IPv4 Address Lifetime Expectancy Revisited

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Previous Work

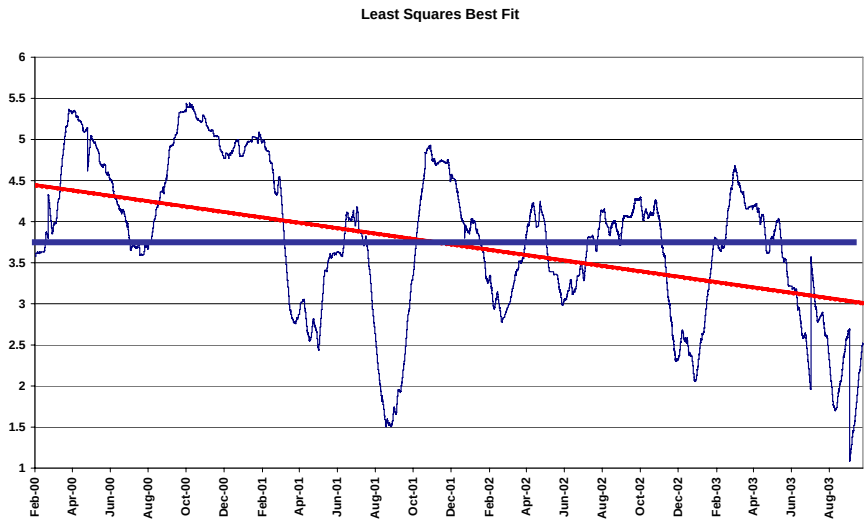
- Presentation at RIPE, September 2003, using the rate of growth of BGP advertised address space as the address consumption driving factor

- The approach analyzed the roles of the IANA and the RIRs and created an overall model of address consumption based around the demand models generated by network address growth

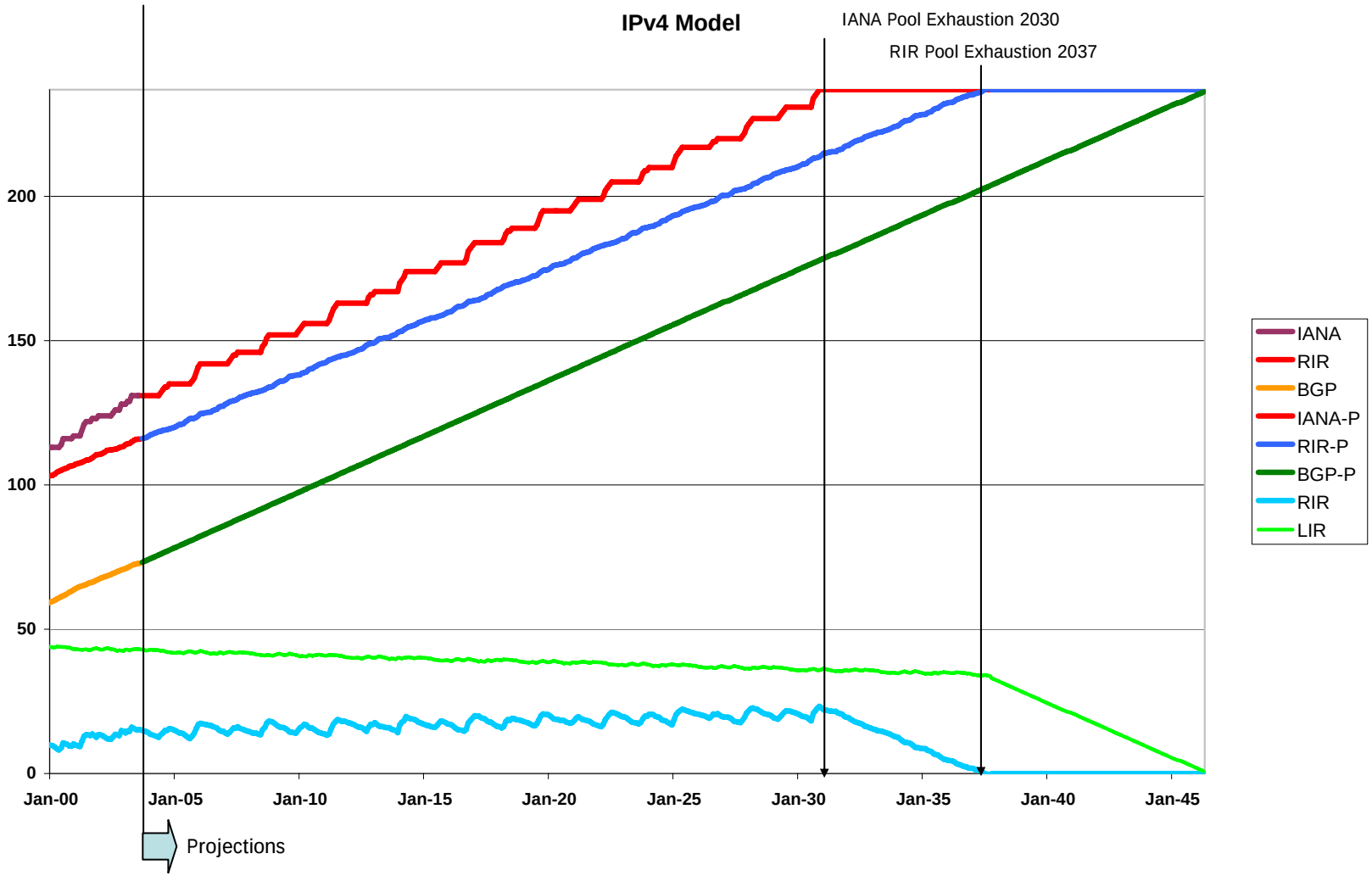
Previous IPv4 Consumption Model

- The basic drivers in this 2003 work was that address space demand remained at a constant 3.75 /8s per year, and the unadvertised address pool declined by 0.5 /8s per year

- In this model RIR address pool exhaustion would've occurred in 2037



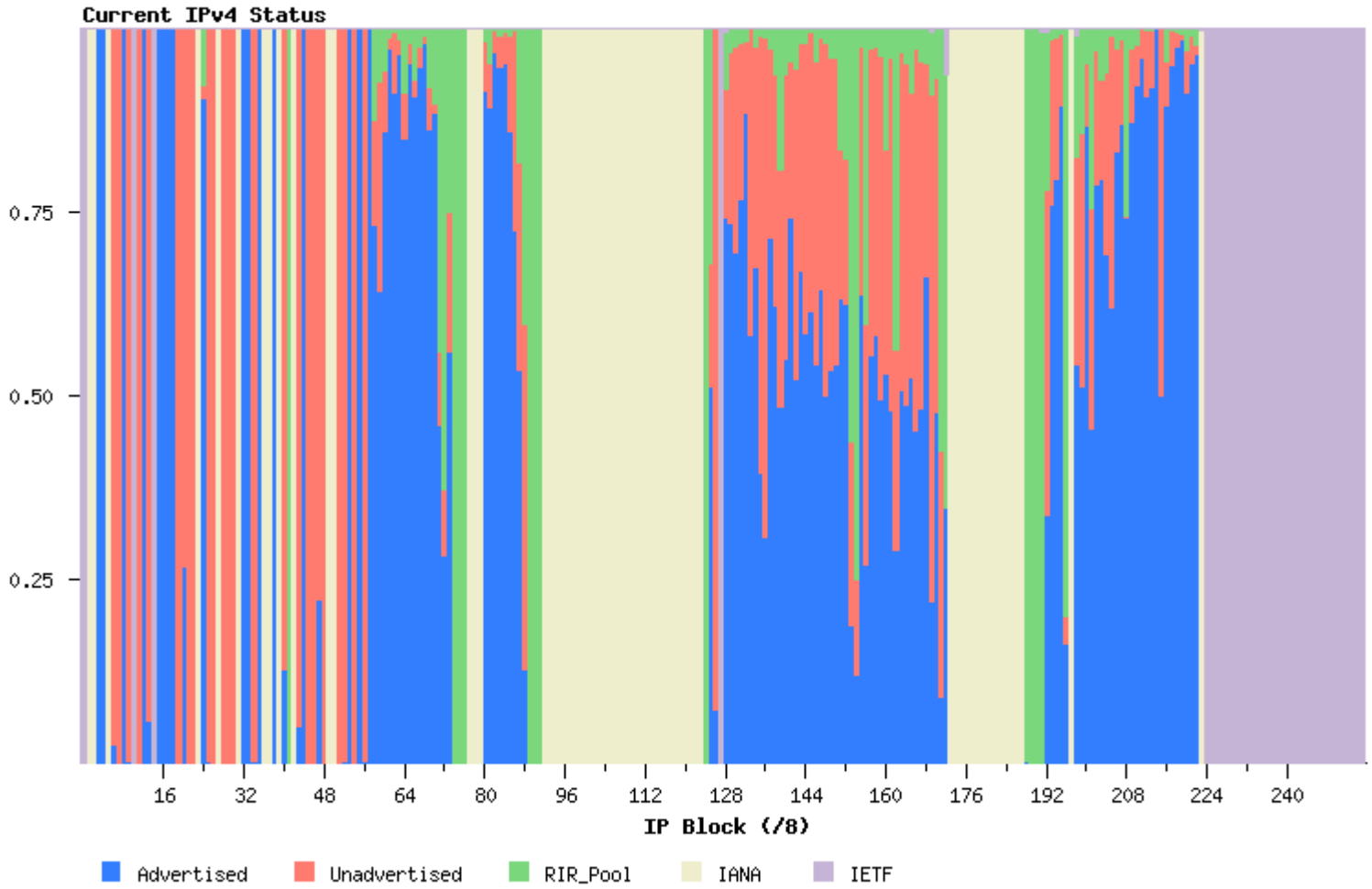
Modeling the Process – Sept 2003



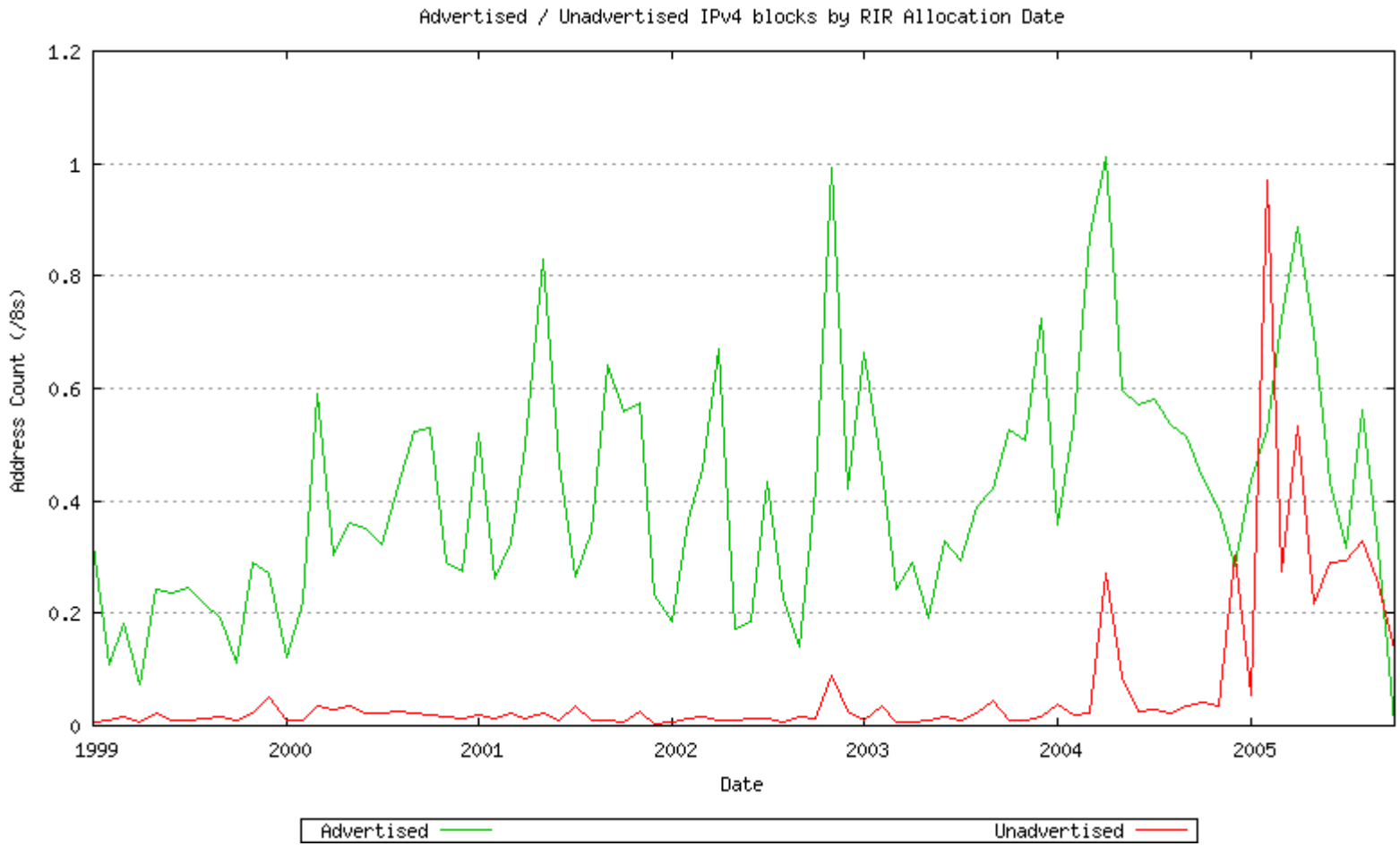
A new look at the data

- Retain the fundamental assumption that the driver for address consumption is the public Internet, and that the growth of the Internet is reflected in address consumption demands
- Adjust the model to include each individual RIR's allocation behaviour over time
- Set the 'exhaustion' date at the point when any RIR cannot honor an address request

Current Status



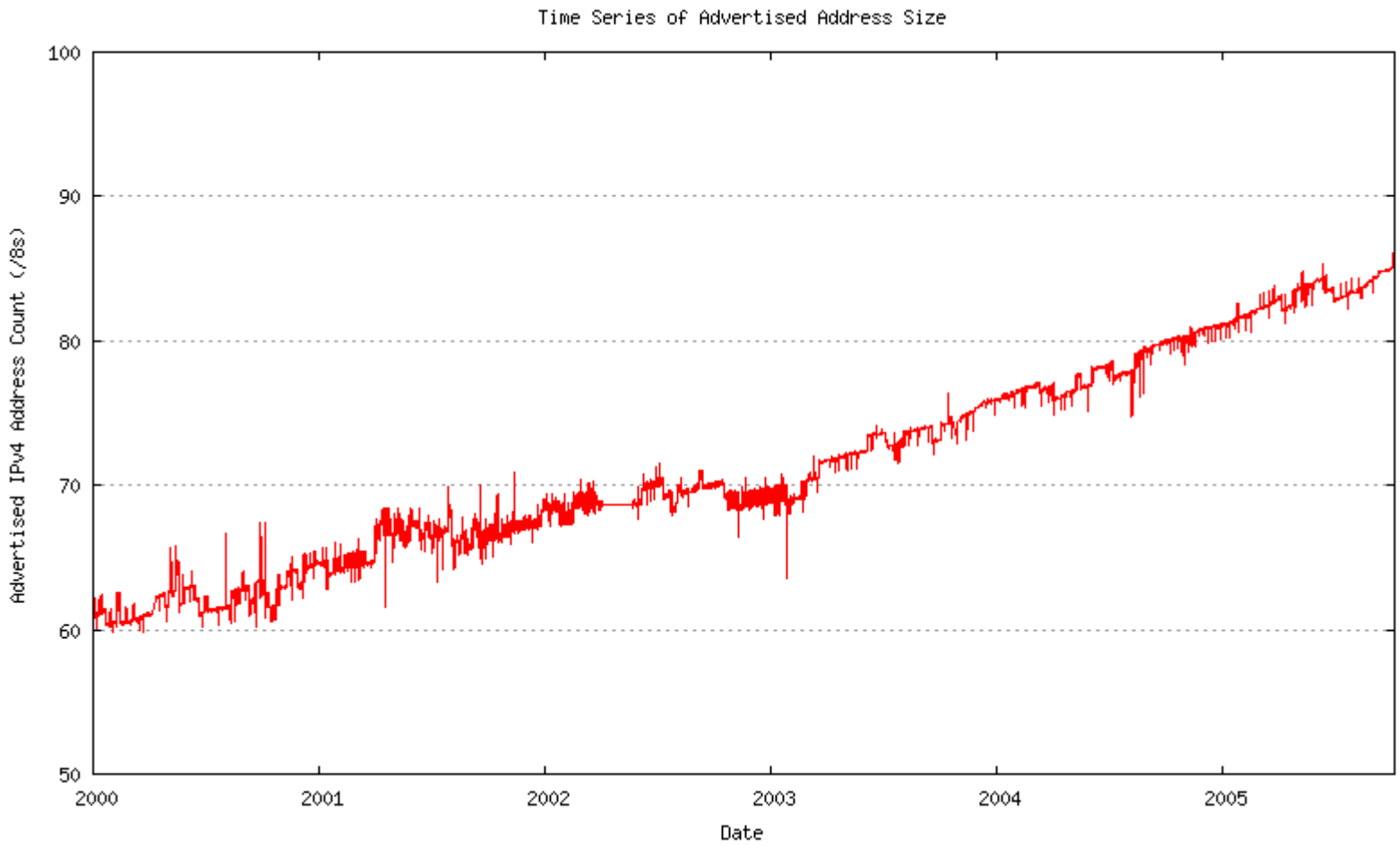
Advertised and Unadvertised Addresses



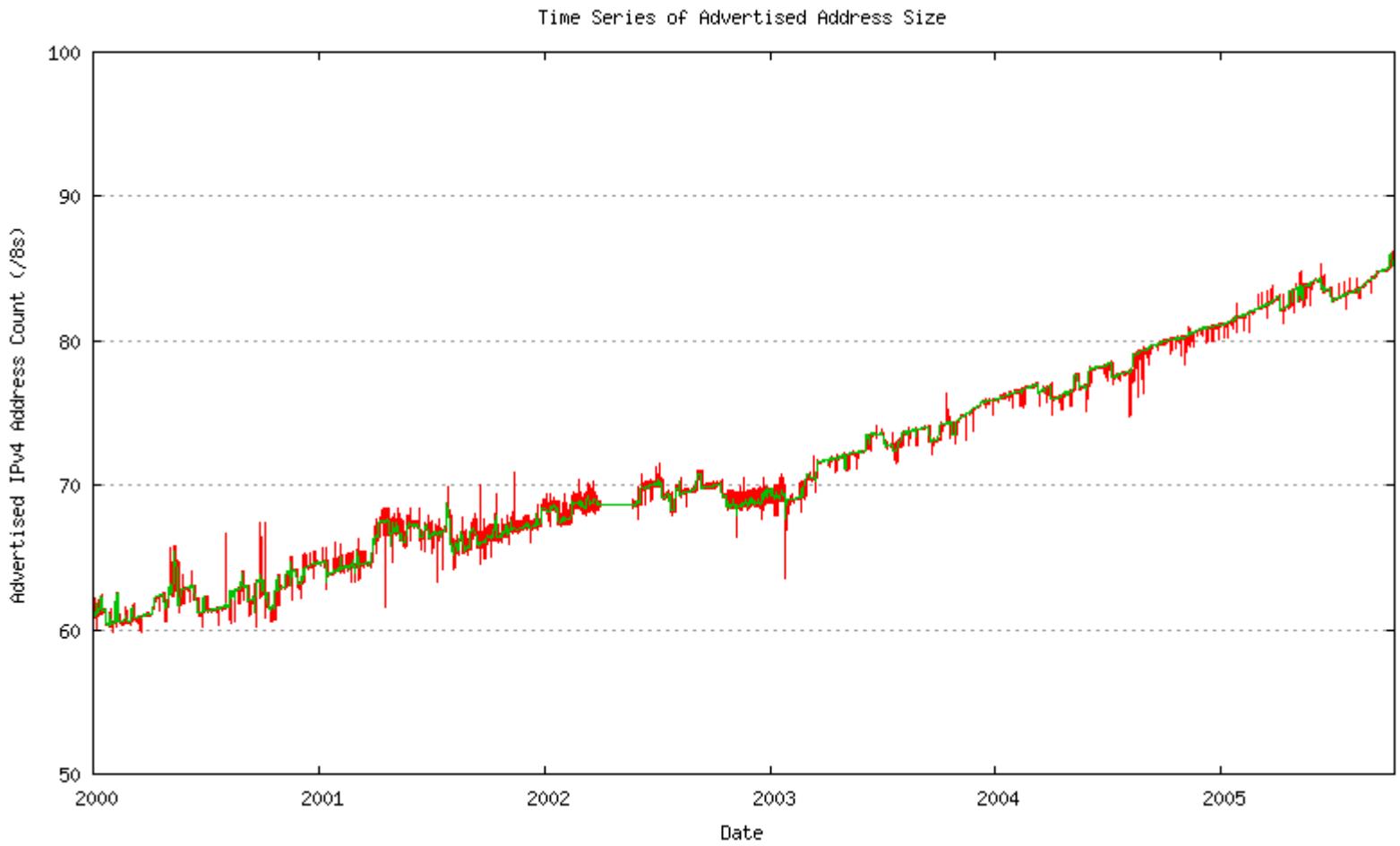
The approach used here

- The post-1999 data indicates that more than 95% of all allocated address space is advertised in BGP on the public IPv4 Internet
- This implies that the drivers for address consumption can be found in the advertised address pool behaviour
- From the advertised data time series remove the high frequency noise components, generate a best fit trend, then model interactions with unadvertised and RIR address pools
- Perform forward extrapolation from this model

Advertised Address Space



Advertised Address Space



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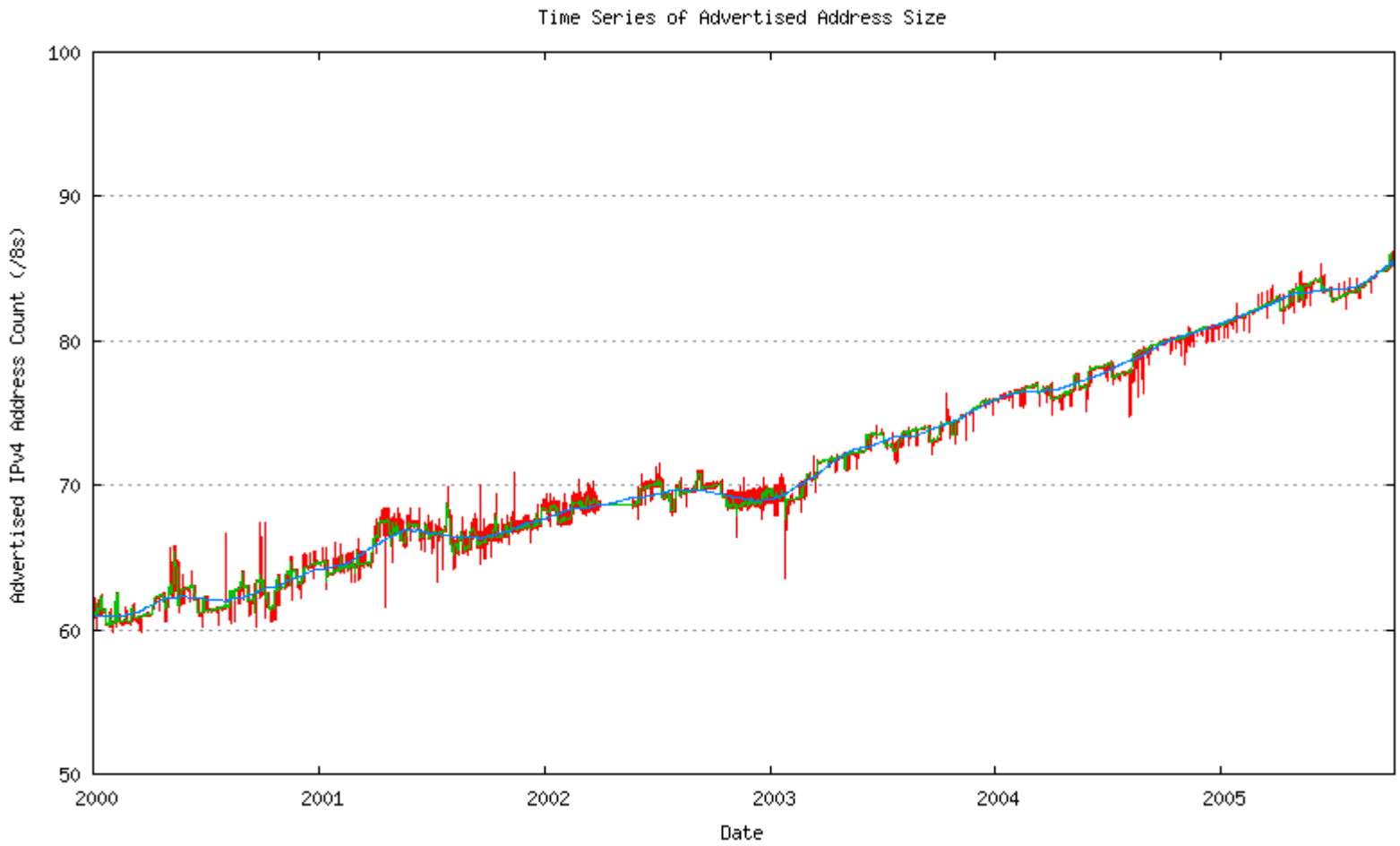
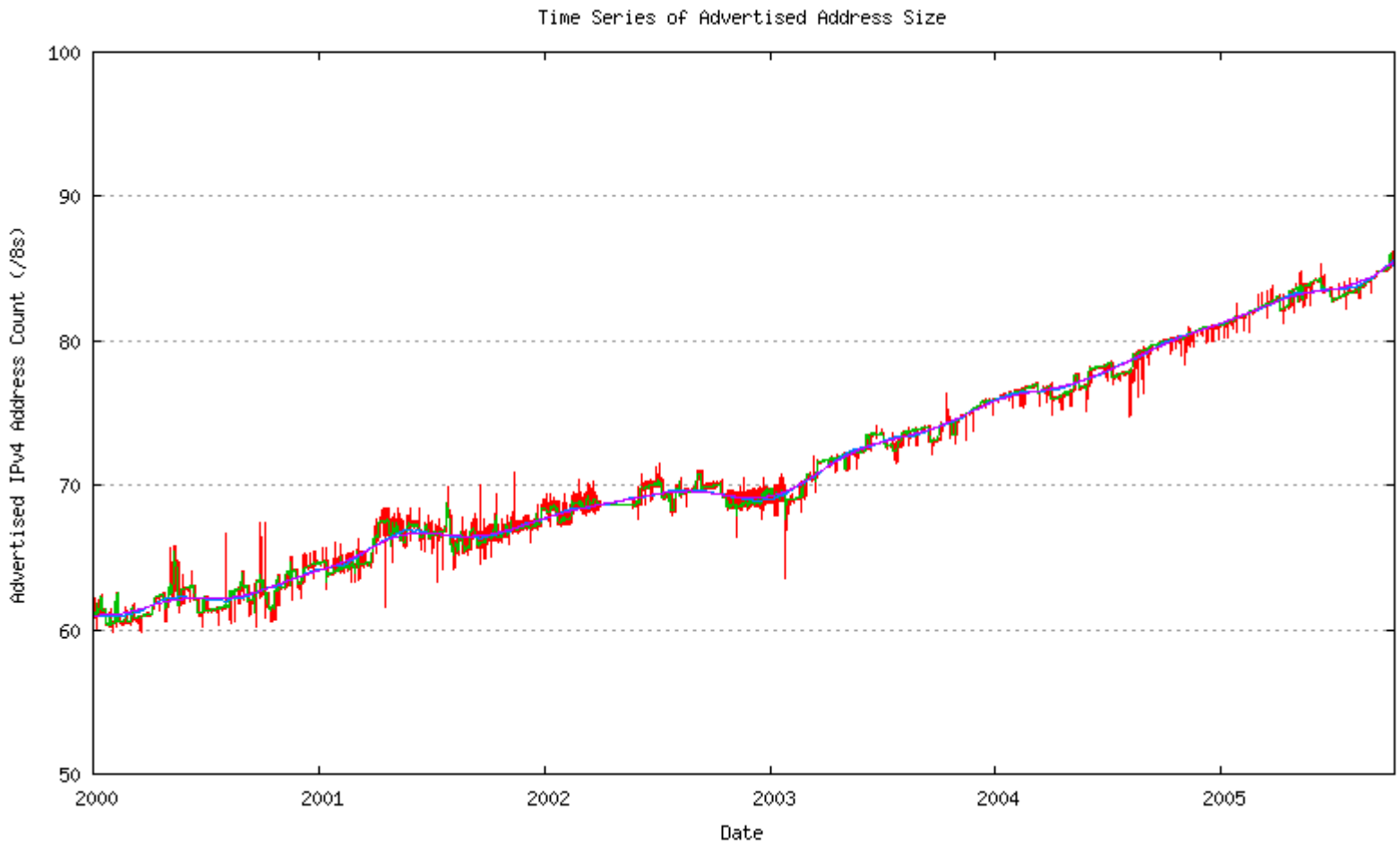
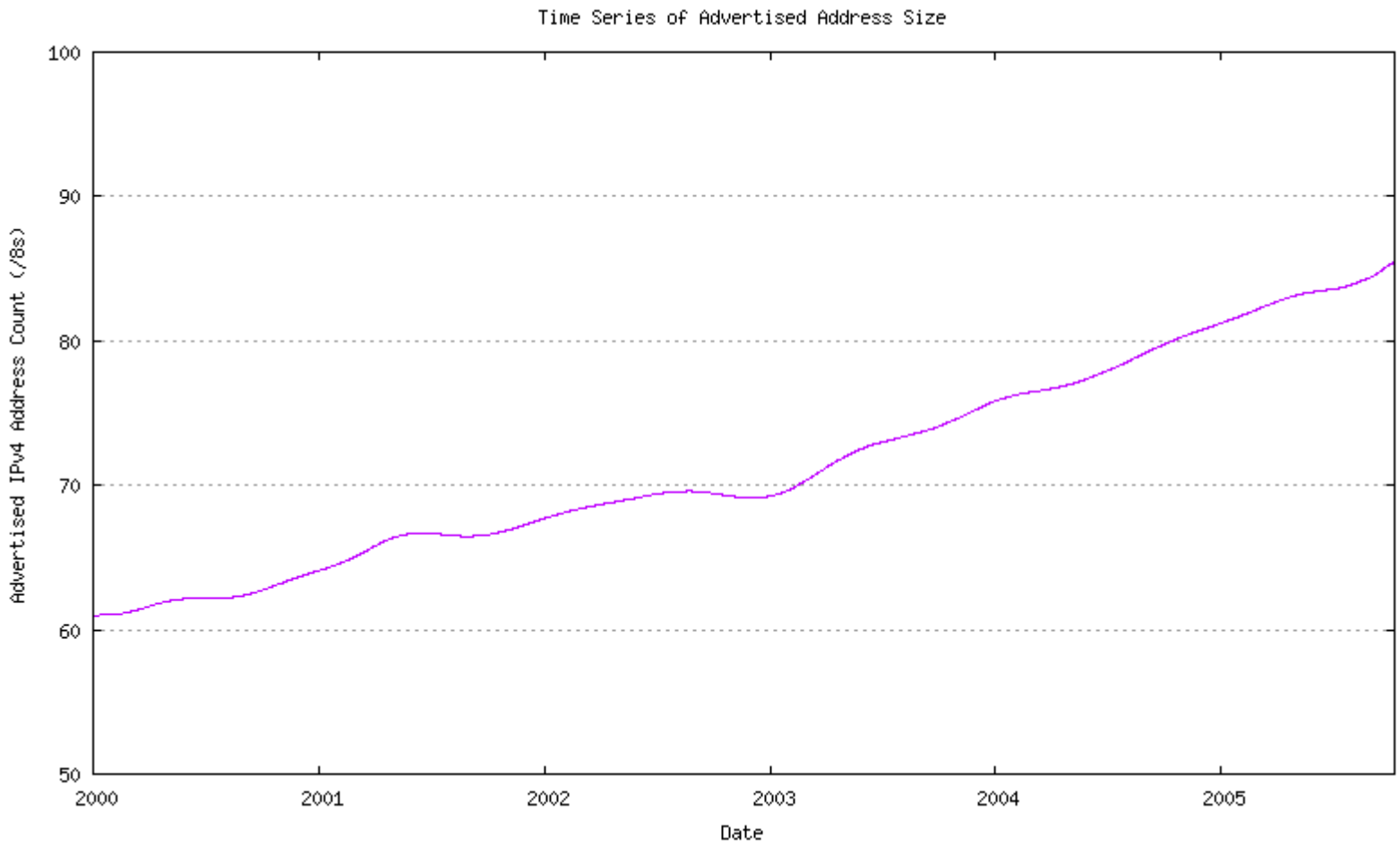


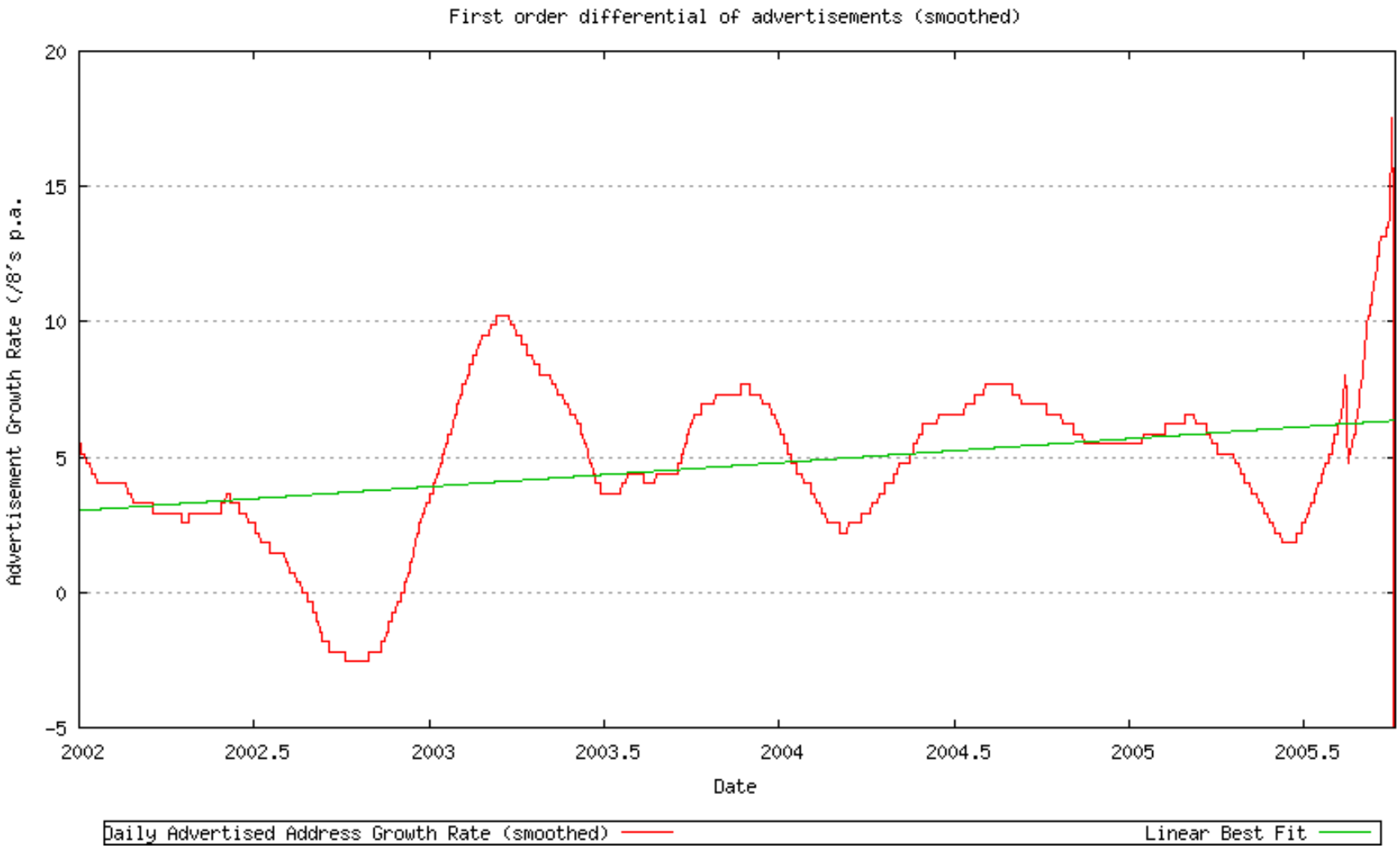
Advertised Address Space



Advertised Address Space

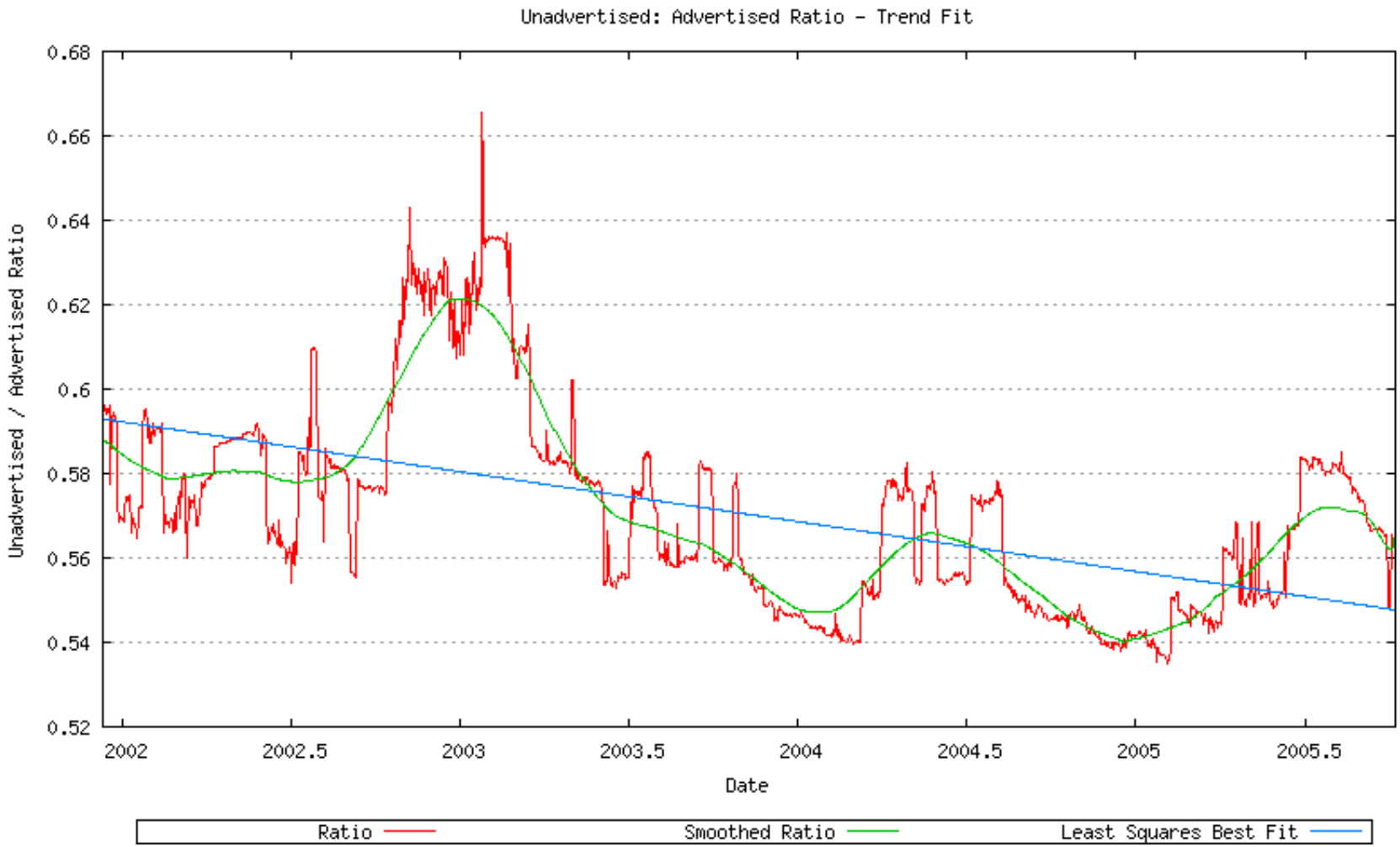


Advertised Address Growth



Unadvertised Address Space

Unadvertised / Advertised Ratio



Modelling Advertised Growth

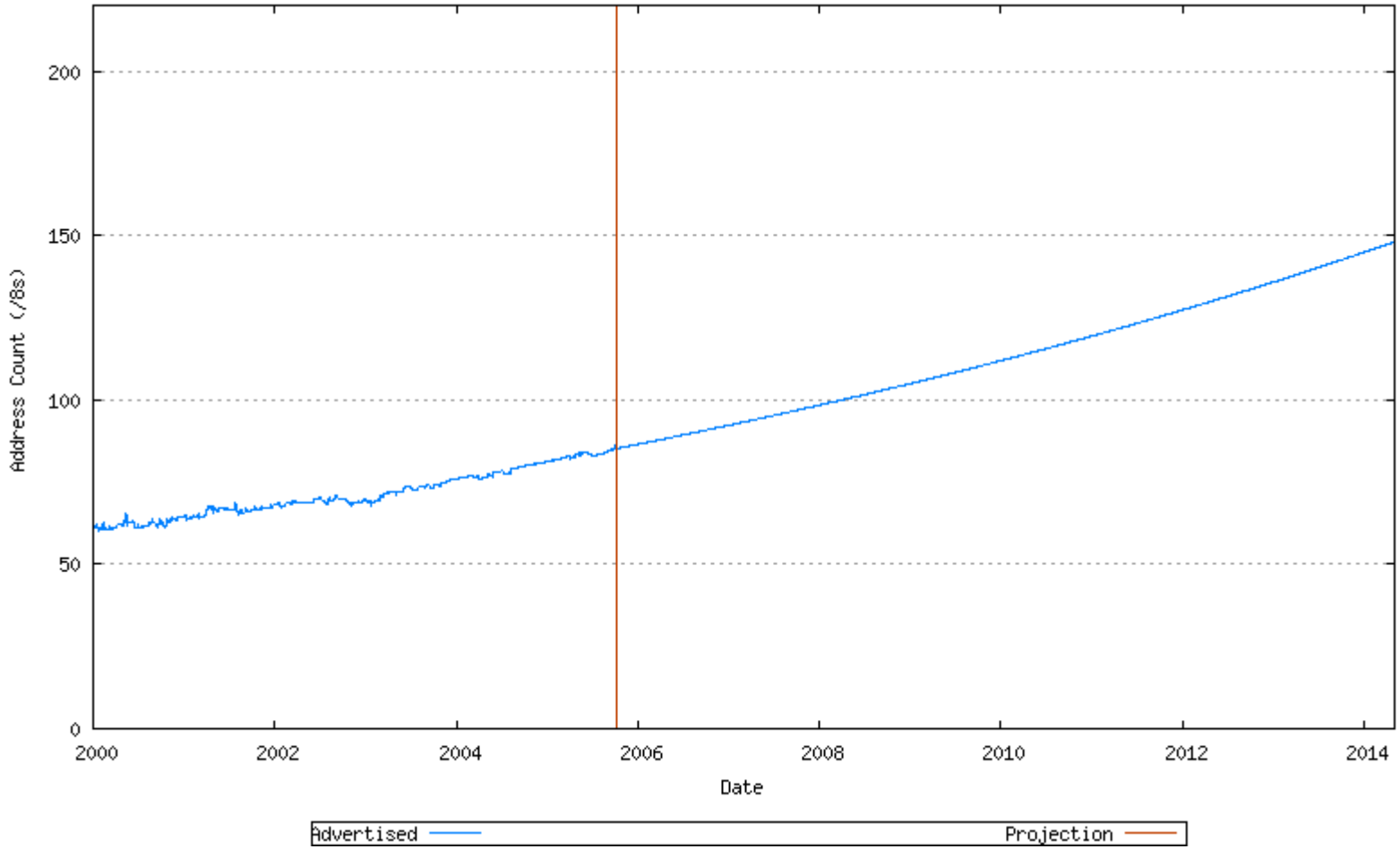
- Best fit to previous 3.5 years data appears to be a compound rather than constant growth rate
  - Best fit to the first order differential of the data is non-constant
- Average network growth of some 5 /8's per year - rising
- To reach an 'exhaustion point' the model uses:
  - an exponential growth trend model based on previous 1,400 days (~ 4 years) advertised address data
  - a linear trend growth model of the ratio of unadvertised to advertised addresses
  - An assumption that the pooled "various" blocks will be exhausted following IANA pool exhaustion

Advertised Addresses

- Advertised addresses grow at an exponential rate
- Previous work applied a best fit of a linear (constant) rate

The Address Consumption Model

Advertised Addresses



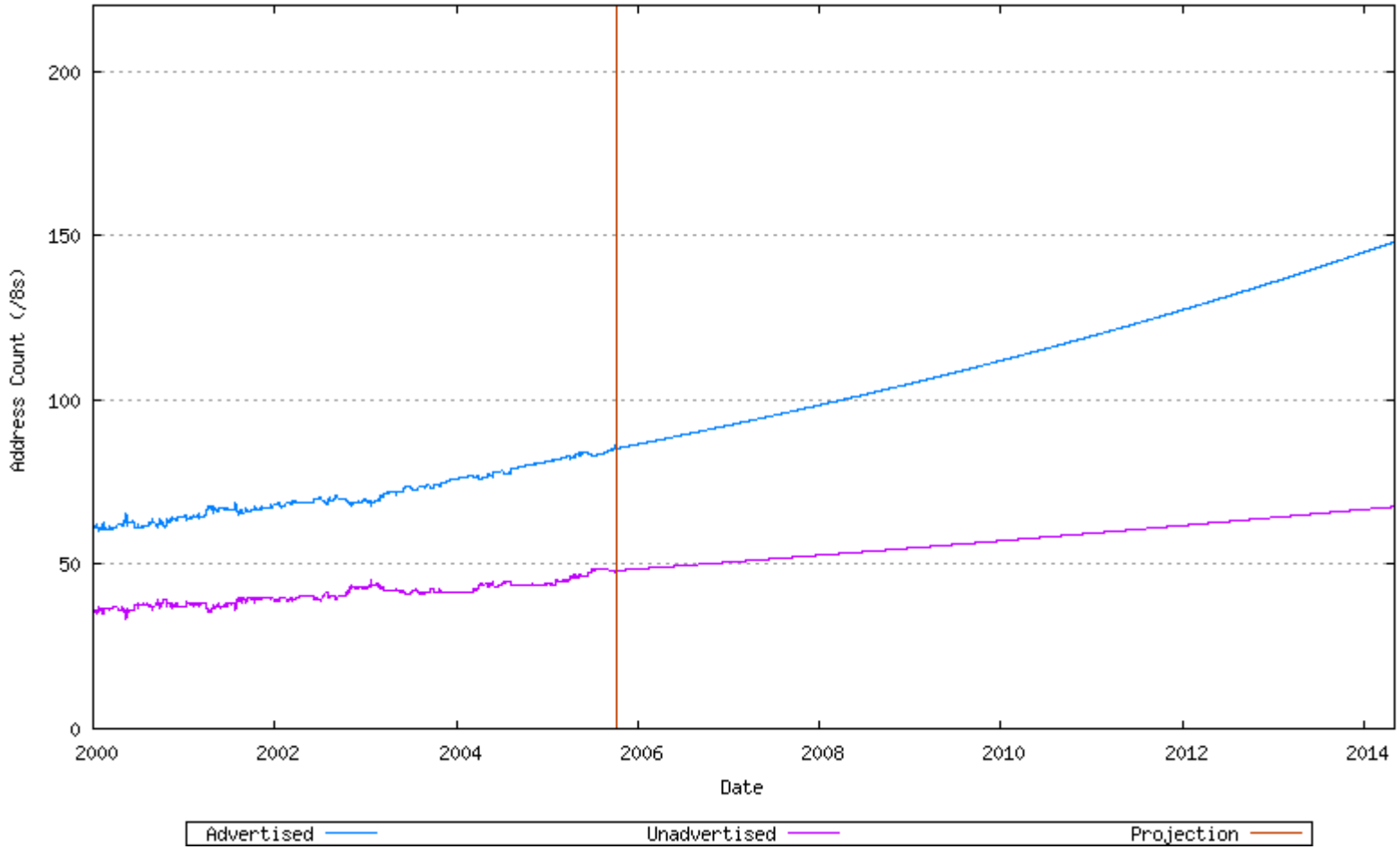
Unadvertised Addresses

- Unadvertised addresses grow at a slower exponential rate
- Reuse, reclamation and return rates for addresses drops to negligible levels

- Previous work used a negative linear trend, assuming that reuse and return rates would pick up

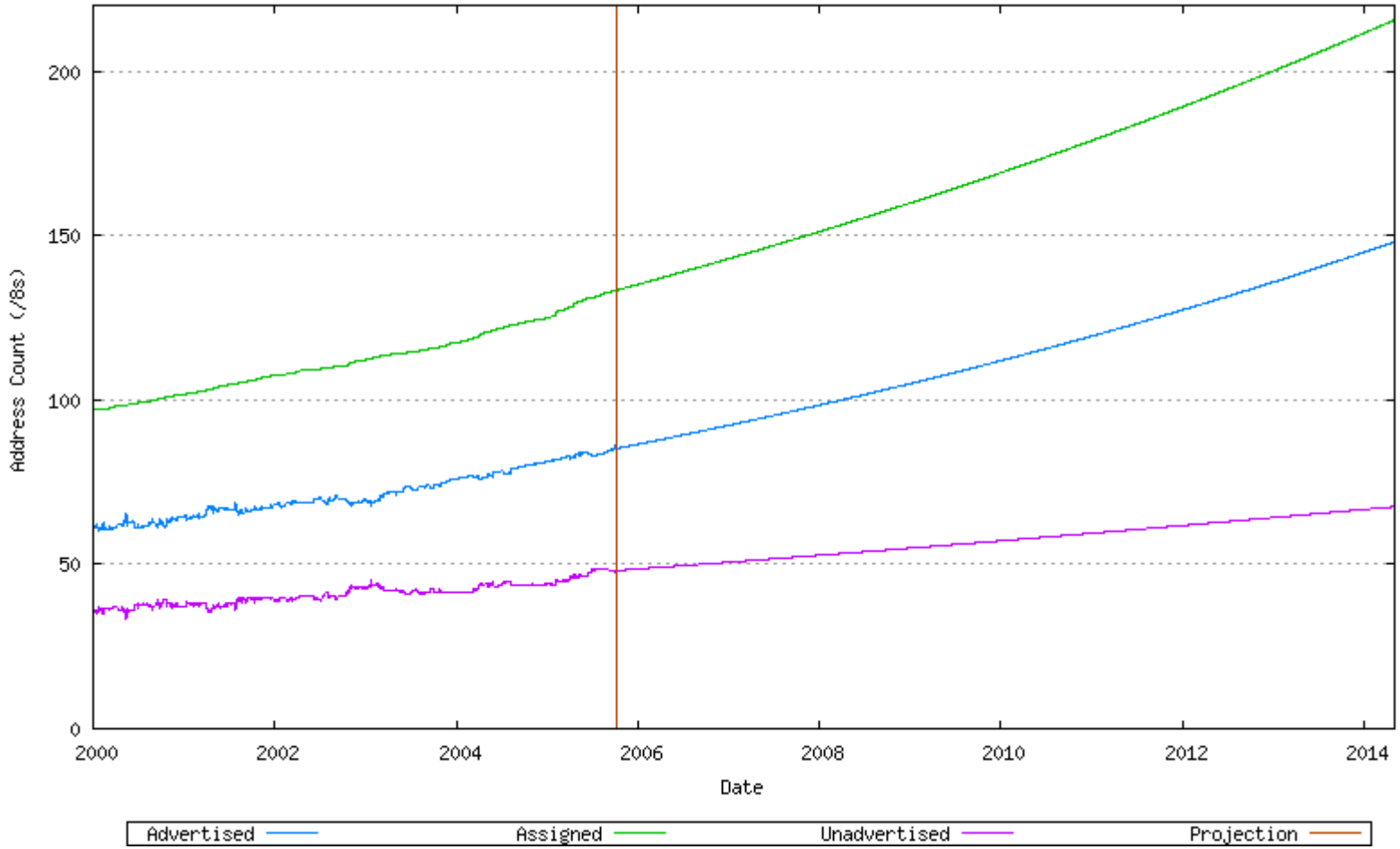
The Address Consumption Model

Unadvertised Addresses



The Address Consumption Model

Total demand level



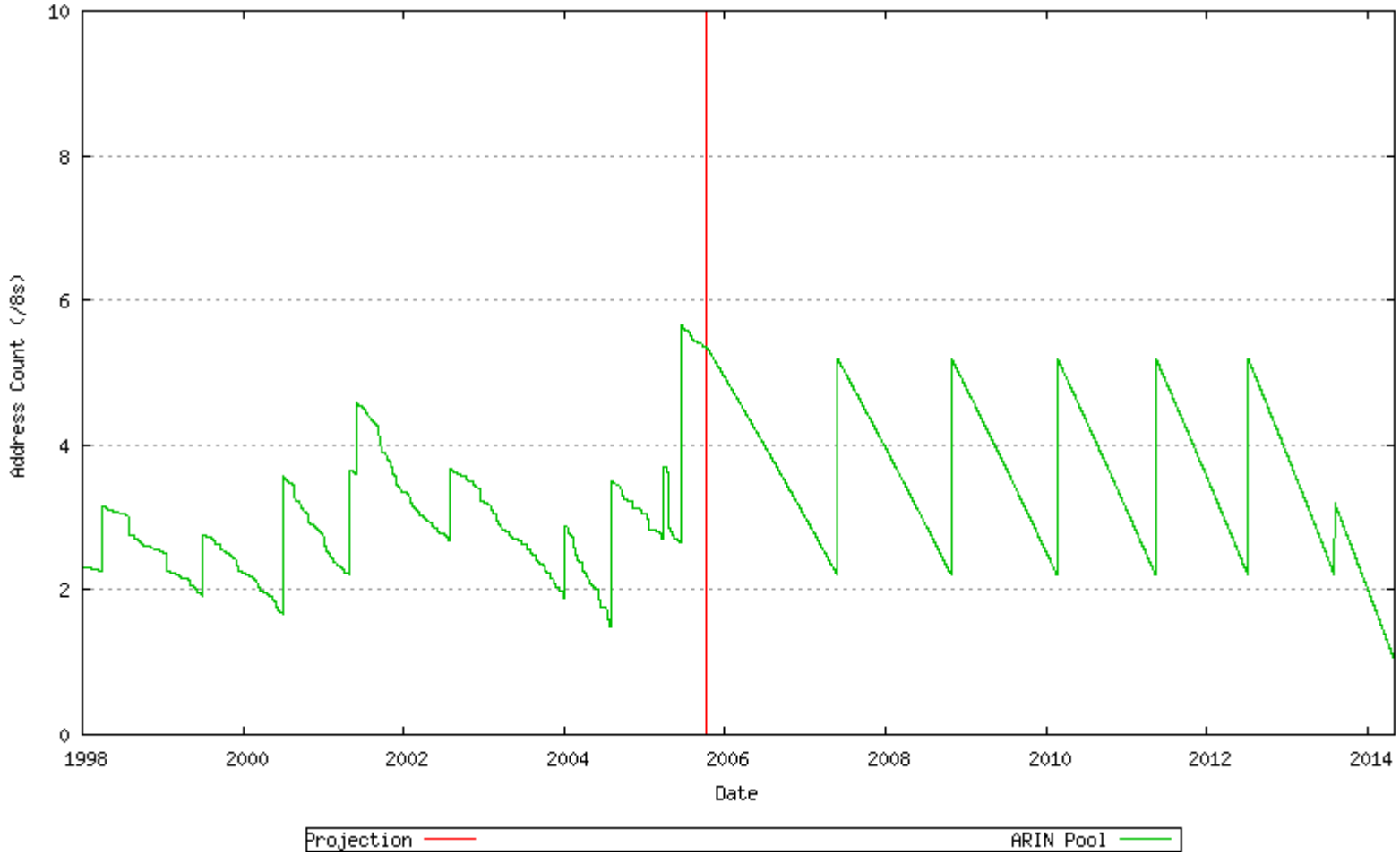
RIR Model

- Assumes that the relative rate of RIR allocation between the RIRs remains steady across the projection
- Absolute rate of RIR allocation is driven by the total address consumption growth
- Assumes exhaustion occurs when any single RIR's pool drops to zero

- Previous work used an exhaustion condition when the combined RIR pool dropped to zero

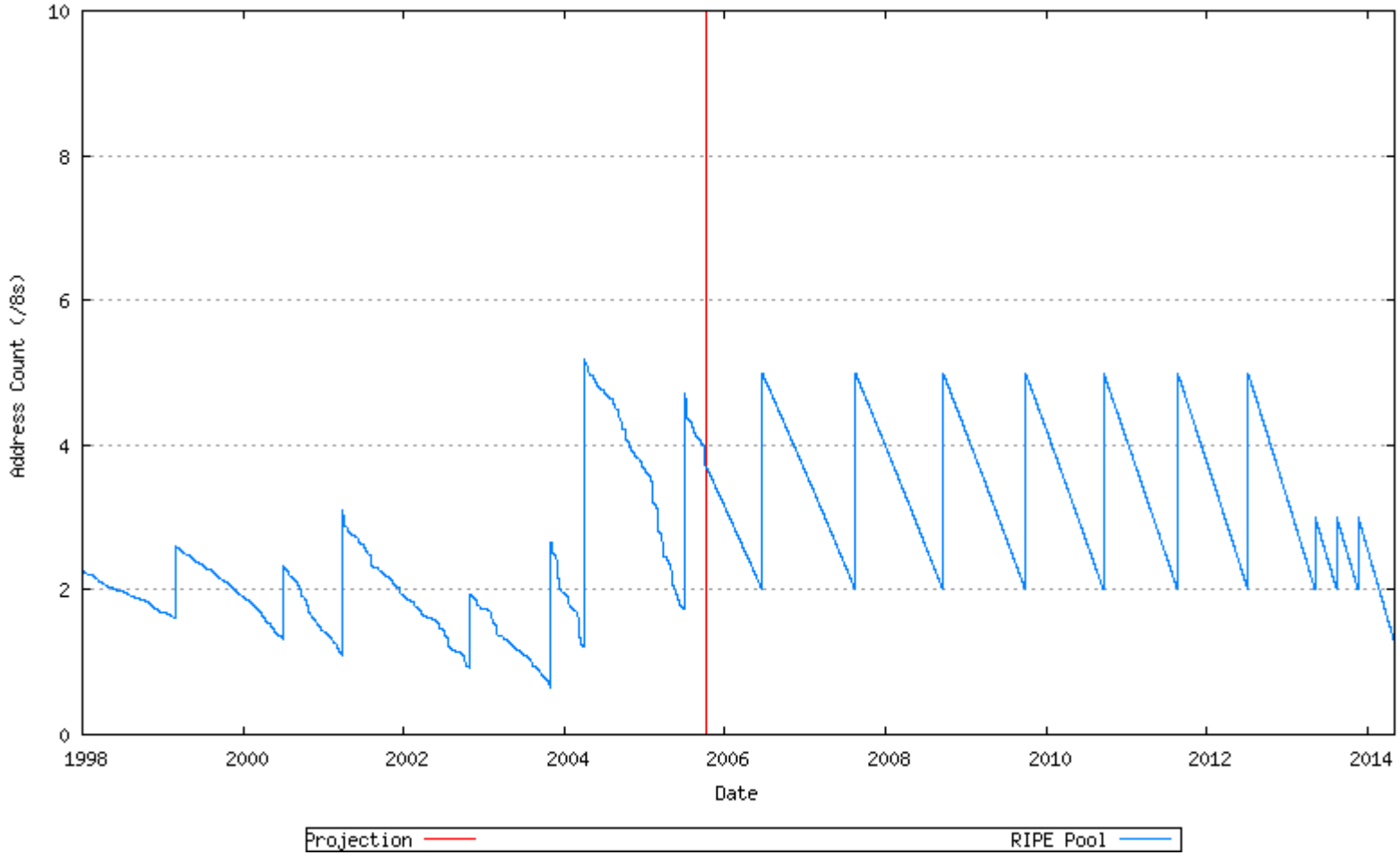
The Address Consumption Model

ARIN



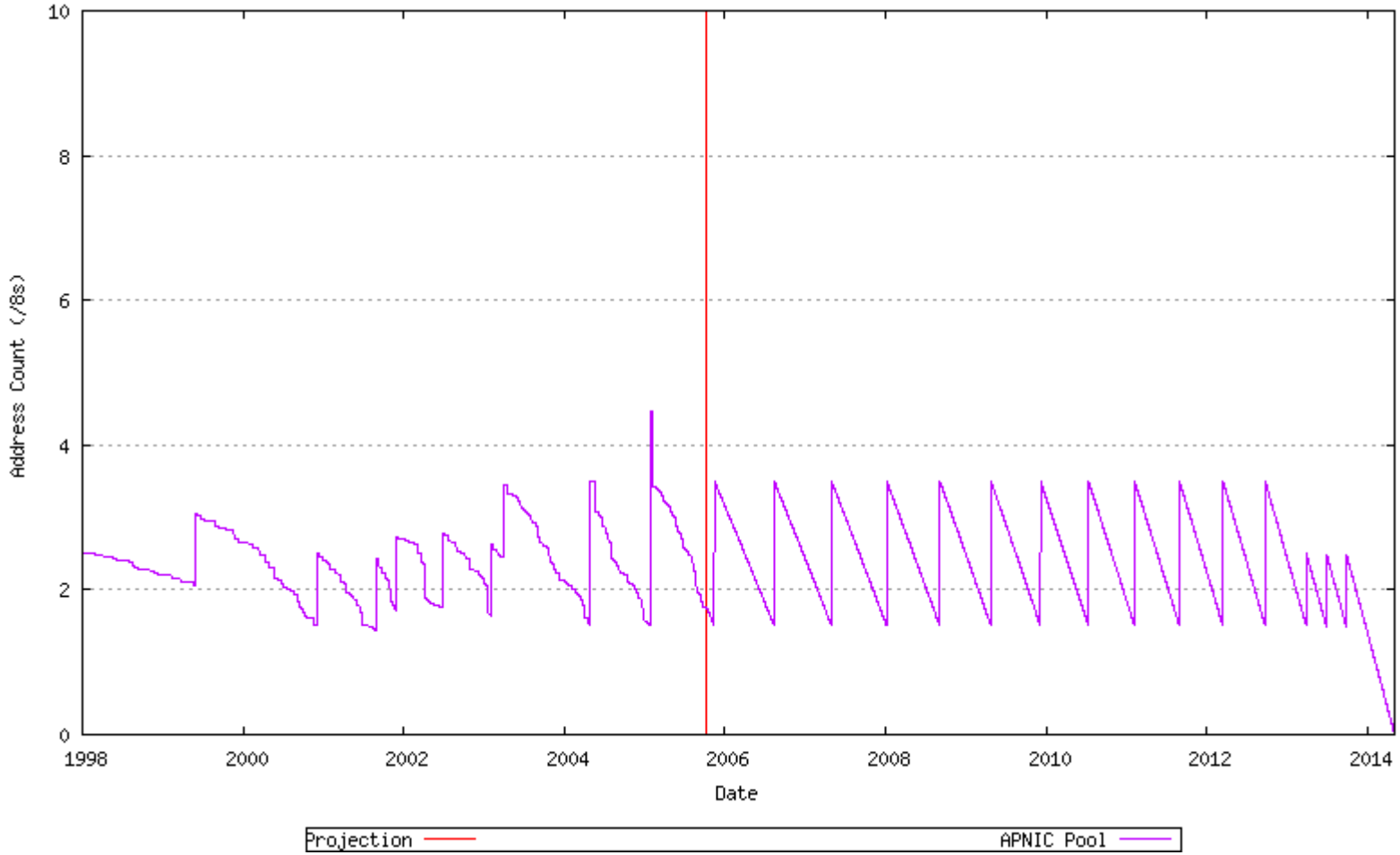
The Address Consumption Model

RIPENCC



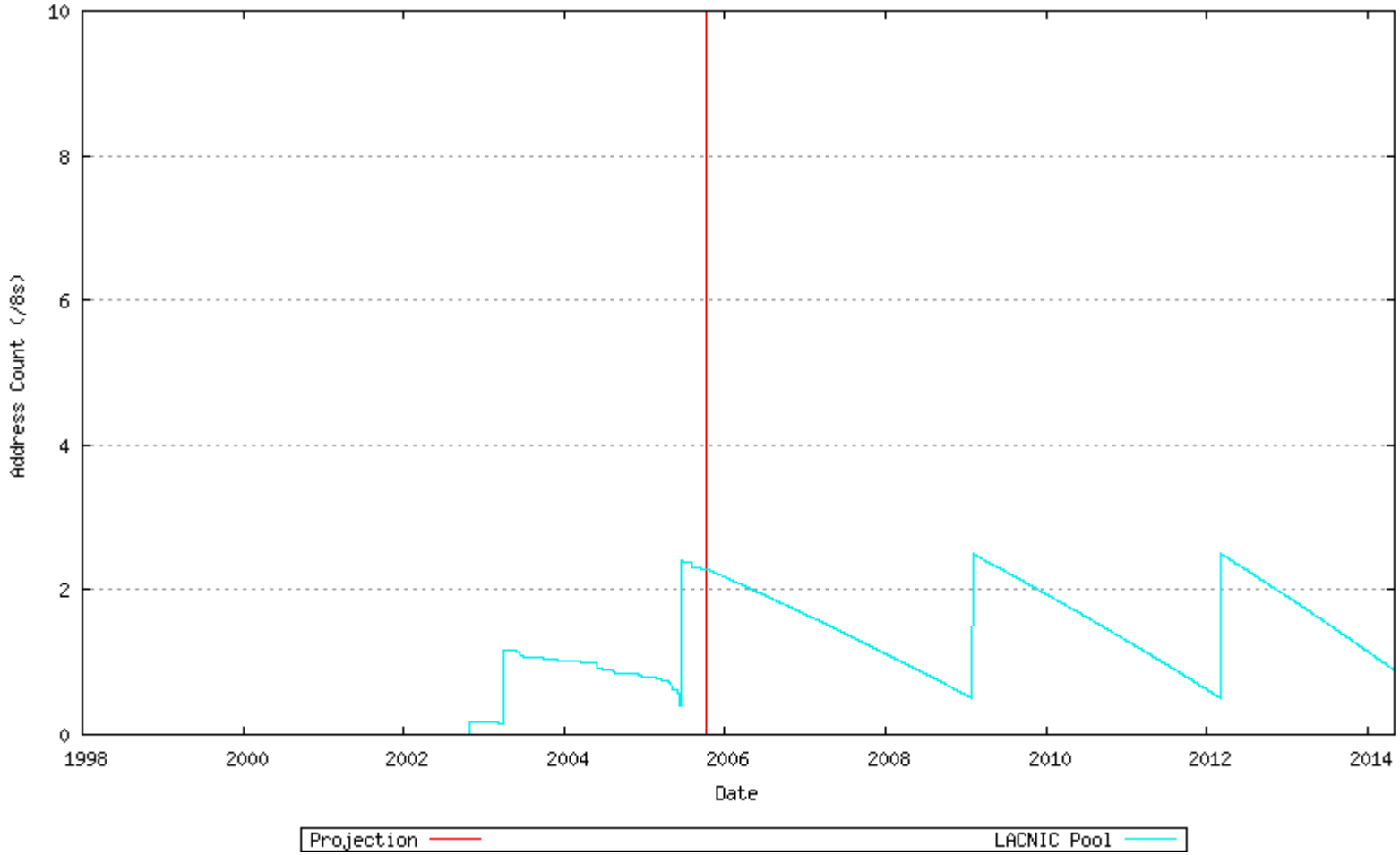
The Address Consumption Model

APNIC



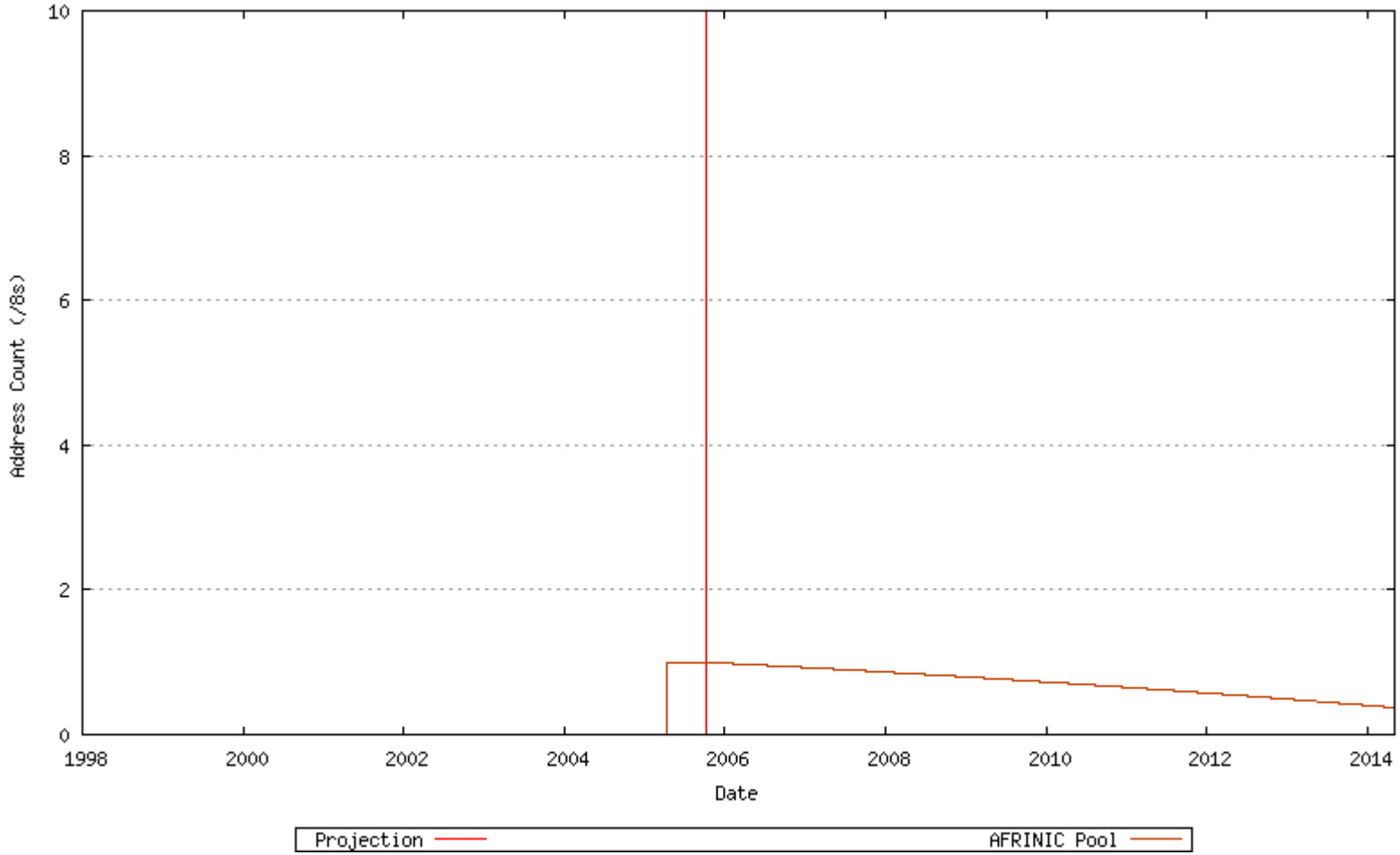
The Address Consumption Model

LACNIC



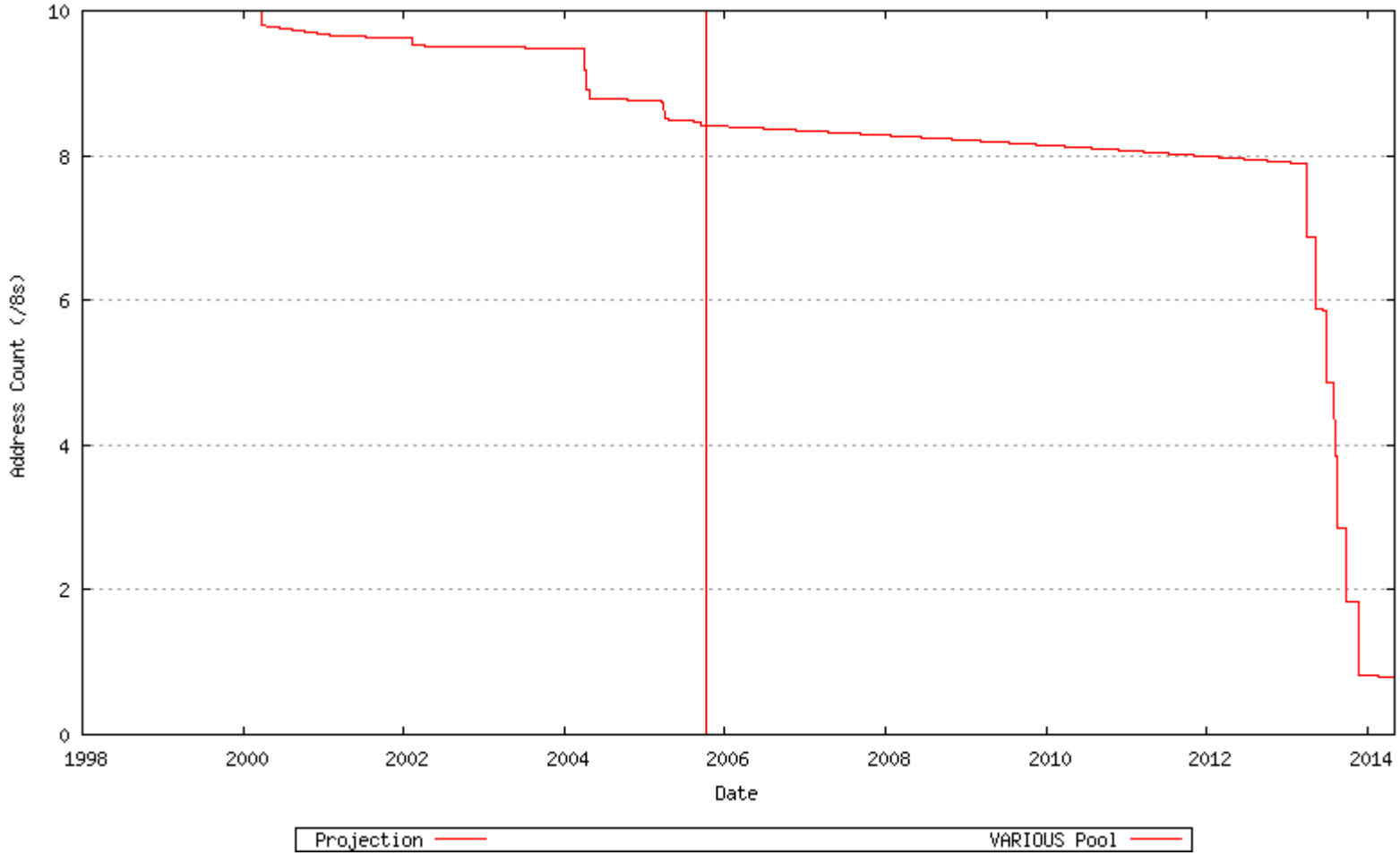
The Address Consumption Model

AFRINIC



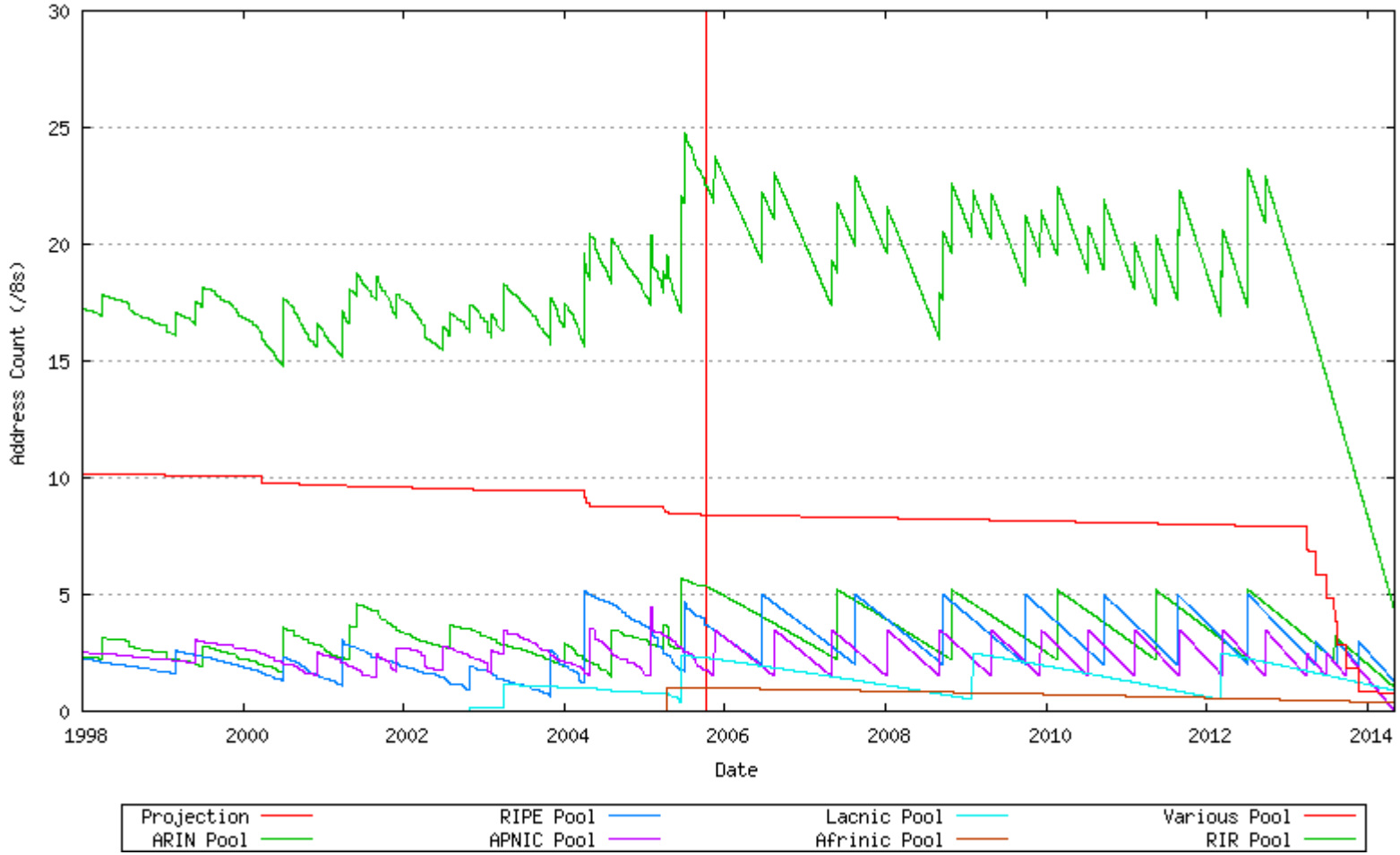
The Address Consumption Model

Various



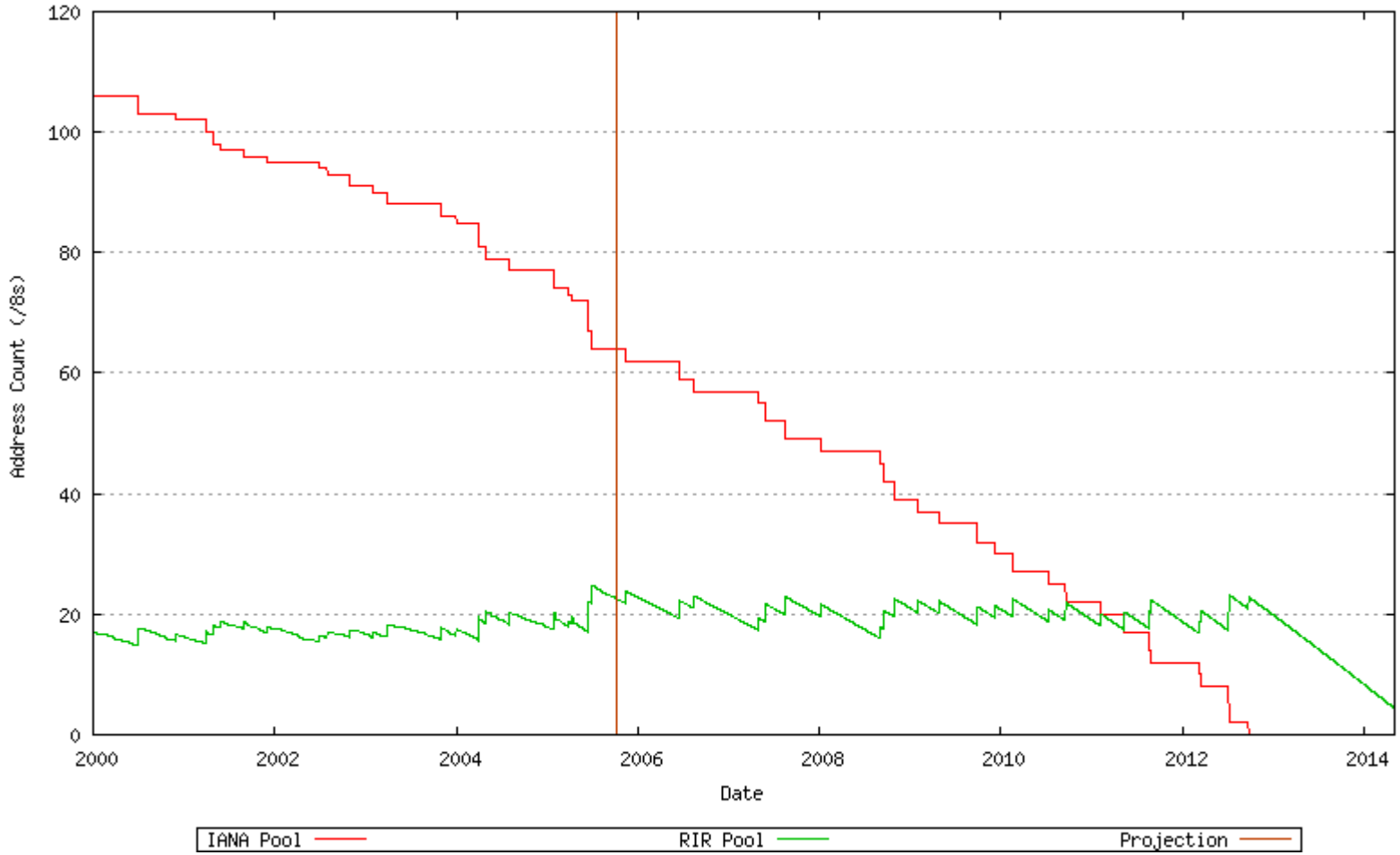
The Address Consumption Model

Combined RIR Model

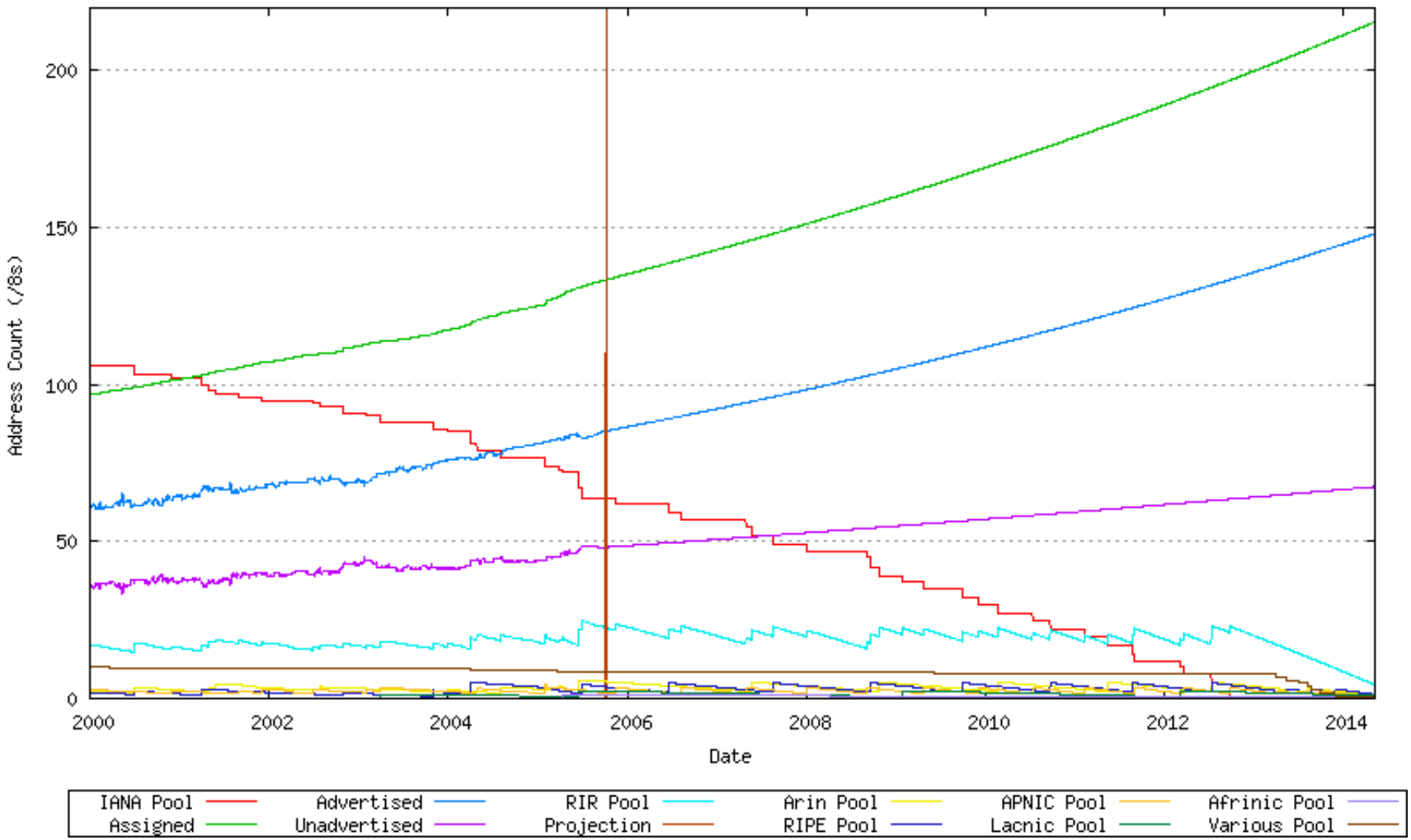


The Address Consumption Model

IANA Pool Consumption



The Address Consumption Model



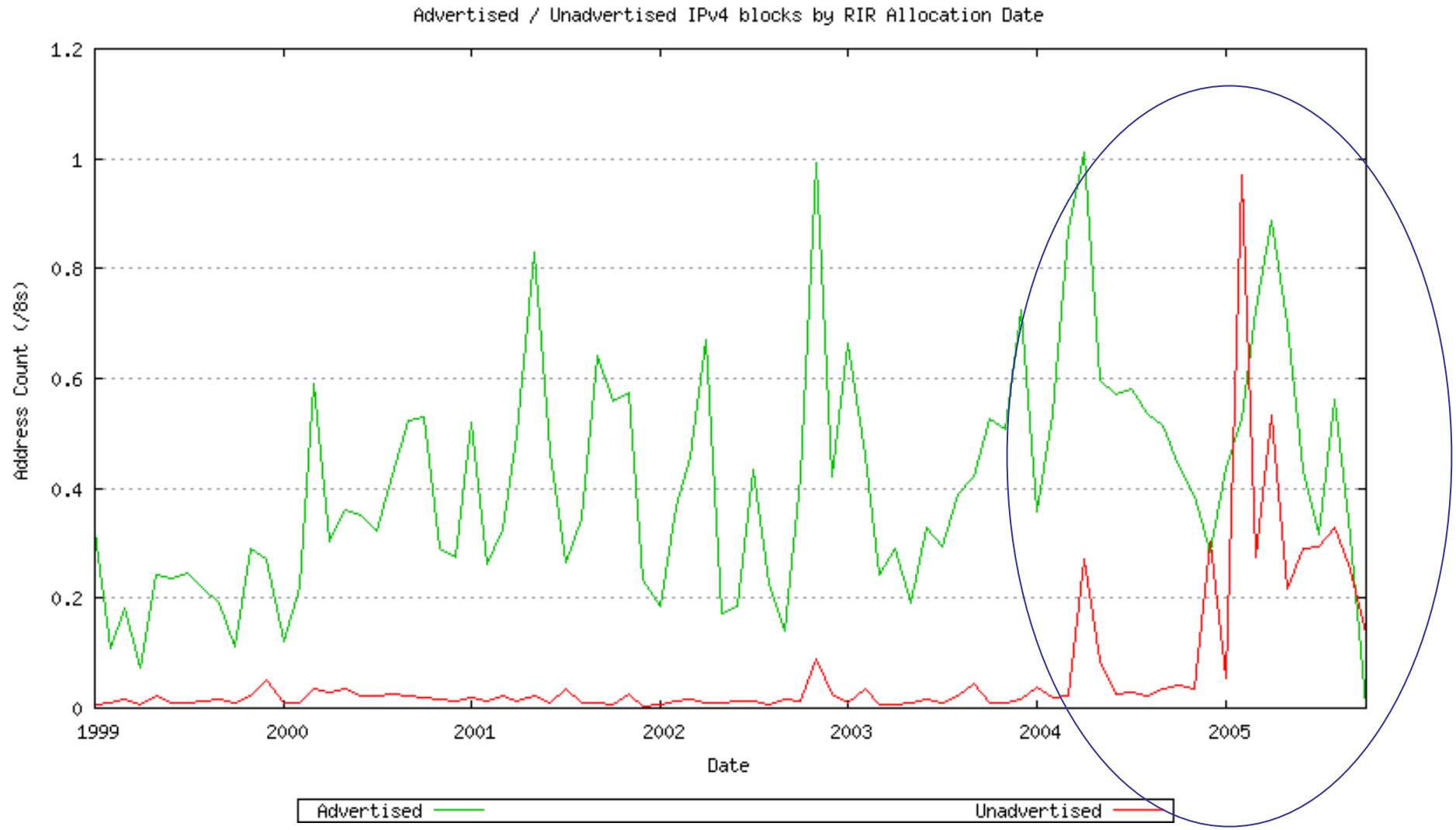
Some Projections from this Model

- IANA Pool exhaustion
  - 5 August 2012
- RIR Pool exhaustion
  - 2 May 2014

Comment

- This model assumes an orderly procession right up to the point of effective exhaustion of the unallocated address pool
  - This is **highly unlikely** to eventuate
  - Within the current policy framework a more likely industry response will be accelerating demands as imminent exhaustion becomes more ‘visible’
  - It is not possible to model such ‘last chance rush’ behaviours based purely on the historical address allocation and BGP data
    - Some other form of modelling of social and market behaviour would be better positioned to make some guesstimates here

Early signs of a rush?



Commentary

- Exhaustion of the IPv4 unallocated address pool does not imply complete unavailability of IPv4 address resources to industry players

- The exhaustion of the unallocated IPv4 address pool does not appear to imply a forced IPv6 conversion onto the industry at that point in time

- There is strong reason to believe that the Internet industry will continue to use IPv4 as a base protocol long after this IPv4 unallocated address pool exhaustion date comes and goes

IPv4 Address Markets?

- In the absence of the imposition of specific external control functions, a conventional economic response would be the emergence of various forms of trading markets in address resources
- In conventional markets scarcity tends to operate as a pricing premium factor
- Market behaviours would then imply an entirely different behaviour in terms of IPv4 address distribution functions
- Unadvertised address pools, poorly utilized address pools and release of current address holdings based on conversion to address compression technologies would come into play within a market-based pricing dynamic
- What form of market regulation would be appropriate? How would it be applied? Who would apply it? Why would it be useful to have?
- How can we preserve address utility (the integrity of address uniqueness) in an environment of market-based trading?

Food for Thought

- RIR Allocation Policies:
  - What is the threshold point where the application of different IPv4 address allocation policies may be appropriate? Or is “no change” a wiser course of action?
  - Should the RIRs establish “strategic reserve address pools? Why?
- Emergence of IP Address Markets:
  - Is the emergence of such markets Good or Bad? Avoidable or Inevitable? Appropriate or Inappropriate? Fair or Unfair?
  - Are the any practical alternatives?
  - How are trading markets best supported?
  - Would such markets be regulated? How?
  - What is the RIR role in such an environment?
- Global Implications:
  - What about “Equity”, “Affordability”, “Fairness” of access to address resources at a global level?
  - And in what venue are such concerns best expressed

Address Policy Questions

- What are most appropriate address management policy measures that will support the continued well-being of the global Internet and its users?

- And when will they be needed?

Thank You