Understanding IPv4 Address Exhaustion
by Dale Geesey, Vice President of Consulting, v6 Transition

Introductions

The Federal Government has set 2008 as the date that all Government Agencies must start using IPv6 across their core networks and the Agencies are working to meet that deadline. However, utilizing IPv6 in the core is different from utilizing IPv6 across the entire Enterprise. Questions are already rising on what are the next steps beyond 2008 to continue the transition and what are the right dates to target for a complete transition to IPv6. The US Army has developed a transition approach in which their plan tries to limit the period of IPv4 and IPv6 coexistence. They plan to achieve IPv6 Dominance between 2010 and 2013, and begin actively removing support for IPv4 from their Enterprise. There may be limited systems utilizing IPv4 until they are phased out in favor of newer ones, but these would be the exception rather than the rule. As Agencies move forward in their transition planning efforts, they must determine what are the drivers and constraints impacting their transition. Figure 1 below shows examples of drivers and constraints that may impact an Agency's IPv6 Transition timeframes.

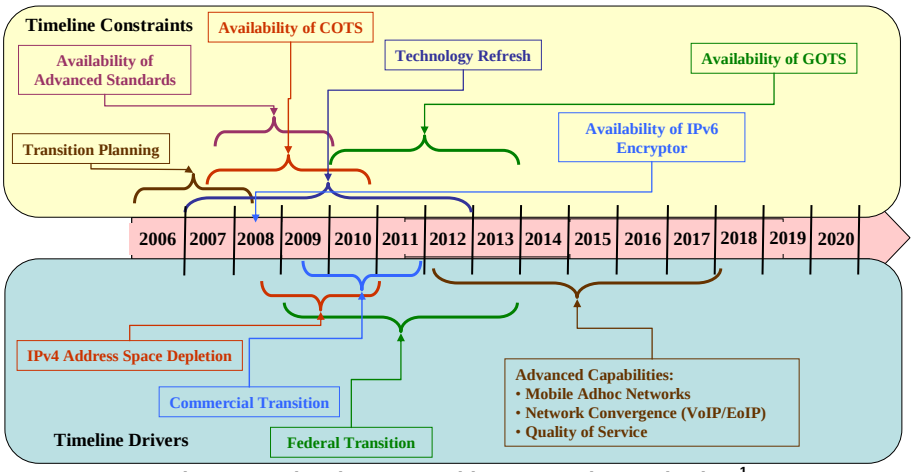

Figure 1 Notional IPv6 Transition Constraints and Driver[1]

The topic of IPv4 address exhaustion is one many organizations are watching closely, especially as the plans for transitioning to IPv6 are ramping up within the US. The IPv4 address space is limited and there is general consensus that the IPv4 address space, managed by Internet Corporation for Assigned Names and Numbers (ICANN) and the Regional Internet Registries (RIR)s, is headed towards exhaustion. However, there are varying opinions on the timing of when there will be no more addresses available from the RIRs.

Current Projection for IPv4 Address Exhaustion

Many people within the Internet community have analyzed the question of IPv4 address exhaustion and published their reports. The confusing aspect is that the estimates vary greatly based on the report. Some predict IPv4 address exhaustion within the next 12-24 months and others say it will not happen until 2013. Figure 2 shows an IPv4 address space exhaustion prediction based on the assignment history of the past five years by Tony Haines (Cisco Systems). In this case, he estimates IPv4 address exhaustion will occur prior to 2009.

[1] Geesey, D., "The IPv6 Best Practices World Report Series: Guide for Federal Agencies Transitioning to IPv6", January 2006, IPv6 Summit, Inc in cooperation with Juniper Networks http://www.juniper.net/federal/IPv6/

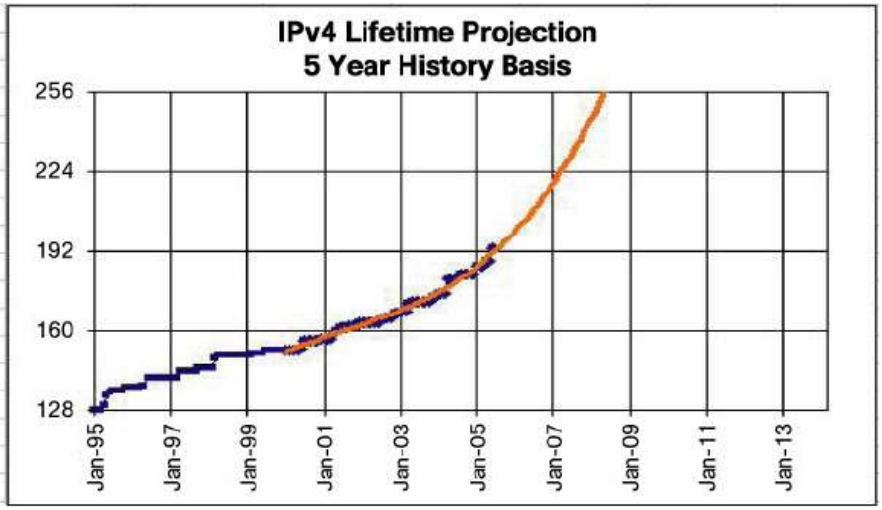

Figure 2 IPv4 Address Space Exhaustion Predictions Based on the Assignment History of the Past Five Years[2]

Figure 3 shows an IPv4 address consumption model developed by Geoff Houston (APNIC). Utilizing his estimates, IPv4 address exhaustion will not occur until the 2012 – 2013 timeframe.

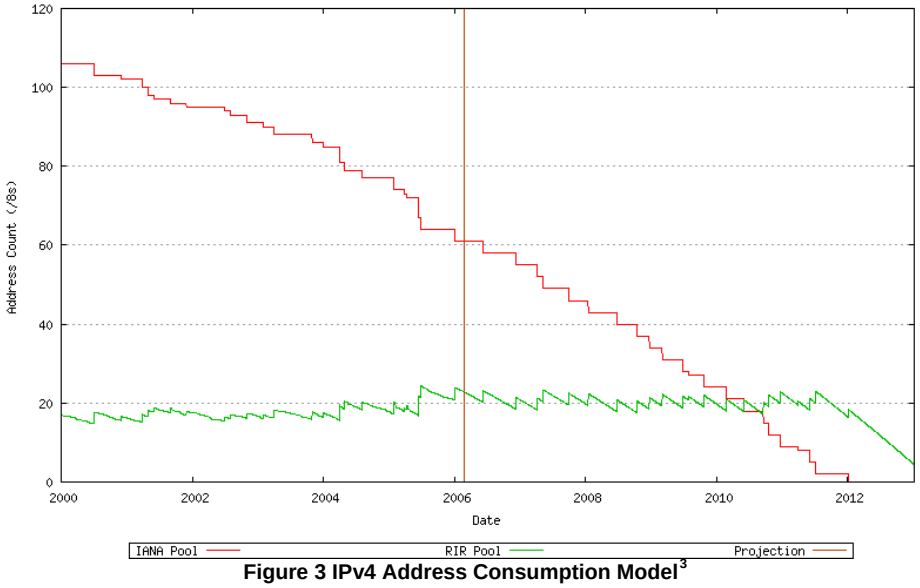

Figure 3 IPv4 Address Consumption Model[3]

The results of these models are very different; they vary by almost five years. So how can someone concerned with this issue develop a better understanding of the facts? Go straight to the source of the information, the RIRs.

What do the RIRs Say?

The Numbers Resource Organization (NRO) is made up of the RIRs including:

- African Network Information Center (AFRINIC)
- Asia Pacific Network Information Centre (APNIC)
- American Registry for Internet Numbers (ARIN)
- Latin American and Caribbean Internet Address Registry (LACNIC)
- RIPE Network Coordination Centre (RIPE NCC)

Why is it important to understand what the NRO and RIRs are saying? Primarily because they are charged by ICANN to handle the IP address distribution for both IPv4 and IPv6. Figure 4 shows their regional responsibilities.

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[2] IPv6 and National Strategies on Information and Communication Technologies, September 2005, Cisco Systems
[3] Huston, G., IPv4 Numerology, March 2006, Presentation at APRICOT 2006

Figure 4 RIRs and Area of Responsibility[4]

The NRO regularly releases the "Internet Number Resource Status Report". This is prepared by the RIRs. Figure 5 shows the current allocation of IPv4 address space. In this report IPv4 addresses are tracked in what is called Classless Internet Domain Routing (CIDR) /8 increments. The entire IPv4 address space is composed of 256 /8 increments and a /8 has 2^{24} or 16,777,216 IPv4 addresses. ICANN holds /8s in reserve and allocates them to the RIRs as necessary for further delegation to Internet Service Providers and Local Internet Registries.

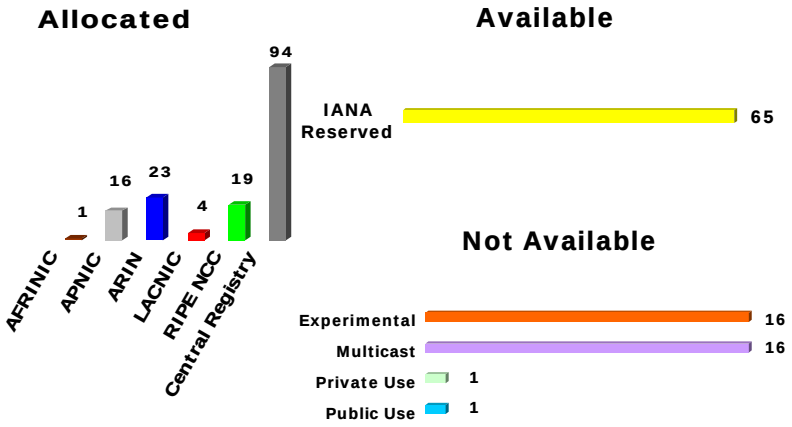

Figure 5 Current IPv4 Address Space Allocation[5]

Figure 6 shows the allocation trends since 1999 of Classless Inter-Domain Routing (CIDR) /8s by regional registry. The numbers of /8s allocated are shown by new allocations each year and are not cumulative.

[4] www.nro.org
[5] Internet Number Resource Status Report as of December 2005, NRO

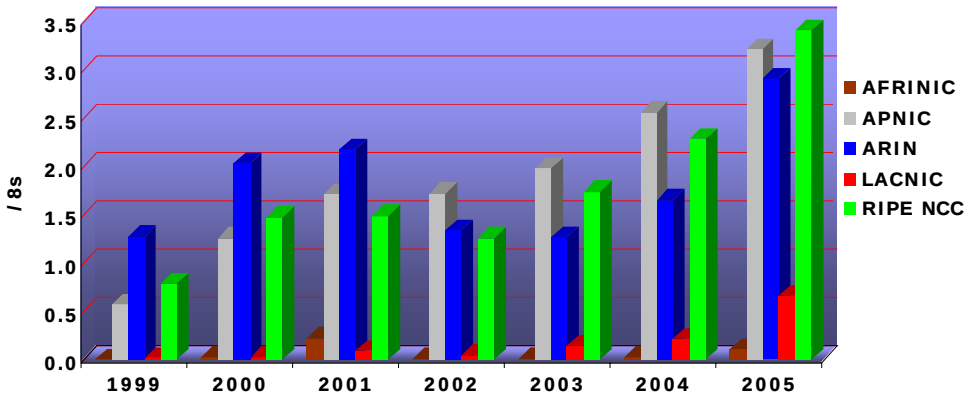

Figure 6 IPv4 CIDR /8 Allocations per Year[6]

So Who is Right and How Long Will there be Available IPv4 Address Space?

From Figure 5 we are able to see that as of December 2005 ICANN has 65 /8 allocations held in reserve for the RIRs. This accounts for about 25% of the entire IPv4 address space. Figure 6 shows the RIRs allocated over 10 /8 in 2005. Using the information from the figures above, Figure 7 was created to show potential IPv4 address space exhaustion dates based on steady-state allocations and the past 4 year growth rates of IPv4 address space and the continued growth of address allocation.

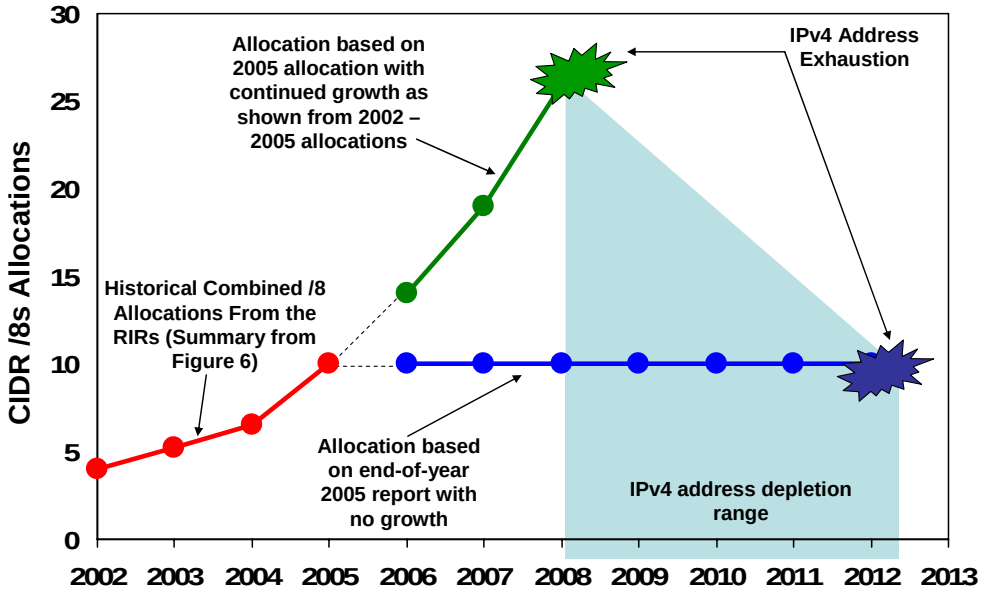

Figure 7 IPv4 Address Exhaustion Timeline

By applying the different assumption sets we see that the IPv4 address exhaustion could occur as early as 2008/2009 (assuming similar growth rates from the past four years) or as late as 2012 (assuming no growth over the 2005 allocations). It is also possible that the demand for new IP addresses will decline or cease altogether, but this is so unlikely as to not be considered. It is also possible that the growth rate for new globally routable IPv4 addresses will accelerate at an even greater rate than shown from the past few years, and IPv4 address exhaustion will occur earlier.

So the answer to the question of when the IPv4 address space will be exhausted revolves around the assumptions applied within the various models. If you believe the growth of the number of devices on the Internet will be stable/flat over the next decade, then the models showing the 2012 date are better estimates for your purpose. If you believe the number of devices connected to the Internet will continue to accelerate over the next decade, then the shorter timeframe and IPv4 address exhaustion as soon as 2008/2009 is the likely scenario. It is also important to note that this assumes that the rules governing the allocation of IPv4 addresses remain the same and no rush to acquire address space occurs.

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[6] Internet Number Resource Status Report as of December 2005, NRO

It is interesting to note that throughout this discussion, the definition of IPv4 address exhaustion implies that ICANN and the RIRs have allocated all of the reserve address space. The question that should be considered is: Is the correct definition of address exhaustion the allocation of all reserve address space? Or should the definition of IPv4 address exhaustion be defined as occurring when an organization requiring IPv4 addresses can not obtain them at a reasonable cost? (The addition of “at a reasonable cost” adds to the definition an interesting twist that needs to be discussed in future articles). If the latter becomes the real definition, then it can be argued that IPv4 address exhaustion has already occurred. The policies that have allowed for greater efficiency of the IP address space have come at a cost, and many organizations implement architectures and work-arounds focused on conserving IP address space.