IPv6 HD Ratio

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Background

- Current IPv6 Address Allocation policies refer to the use of the Host Density Ratio as a metric for 'acceptable' utilization of address space
 - Original Def'n: RFC 1715
 - Re-stated Def'n: RFC 3194
- Current IPv6 Address Allocation policies use an HD-Ratio value of 0.8 as an allocation threshold value
- Why 0.8?
 - This value is based on a small number of case studies described in RFC 1715 – no further analysis of the underlying model or the selection of an appropriate threshold value as an IP network efficiency metric has been published
- Does this HD-Ratio value provide "reasonable" outcomes in terms of address utilization?

The HD Ratio Metric

• IPv4 fixed 80% Density Host-Count / Address-Count = 0.8

IPv6 0.8 HD Ratio
log(Host-Count) / log(Address-Count) = 0.8

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Under the HD-Ratio, the overall address utilization efficiency level falls exponentially in line with the size of the address block. Large allocations have a very small density threshold, while smaller allocations have a much higher threshold.

IPv4 / IPv6 Allocation equivalence table

Host Count	80%	HD = 0.8
End Customer Size	IPv4 Allocation	IPv6 Allocation
205	/24	/32
410	/23	/32
819	/22	/32
1638	/21	/32
3277	/20	/32
7131	/18	/32
12416	/18	/31
21618	/17	/30
37640	/16	/29
65536	/15	/28
114104	/14	/27
198668	/14	/26
345901	/13	/25
602248	/12	/24
1048576	/11	/23
1825676	/10	/22
3178688	/10	/21
5534417	/9	/20
9635980	/8	/19
16777216	/7	/18

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IPv6 Address Efficiency Table

IPv6	Block Size	HD = 0.8	Address
Prefix	(/48s)	Host Count	Efficiency
/32	65,536	7,132	11%
/31	131,072	12,417	9%
/30	262,144	21,619	8%
/29	524,288	37,641	7%
/28	1,048,576	65,536	6%
/27	2,097,152	114,015	5%
/26	4,194,304	198,668	5%
/25	8,388,608	345,901	4%
/24	16,777,216	602,249	4%
/23	33,554,432	1,048,576	3%
/22	67,108,864	1,825,677	3%
/21	134,217,728	3,178,688	2%
/20	268,435,456	5,534,417	2%
/19	536,870,912	9,635,980	2%
/18	1,073,741,824	16,777,216	2%

Using a fixed 16 bit subnet length

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Modelling the HD Ratio

• Does this HD Ratio value produce reasonable outcomes?

 The approach reported here is to look at recent IPv4 allocation data, and simulate an equivalent IPv6 registry operating user a similar address demand profile

IPv6 Registry simulation exercise

- Use recent RIR IPv4 allocation data to create a demand model of an IPv6 address registry
 - Assume a sequence of IPv6 transactions based on a demand model derived from the sequence of recorded IPv4 allocations
 - Convert IPv4 to IPv6 allocations by assuming an equivalence of an IPv4 end-user-assignment of a /32 with an IPv6 end-user-assignment of a /48
 - IPv4 uses a constant host density of 80% while IPv6 uses a HD-Ratio of 0.8
 - Use a minimum IPv6 allocation unit of a /32
 - Assume IPv4 allocation timeframe mean of 12 months

Allocation Simulation Results

IPv6 Registry Allocation SImulation - 2002 - 2005



Allocation Simulation results

Registry Allocations



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Prefix Distribution





HD Ratio Observations

 One interpretation of the HD Ratio is that it corresponds to a network model where an additional component of internal network hierarchy is introduced for each doubling of the address block size

 A HD Ratio of 0.8 corresponds to a network with a per-level efficiency of 70%, and adding an additional level of hierarchy as the network increases in size by a factor of 8



Hierarchical Network Model



Comparison of HD Ratio and Compound Hierarchy



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Interpreting the HD Ratio

- For a /32 allocation the 0.8 HD ratio is comparable to 6 levels of internal hierarchy with 70% efficiency at each level
- For a /24 this corresponds to an internal network hierarchy of 9 levels, each at 70% efficiency

 Altering the HD Ratio effectively alters comparable model rate of growth in internal levels of network hierarchy

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HD = 0.94

 This corresponds to a network model that uses base efficiency of 0.75 at each level of internal network structure, with a new level of hierarchy added for each additional 5 bits of address prefix length (x 32)





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Varying the HD Ratio – Total Address Consumption



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Allocation Simulation – HD = 0.94

IPv6 Registry Allocation SImulation - 2002 - 2005



Allocation Simulation – HD = 0.94 Registry Allocations (HD = 0.94)

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Comparison of prefix size distributions

Comparison of Prefix Distributions

100000 10000 1000 -■ HD = 0.8 ■ HD = 0.87 \square HD = 0.94 100 10 1 /22 /23 /18 /19 /20 /21 /24 /25 /26 /27 /28 /29 /30 /31 /32

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Observations

- 80% of all allocations are /31 and /32 for HD ratio of 0.8 or higher
 - Changing the HD ratio will not impact most allocations in a steady state registry function
- Only 2% of all allocations are larger than a /27
 - For these larger allocations the target efficiency is lifted from 4% to 25% by changing the HD Ratio from 0.8 to 0.94 (25% is equivalent to 5 levels of internal hierarchy each with 75% efficiency)

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• Total 3 year address consumption is reduced by a factor of 10 in changing the HD ratio from 0.8 to 0.94

What is a "good" HD Ratio to use?

- Consider <u>what is common practice</u> in today's network in terms of internal architecture
 - APNIC is conducting a survey of ISPs in the region on network structure and internal levels of address hierarchy and will present the findings at APNIC 20
- Define a <u>common 'baseline' efficiency level</u> rather than an average attainable level
 - What value would be readily achievable by large and small networks without resorting to renumbering or unacceptable internal route fragmentation?

Consider overall longer term objectives

- Anticipated address pool lifetime
- Anticipated impact on the routing space





Questions?

