IPv4 Address Lifetime Expectancy

Geoff Huston, APNIC
31 October 2005
Australian IPv6 Summit
If 42 is the answer

Then what was the question?
   – Part of the reason for differences in outcomes in this area lies in the difference of the question being posed

So - to be clear – the question posed in this study is:

When can we expect that the current address allocation policies for IPv4 will no longer apply?
A look at the IPv4 data

• Use a 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 honour an address request
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

Time Series of Advertised Address Size

![Graph showing the trend of advertised IPv4 address size over time from 2000 to 2005. The graph displays a steady increase in the count of advertised addresses with minor fluctuations.]
Advertised Address Space
Advertised Address Space

Time Series of Advertised Address Size

Advertised IPv4 Address Count (*/8)

Date

2000 2001 2002 2003 2004 2005
Advertised Address Space

Time Series of Advertised Address Size

Date

2000 2001 2002 2003 2004 2005

Advertised IPv4 Address Count (B/8)
Advertised Address Growth
Advertised Address Growth

First order differential of log(advertisements)
Unadvertised Address Space

Time Series of Advertised and Unadvertised Addresses

IPV4 Address Count (/8s)

Date

Advertised
Unadvertised
Modelling Advertised Growth

- Best fit to previous 3.5 years data appears to be a compound rather than constant growth rate
  - Use an exponential growth model \(\text{adv} = e^{ax+b}\)

- Average network growth of some 6 /8’s per year – accelerating at a rate of 0.3 /8’s per year

- To reach a ‘policy exhaustion point’ the model uses:
  - an exponential growth trend model based on previous 1,200 days (~ 3.5 years) advertised address data
  - a (decreasing) 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 address count grows at an exponential rate
The Address Consumption Model

Advertised Addresses

![Graph showing the increase in advertised addresses from 2000 to 2012. The graph includes a trend line for projection.]
Unadvertised Addresses

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

Unadvertised Addresses
The Address Consumption Model

Total demand level

![Graph showing the total demand level over time from 2000 to 2012. The x-axis represents the date, and the y-axis represents the address count. There are multiple lines representing different categories: Advertised, Assigned, Unadvertised, and Projection. The graph shows a rising trend in all categories, with the Advertised and Assigned lines starting at lower counts and the Unadvertised and Projection lines starting at higher counts, indicating a decrease in the difference between advertised and allocated addresses over time.]
RIR Model

• Assumes that the relative rate of RIR allocation between the RIRs varies according to relative allocation trends in previous 3.5 years

• Absolute rate of total RIR allocations is driven by the total address consumption growth
The Address Consumption Model

ARIN
The Address Consumption Model

RIPENCC

![Graph showing address consumption over time with a projection and a pipe pool line. The x-axis represents dates from 1998 to 2012, and the y-axis represents address count. The graph illustrates the consumption pattern and provides a projection for future consumption.](image-url)
The Address Consumption Model

APNIC
The Address Consumption Model

LACNIC

Graph showing address consumption over time with labels for Projection and LACNIC Pool.
The Address Consumption Model

AFRINIC

[Graph showing the address consumption model from 1998 to 2012, with date on the x-axis and address count on the y-axis.]
The Address Consumption Model

Combined RIR Model

![Graph showing address consumption over time for different RIR pools. The x-axis represents the years from 1998 to 2012, and the y-axis represents the address count. The graph includes lines for various RIR pools such as RIPE, LACNIC, ASO NIC, and ARIN, each with a different color. The graph illustrates the decreasing trend in address consumption over time.]
The Address Consumption Model

Full Model

Date

Address Count (/es)


IHNA Pool    Assigned   Unadvertised   Projection   RIPE Pool   LACNIC Pool    African Pool   Various Pool
Some Projections from this Model

- IANA Unallocated Address Pool exhaustion
  13 May 2012

- RIR Unallocated Address Pool exhaustion
  29 May 2013
Comment about date prediction

- 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
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
Policies and 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?
Hmmmm

- Is this address space “melting like ice under the heat of the sun”?
  - Don’t be completely silly!
- Are current policies “strict conservation” measures?
  - No – they have been consistent for a decade now. Address policies have been attuned to industry needs for many years.
- Is this “running into a brick wall”
  - Not at all!
- Is this “rapid exhaustion”
  - Again, not at al!
- Is 2008 a likely date for “the exhaustion of the IPv4 address space”?
  - Don’t be inane – this is just one predicted point of policy change in address distribution mechanisms
- Will anyone be “unable to get additional IPv4 addresses”?
  - Of course not! There will continue to be address distribution functions
- Is this a repeat of “as they did for Y2K”?
  - Only if you interpret y2k as just sign of a PR system getting tragically suckered into its own hype machine!

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?
The Daily Report

The IPv4 Report

http://www.potaroo.net/tools/ipv4/
Thank You