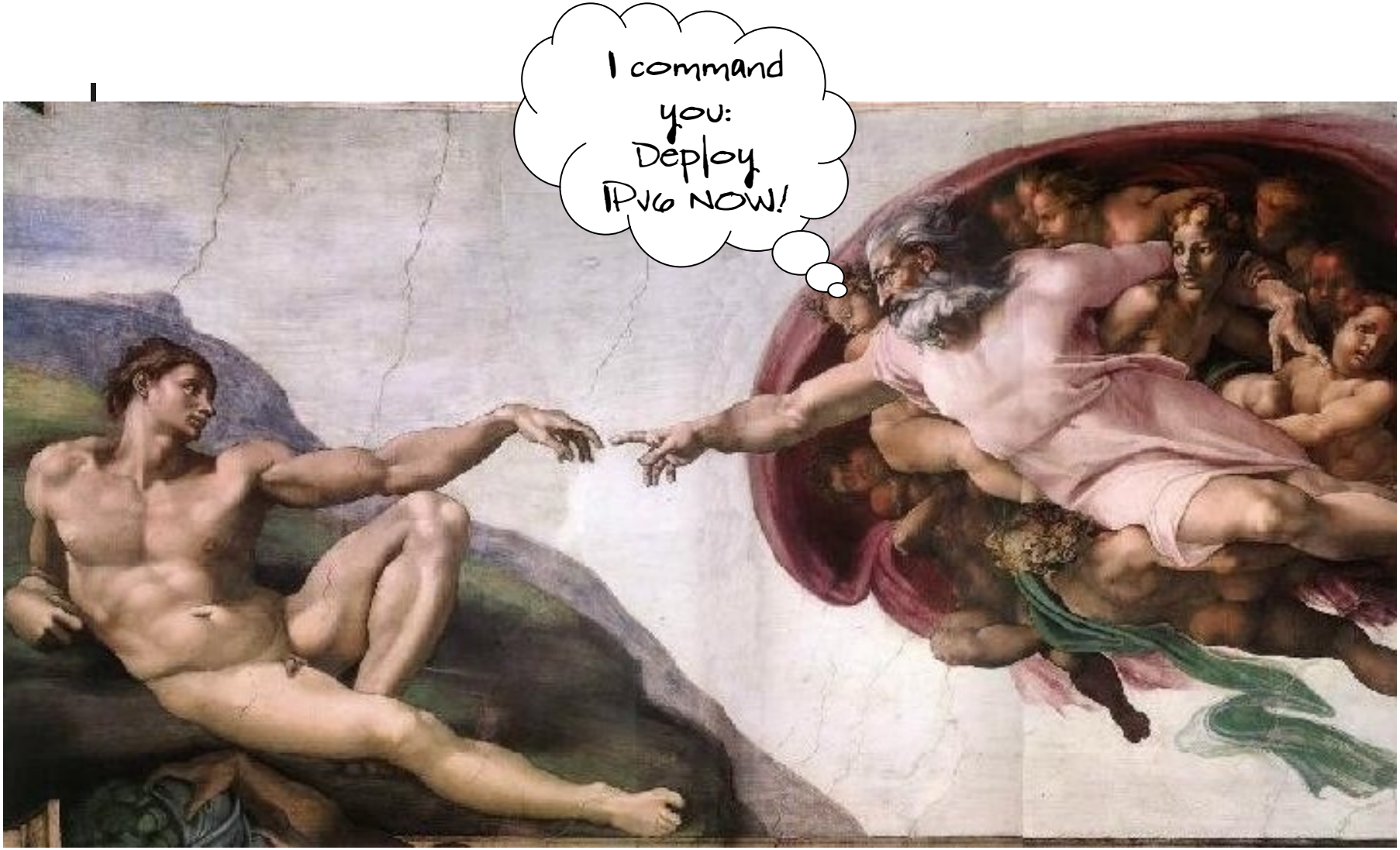
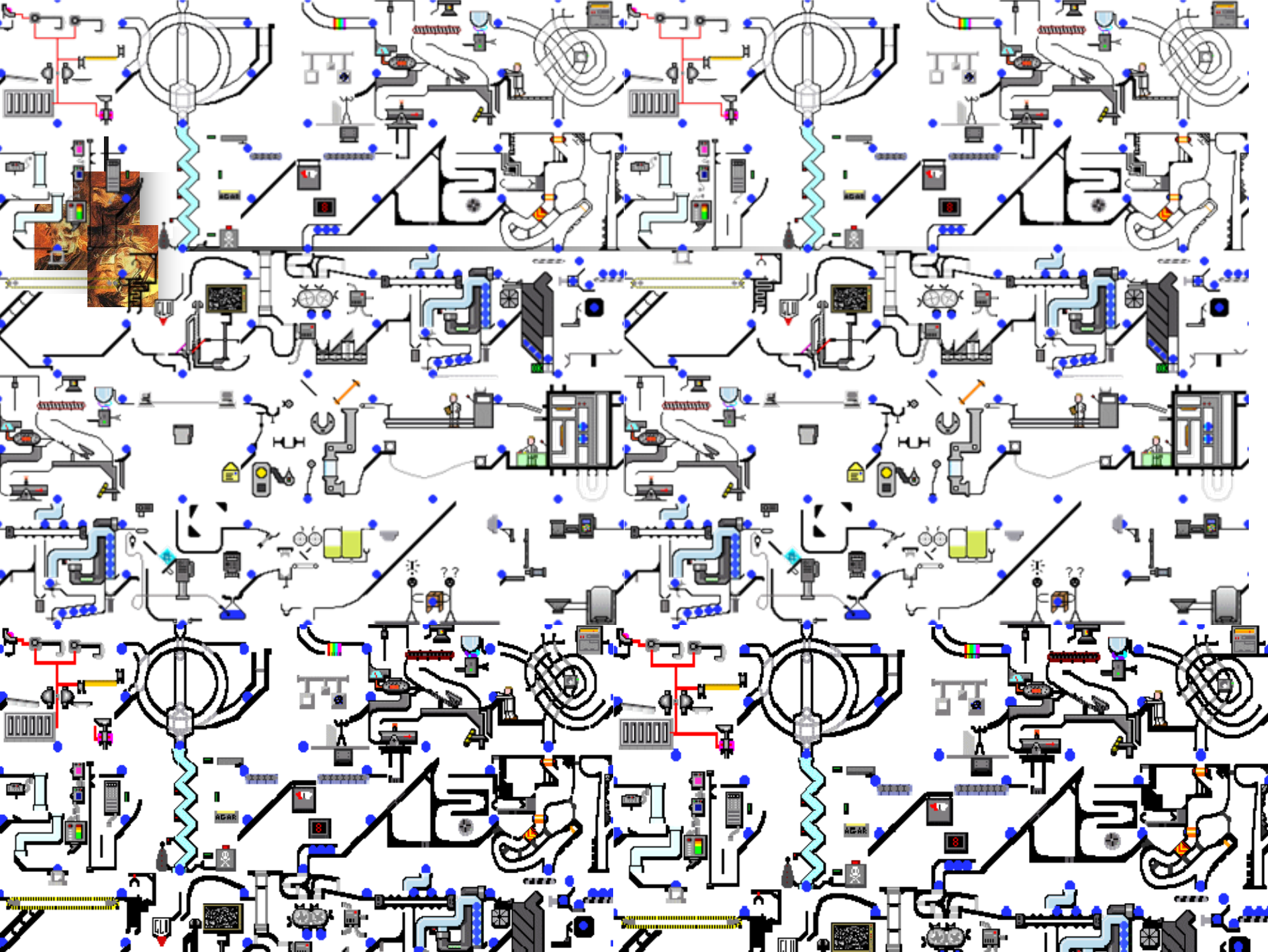
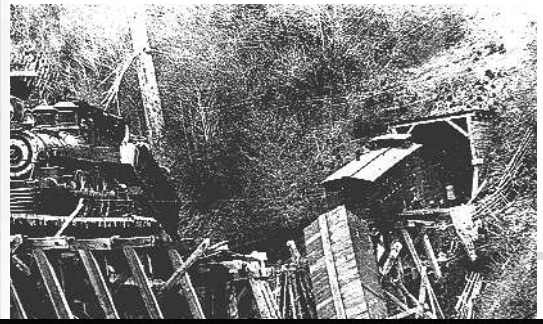
Religion

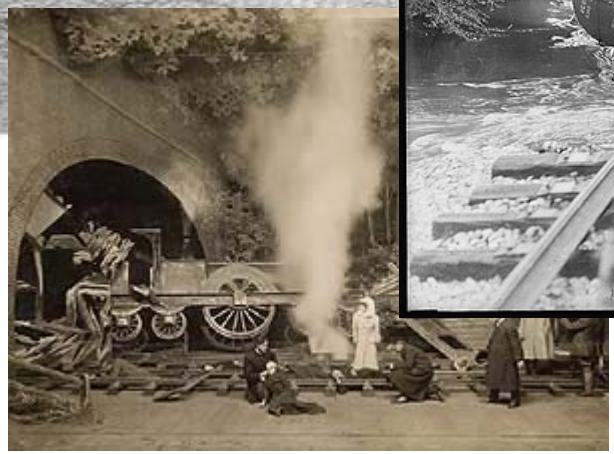

I command you:
Deploy IPv6 NOW!

Religion, Technology,



Religion, Technology, Engineering






PACIFIC FRUIT EXPRESS

Religion, Technology, Engineering and IPv6

IPv4 Unallocated Address Space Exhaustion

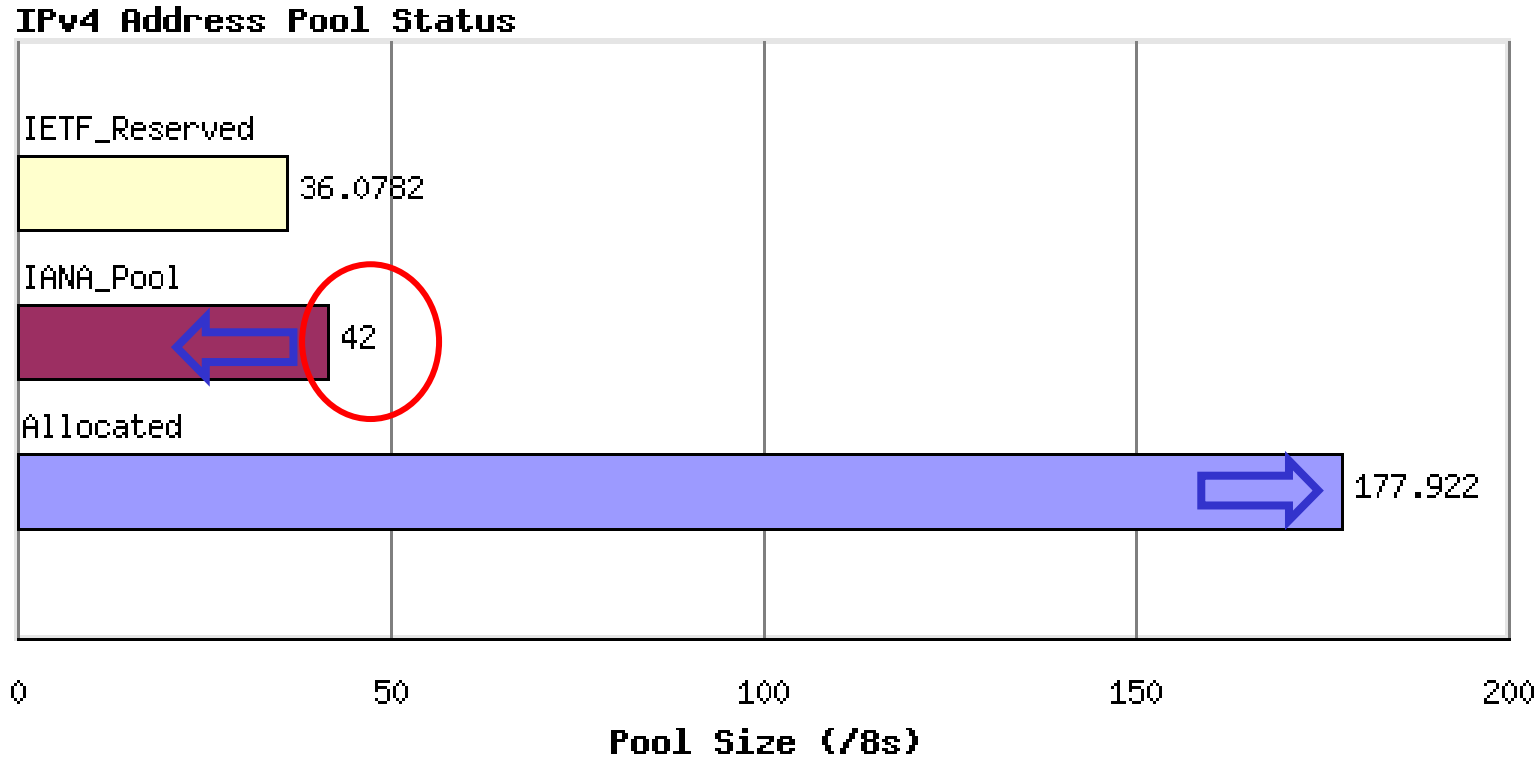
Geoff Huston
Chief Scientist
APNIC

AUSNOG, 15 November 2007

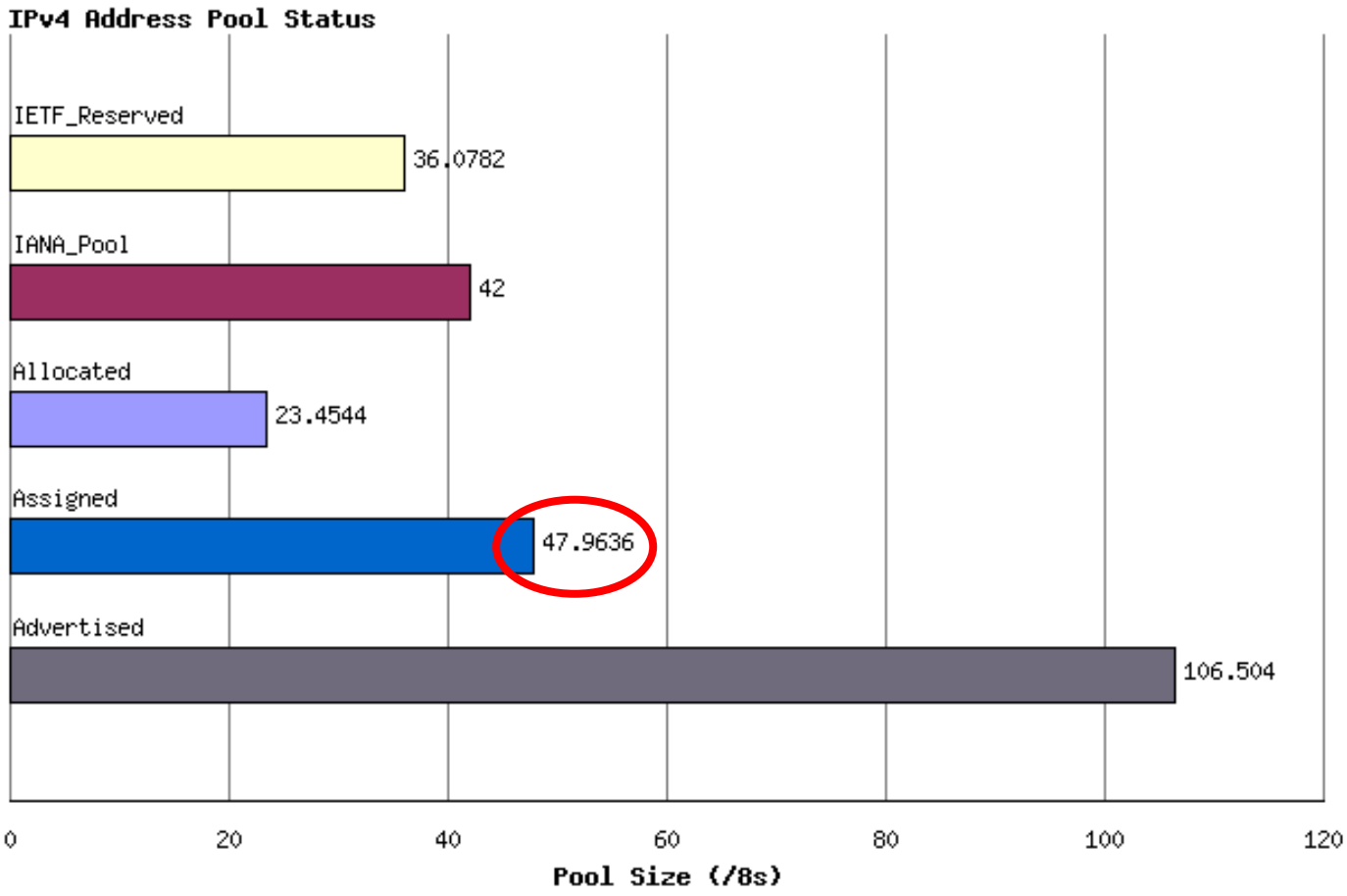
Current Status of IPv4

- Lets look at some data showing the current status of IPv4 address space and recent address consumption rates

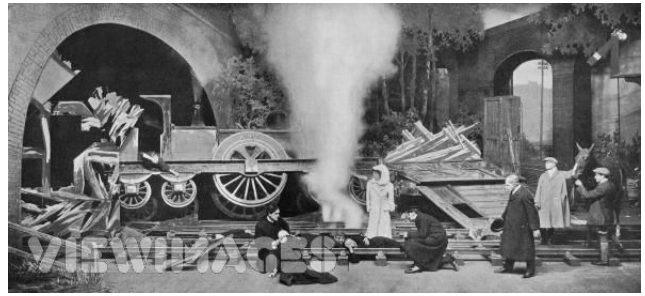
Current Status of IPv4

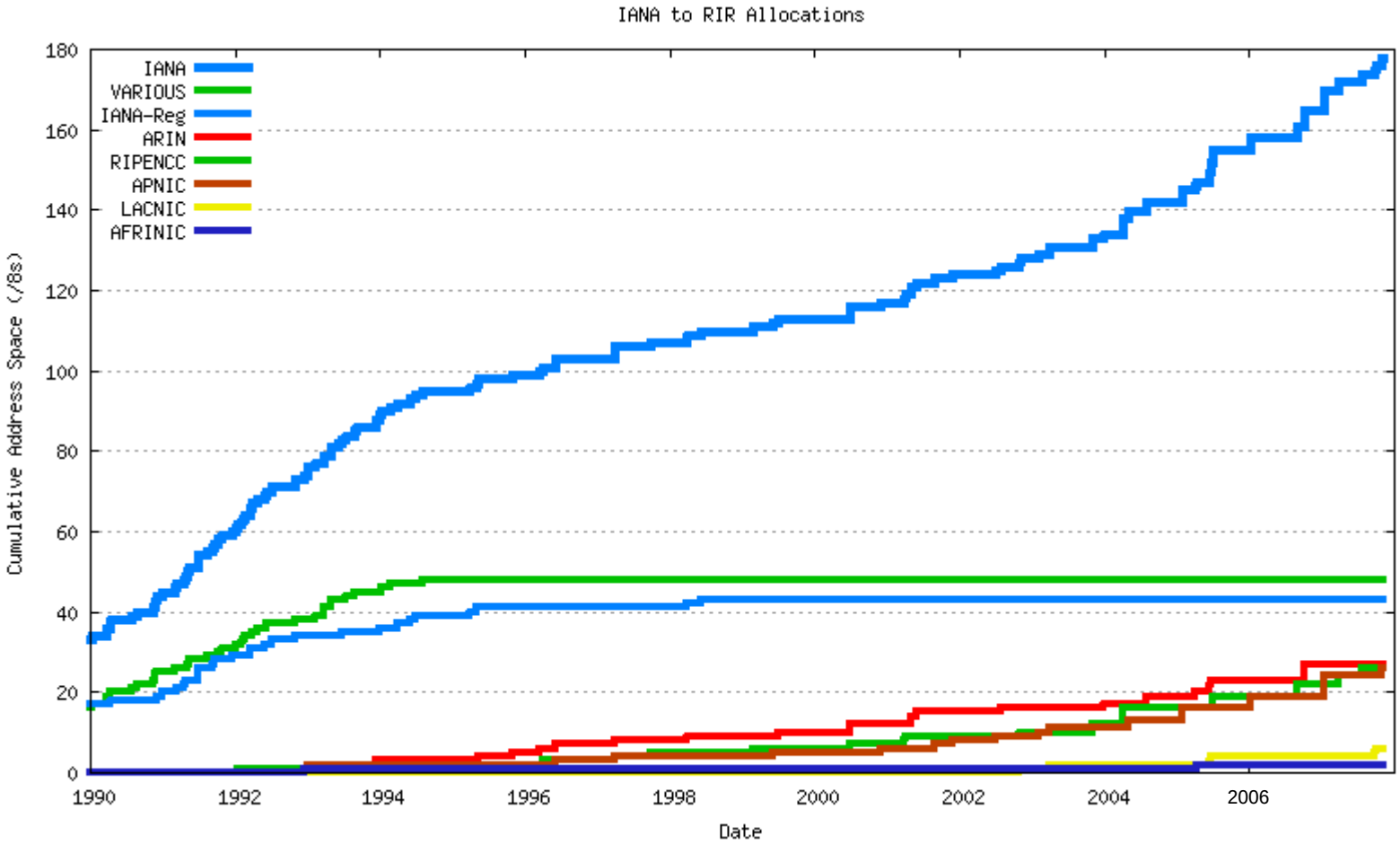


Current Status of IPv4

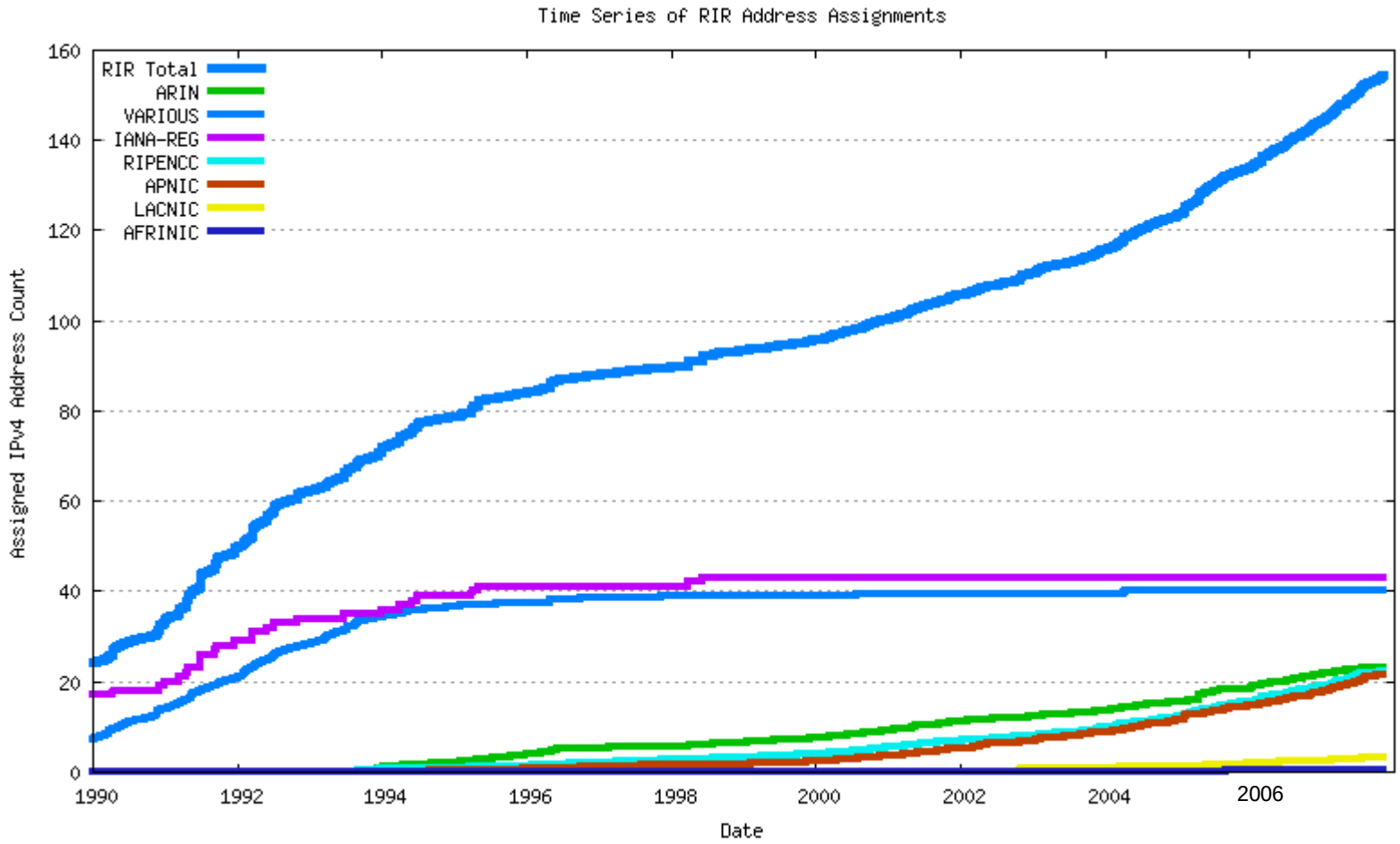


IANA to RIRs

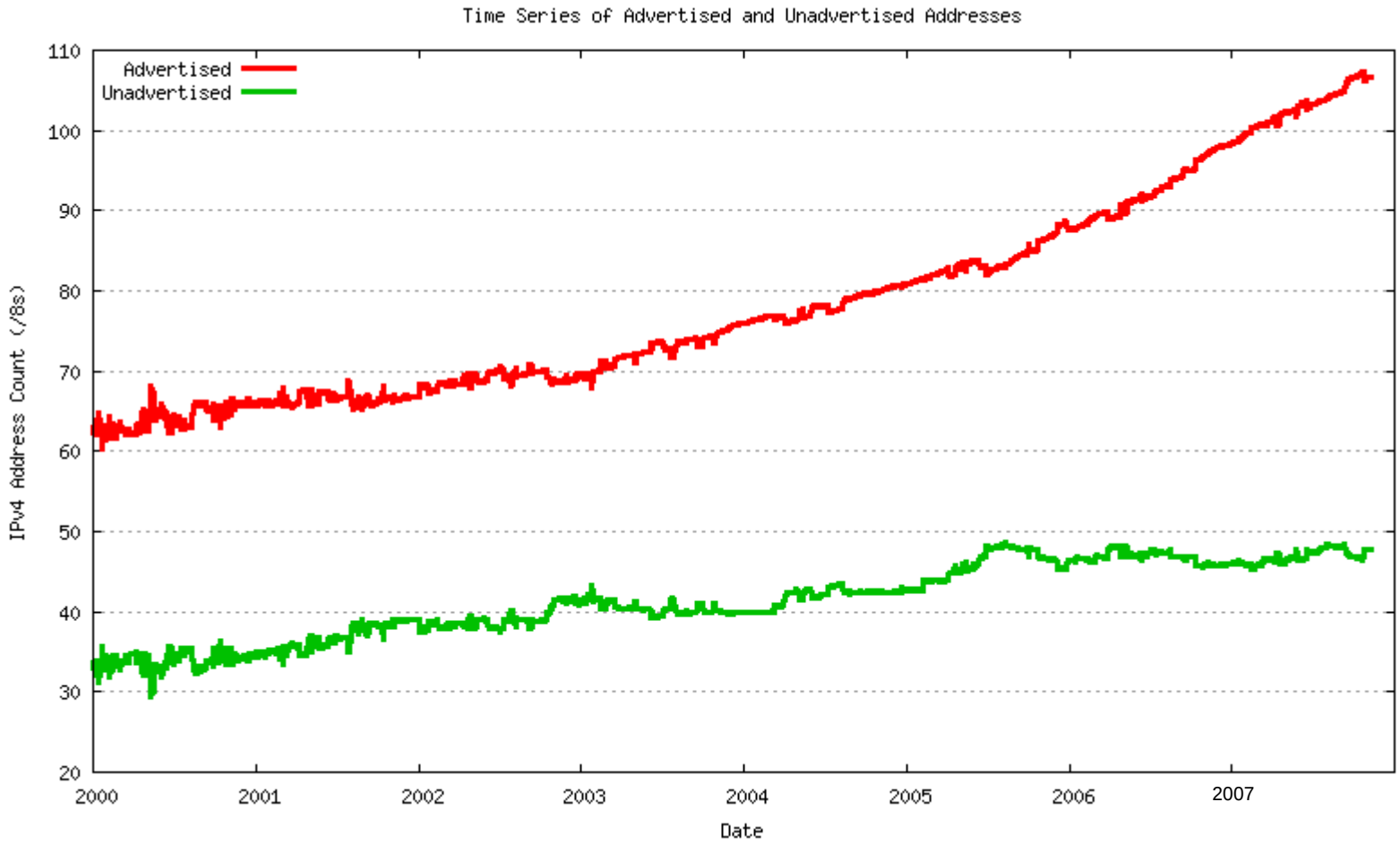



IANA to RIR Allocations
IANA
VARIOUS
IANA-Reg
ARIN
RIPENCC
APNIC
LACNIC
AFRINIC
Cumulative Address Space (/8s)
0
20
40
60
80
100
120
140
160
180
1990
1992
1994
1996
1998
2000
2002
2004
2006
Date

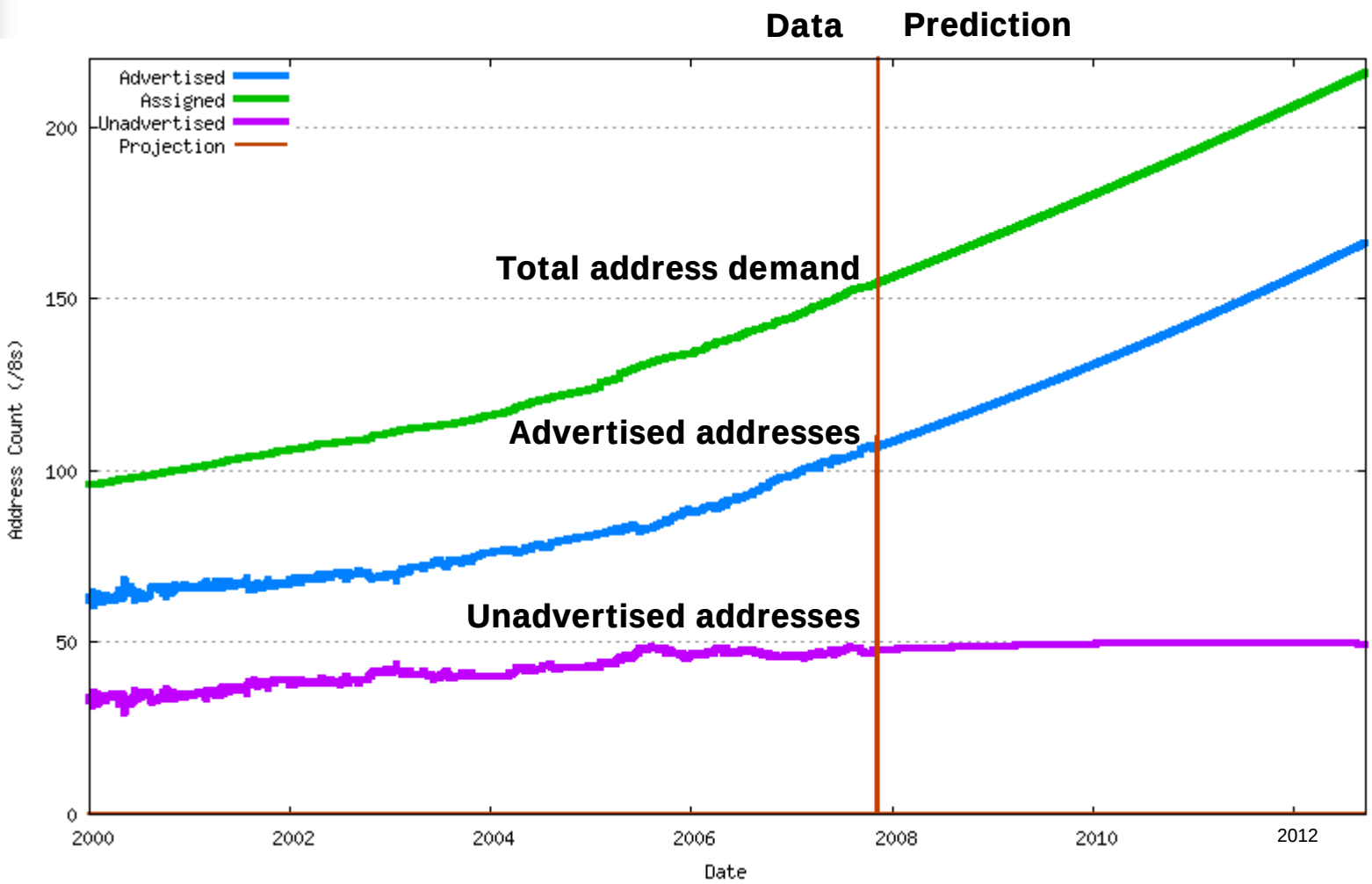
RIR Allocations & Assignments



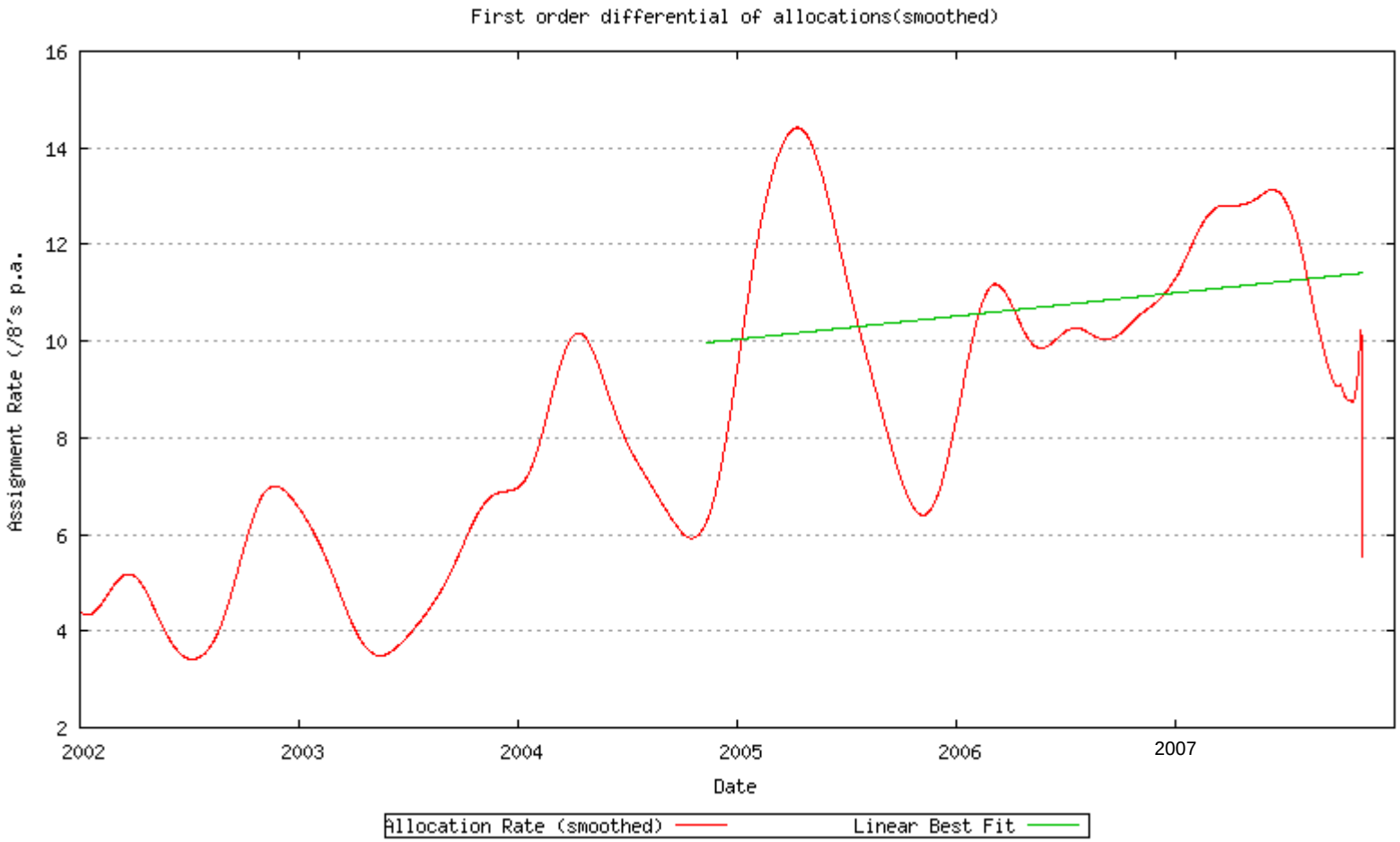
Advertised and Unadvertised Addresses



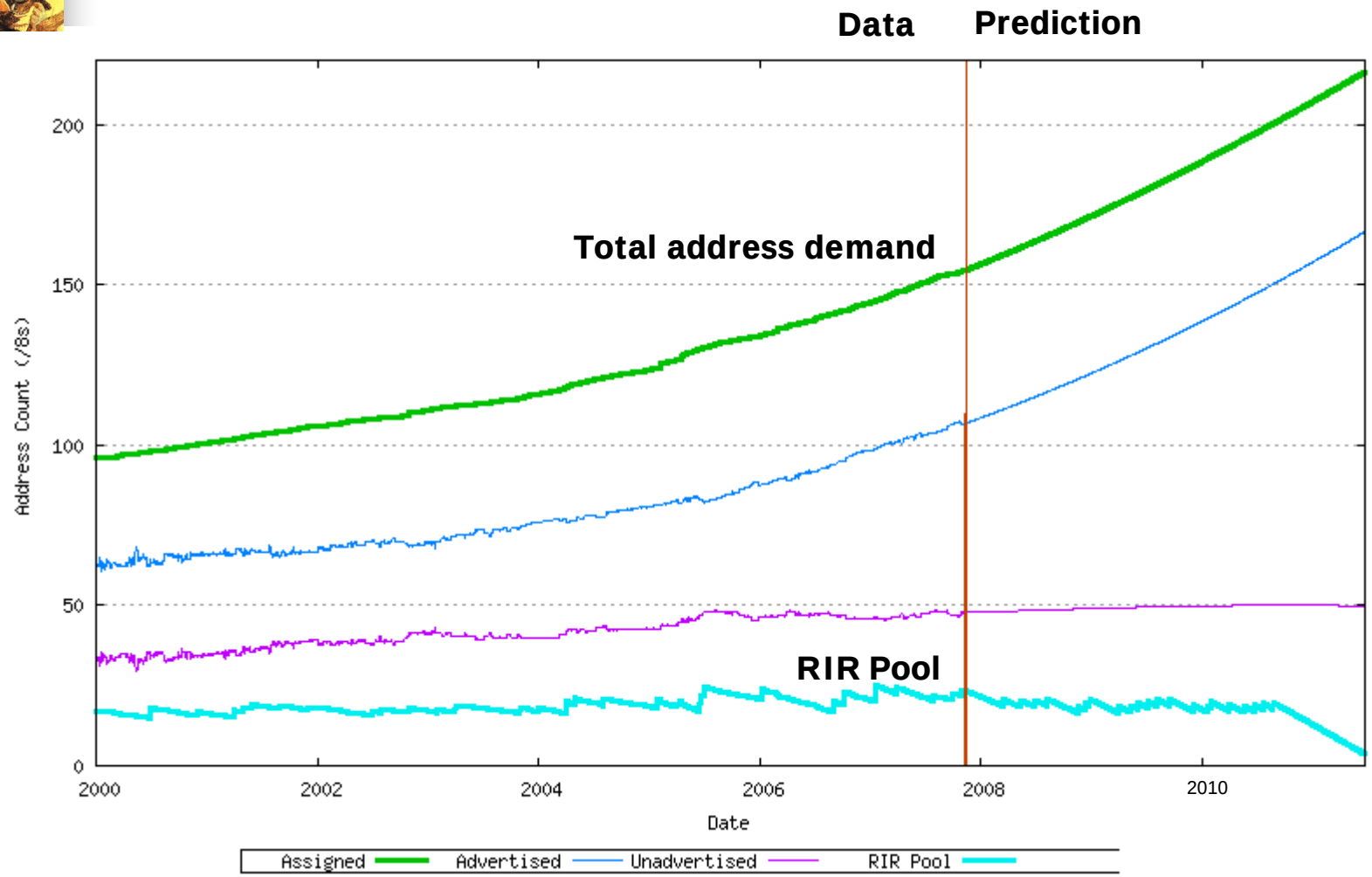
Predictive Model



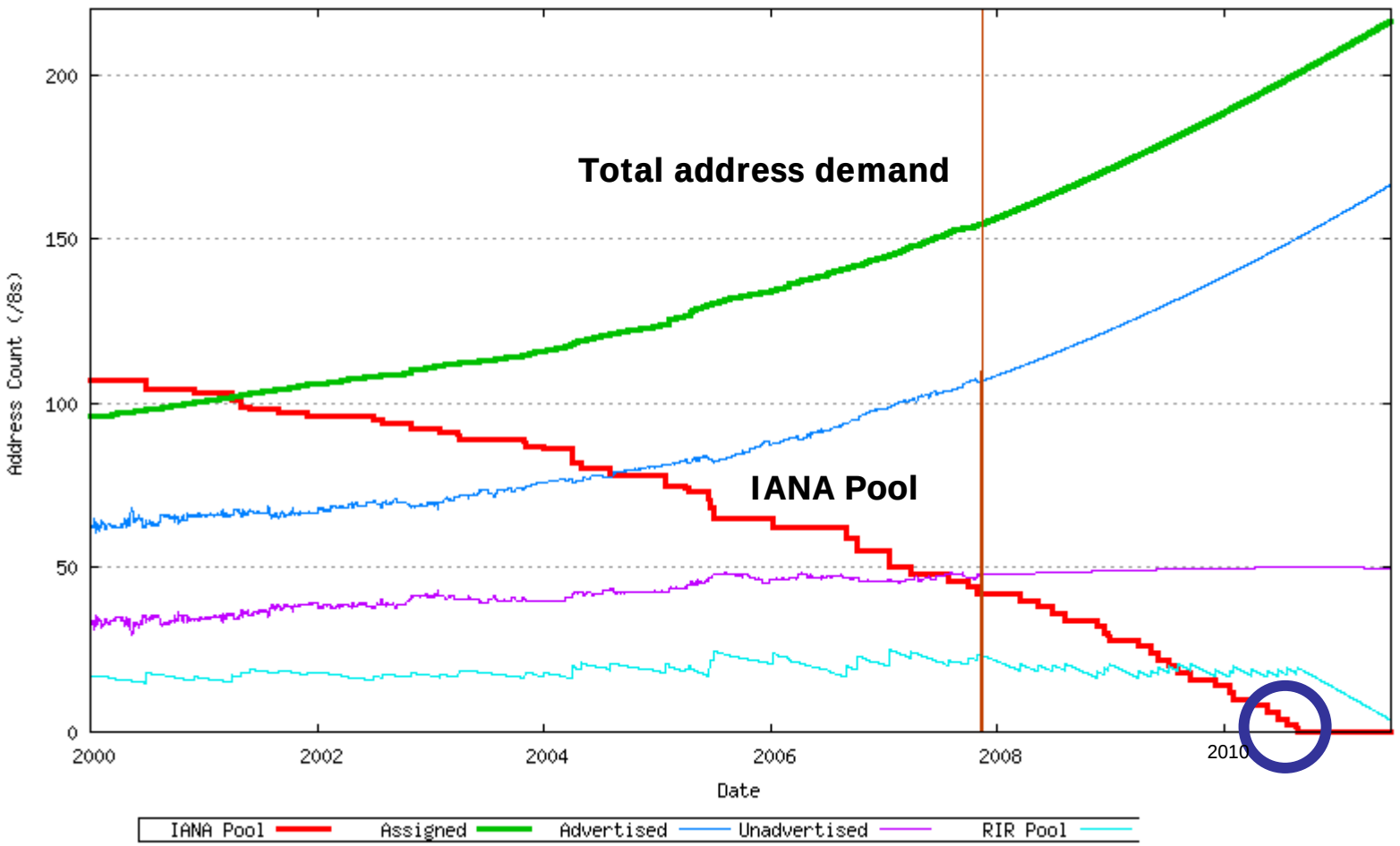
The IPv4 Allocation Model



The IPv4 Consumption Model



The IPv4 Consumption Model



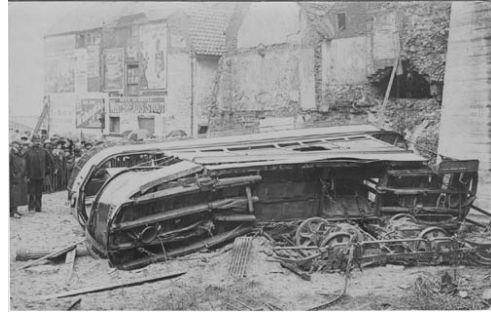
So what?

In this model, IANA allocates its last IPv4 /8 to an RIR on the 20th August 2010

This is the model's predicted exhaustion date as of the 10th November 2007. Tomorrow's prediction will be different!

http://ipv4.potaroo.net

IPv4 Consumption Prediction



- Assumptions
  - Tomorrow is a lot like today
  - Trends visible in the recent past continue into the future
- This model assumes that there will be no panic, no change in policies, no change in the underlying demand dynamics, no disruptive externalities, no rationing, and no withholding or hoarding!
  - No, really!

What then?

- Some possible scenarios:
  - Persist in IPv4 networks using more NATs
  - Address markets emerging for IPv4
  - Routing fragmentation
  - IPv6 transition

IPv4 NATs Today

- Today NATS are largely externalized costs for ISPs
  - Customers buy and operate NATS
  - Applications are tuned to single-level NAT traversal
  - Static public addresses typically attract a tariff premium in the retail market
    - For retail customers, IP addresses already have a market price!

The “Just Add More NATs” Option

- Demand for increasing NAT “intensity”
  - Shift ISP infrastructure to private address realms
  - Multi-level NAT deployments both at the customer edge and within the ISP network
    - This poses issues in terms of application discovery and adaptation to NAT behaviours
  - End cost for static public addresses may increase

NAT Futures

- NATs represent just more of the same
  - NATs are already extensively deployed today
  - More intense use of NATs does not alter the network's current architectural model
- How far can NATs scale?
  - Not well known
  - What are the critical resources here?
    - NAT binding capacity and state maintenance
    - NAT packet throughput
    - Private address pool sizes
    - Application complexity

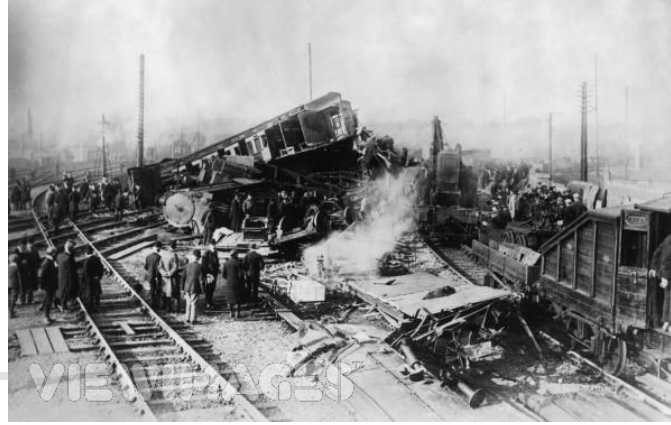
NAT Futures

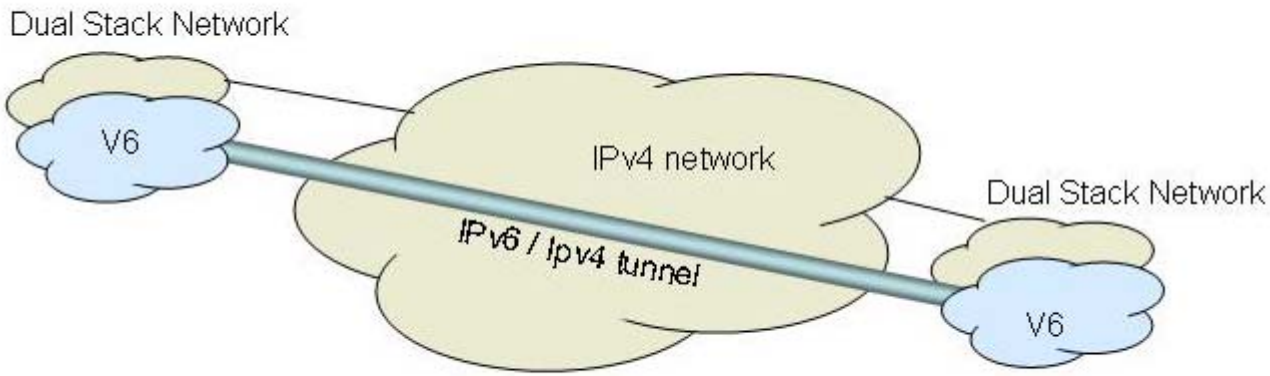
- Do we need to go a few steps further with NATs?
  - NAT + DNS ALG to allow bi-directional NAT behaviours ?
  - NAT Signalling Protocol: Explicit application access to NAT binding functions ?
- In the escalating complexity curve, when does IPv6 get to look like a long term cheaper outcome?

The Other Option: IPv6

- Transition to IPv6
  - But IPv6 is not backward compatible with IPv4 on the wire
  - So the plan is that we need to run some form of a “dual stack” transition process
    - Either dual stack in the host, or dual stack via protocol translating proxies

Dual Stack Transition to IPv6

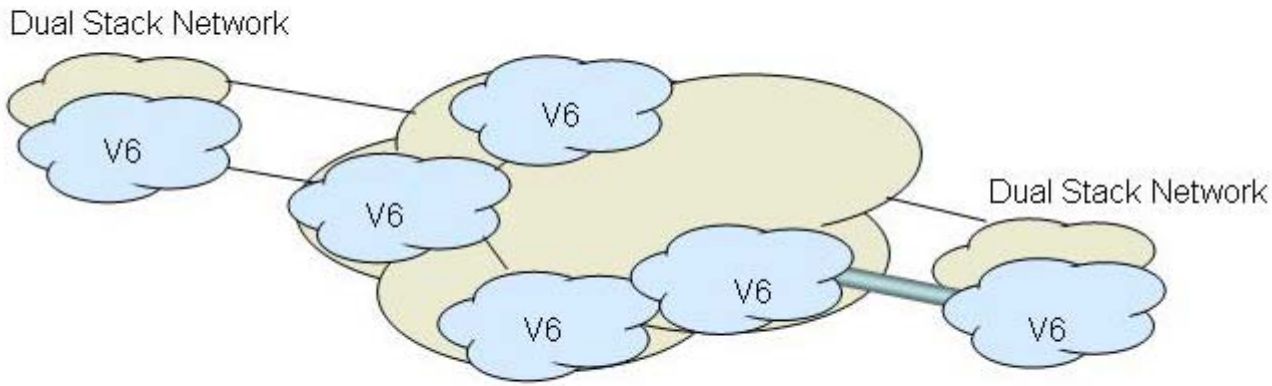




Theology – Phase 1

- "Initial" Dual Stack deployment:
  - *Dual stack* networks with V6 / V4 connectivity
  - Dual Stack hosts attempt V6 connection, and use V4 as a fallback

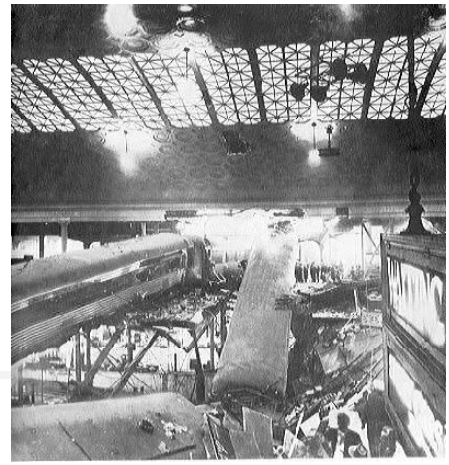
Dual Stack Transition to IPv6

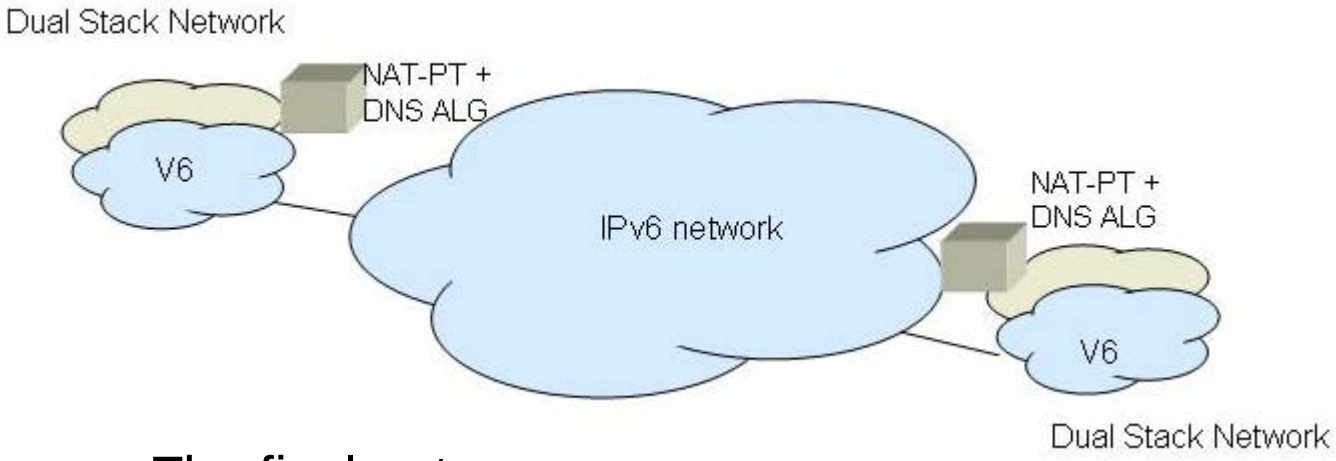


Theology – Phase 2

- “Intermediate”
  - Older V4 only networks are retro-fitted with dual stack V6 support

Dual Stack Transition to IPv6

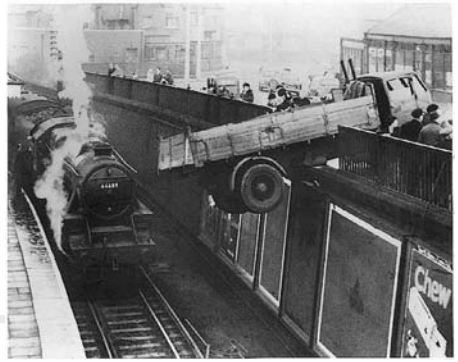




Theology - The final outcome

- "Completion"
  - V4 shutdown occurs in a number of networks
  - Connectivity with the residual V4 islands via DNS ALG + NAT-Protocol Translation
  - Outside the residual legacy deployments the network is single protocol V6

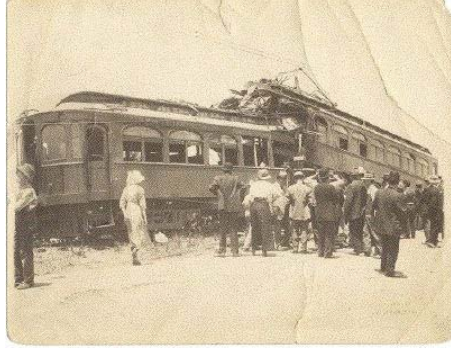
Dual Stack Assumptions



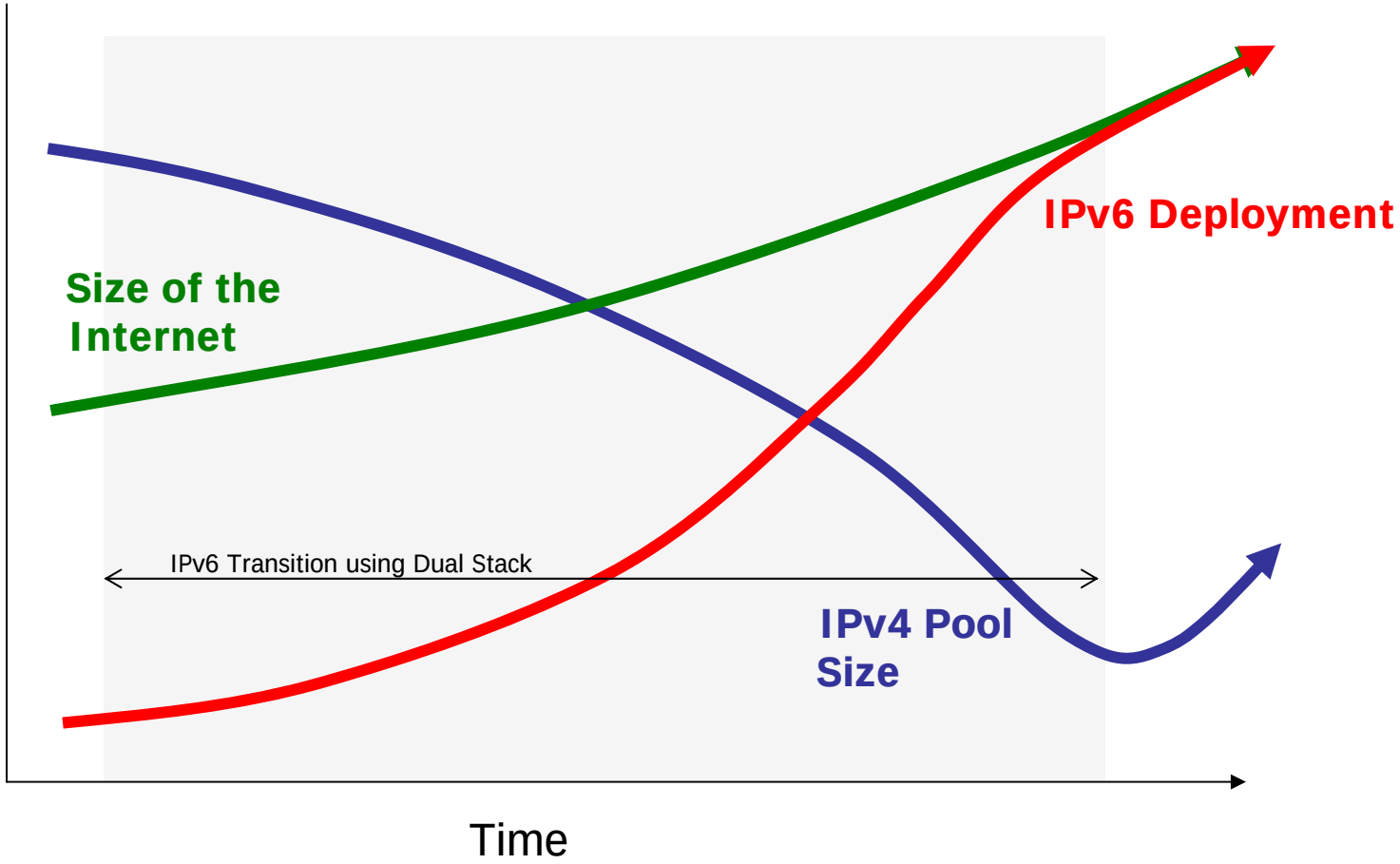
- That we could drive the entire transition to IPv6 while there were still ample IPv4 addresses to sustain the entire network and its growth
- Transition would take some (optimistically) small number of years to complete
- Transition would be driven by individual local decisions to deploy dual stack support
- The *entire* transition would complete *before* the IPv4 unallocated pool was exhausted

Dual Stack

- Dual Stack transition is not a binary proposition
  - Its not a case of IPv4 today, IPv6 tomorrow
- Dual Stack transition is an “and” proposition
  - It’s a case of IPv4 AND IPv6
  - Double the fun and double the cost?
- But we don’t know for how long
  - So we need to stretch IPv4 out to encompass tomorrow’s Internet, and the day after, and ...



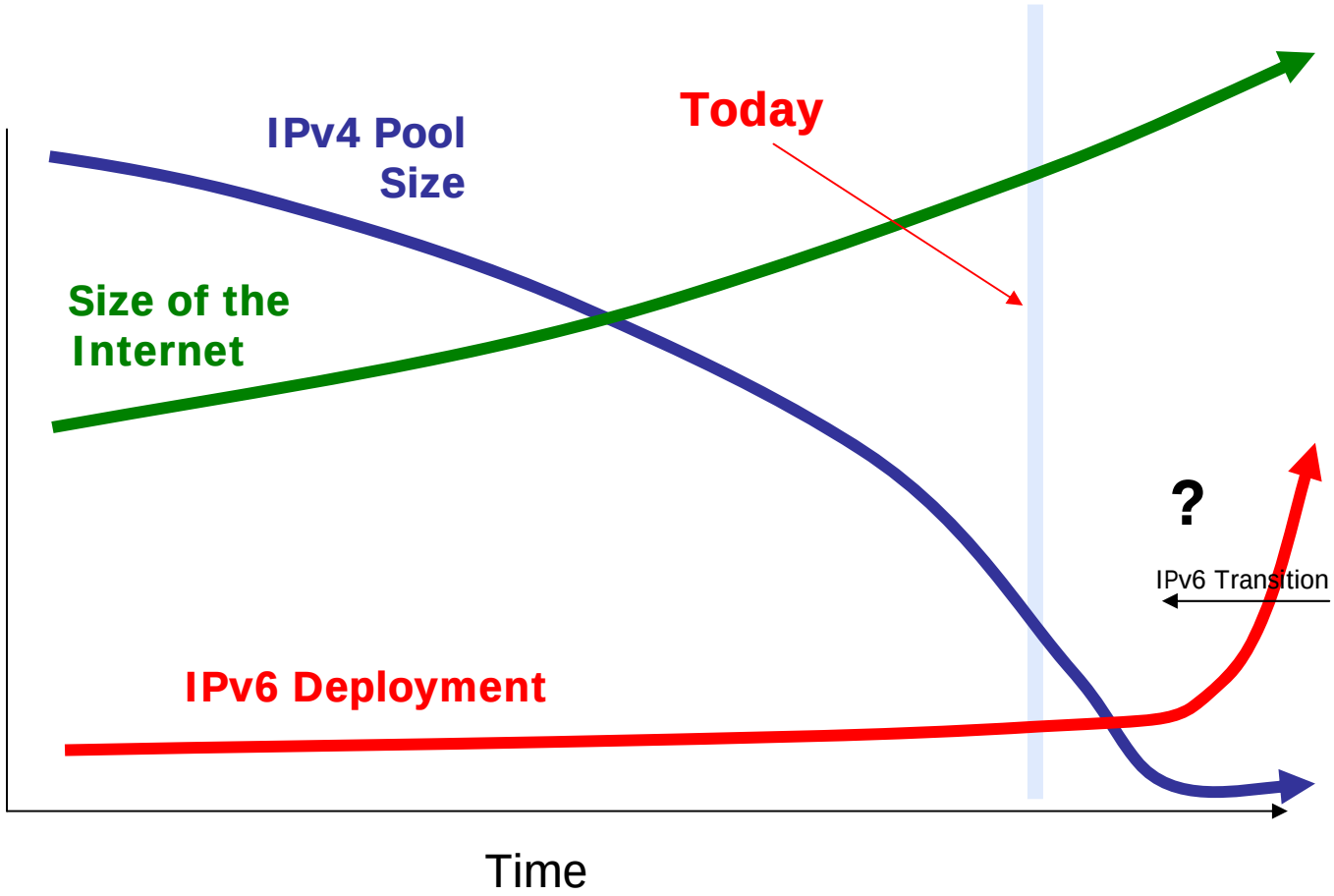
We had a plan ...


IPv6 Deployment
Size of the Internet
IPv6 Transition using Dual Stack
IPv4 Pool Size
Time

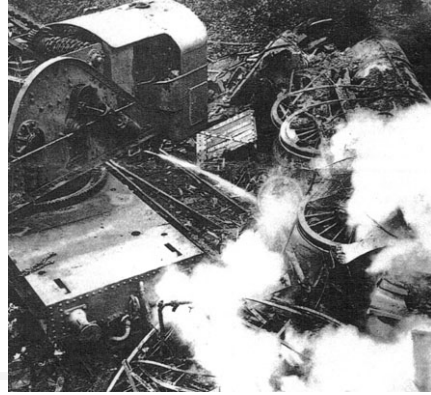
Oops!

- We were meant to have completed the transition to IPv6 BEFORE we completely exhausted the supply channels of IPv4 addresses

What's the revised plan?



Implications

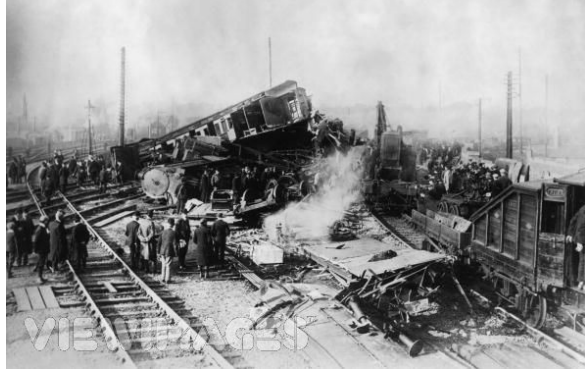


- Whether its just IPv4 NATs OR transition to IPv6 ...
  - IPv4 addresses will continue to be in demand far beyond the date of exhaustion of the unallocated pool
    - In the transition environment, all new and expanding network deployments will need IPv4 service access and addresses for as long as we are in this dual track transition
  - But the process is no longer directly controlled through today's address allocation policies
    - that IPv4 address pool in the sky will run out!
    - the mechanisms of management of the IPv4 address distribution and registration function will necessarily change

Making IPv4 Last Longer

- Its not the IPv4 address pool that's fully consumed
  - It's the unallocated address pool that's been consumed
  - 20% of the address space is not advertised in global routing
- Its not that every IPv4 address is committed and in use today – far from it!
  - Advertised address pools appear to have end host utilization levels of around 5% - 20%
- So we could buy yourselves into some deviant form of Second Life with IPv4
  - But it won't be life as we've known it!

Making IPv4 Last Longer



- Some ideas I've observed so far:
  - Encourage NAT deployment
  - Larger Private Use Address Pool
  - Policies of rationing the remaining IPv4 space
  - Undertake efforts of IPv4 Reclamation
  - Deregulate Address Transfers
  - Facilitate Address Markets
- and/or
  - Encourage an accelerated IPv6 Transition process

Making IPv4 Last Longer


The Wreck of Maine Central Train No. 13, Oakland
(W.H. Bunting)

- For how long?
- For what cumulative address demand?
- For what level of fairness of access?
- At what cost?
- For whom?
- To what end?

- What if we actually achieve what we set out to do?
  - How would the Law of Unintended Consequences apply here?
  - Would this negate the entire “IPv6 is the solution” philosophy?

What should we preserve?

- The functionality and integrity of the Internet as a service platform
  - Functionality of applications
  - Viability of routing
  - Capability to sustain continued growth
  - Integrity of the network infrastructure

What could be useful right now

- Clear and coherent information about the situation and current choices
- Understanding of the implications of various options
- Appreciation of our limitations and strengths as a global deregulated industry attempting to preserve a single coherent networked outcome
- Understanding of the larger audience and the broader context in which these processes are playing out
- Some pragmatic workable approaches that allow a suitable degree of choice for players
- Understanding that some transitions are not ‘natural’ for a deregulated industry. Some painful transitions were only undertaken in response to regulatory fiat
  - Think analogue to digital spectrum shift as a recent example

Implications

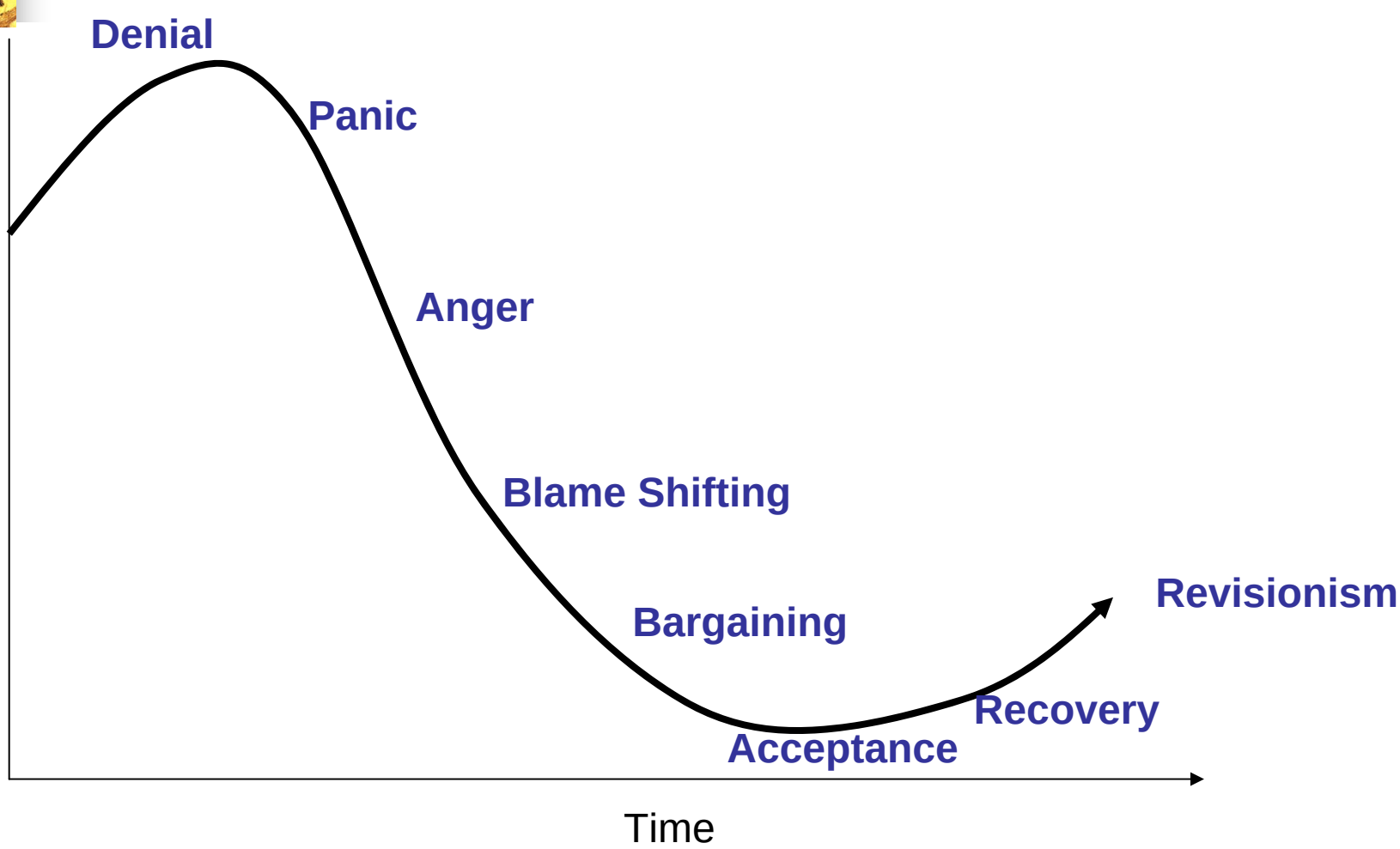
It is likely that there will be some disruptive aspects of this situation that will impact the entire industry

- the original transition plan is a business failure
- resolution of this failure is now going to be tough

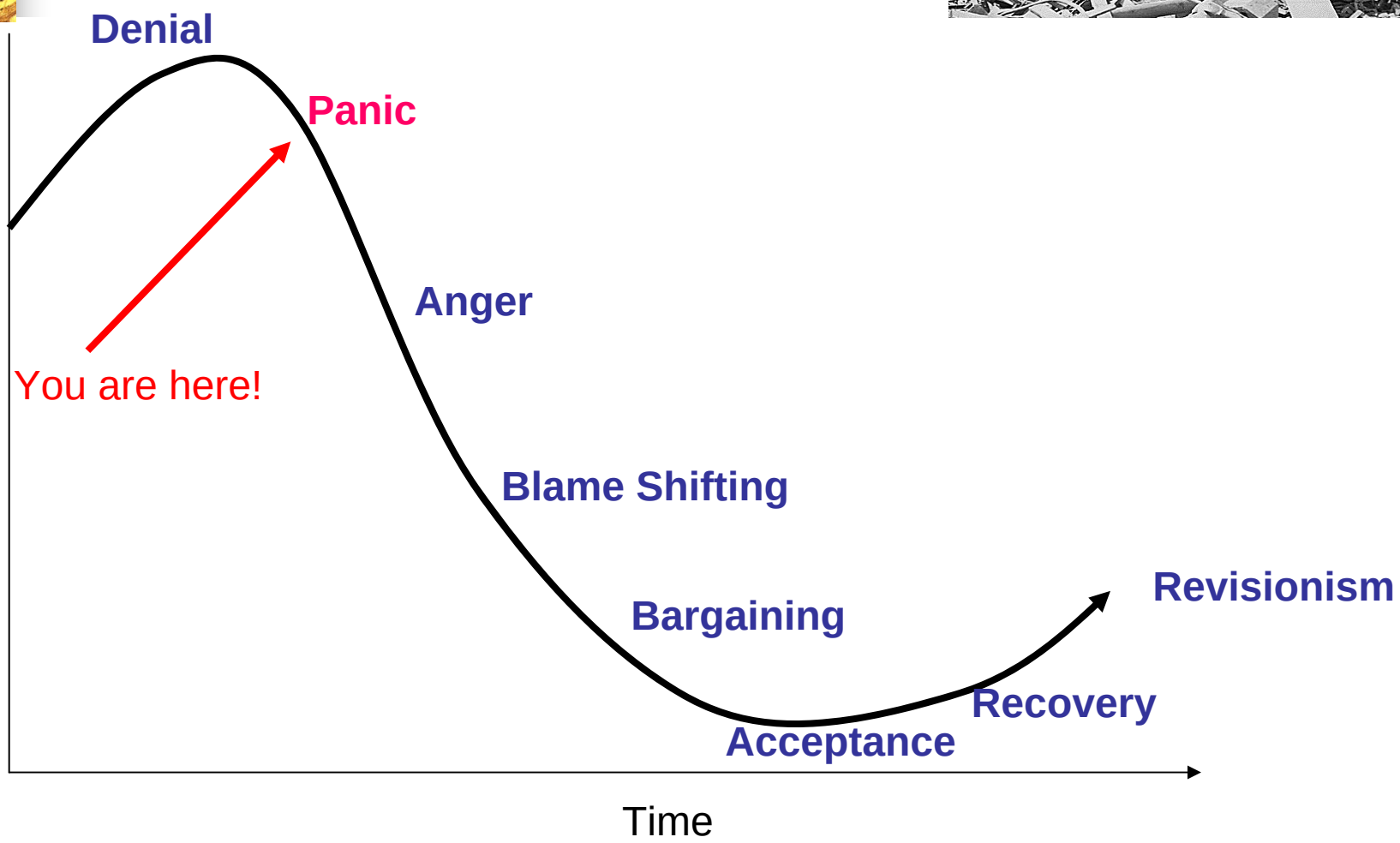
This will probably not be seamless nor costless

And will probably involve various forms of regulatory intervention, no matter what direction we might take from here

Coping with Crises



Coping with Crises
IPv4 Exhaustion



Thank You


STOP
ALL DRIVERS
WAIT HERE
FOR INSTRUCTIONS