IPv6 HD Ratio

ARIN Public Policy Meeting

April 2005

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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`

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**

IPv6 Address Efficiency Table

IPv6 Prefix	Block Size (/48s)	HD = 0.8 Host Count	Address 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

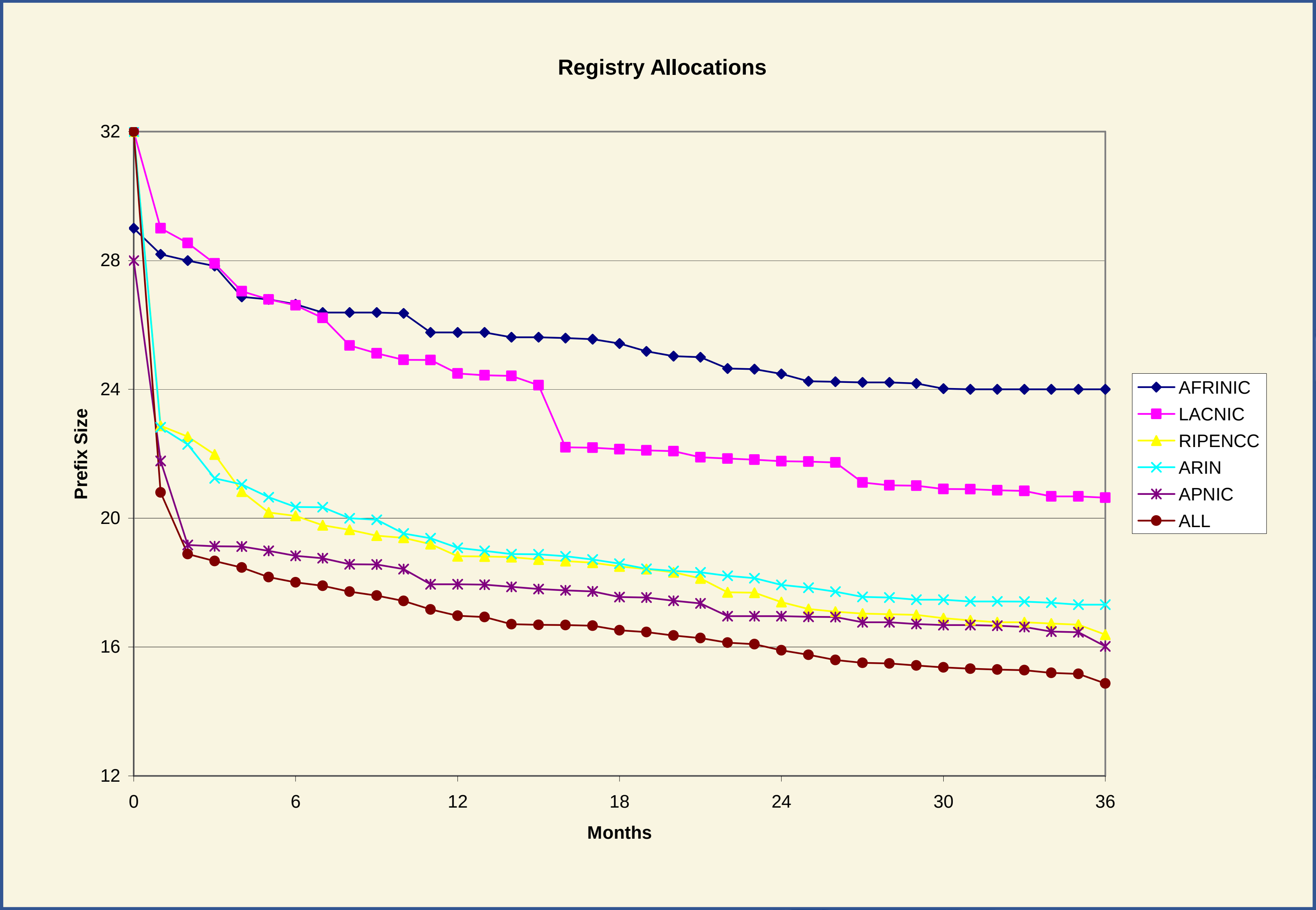
Modelling the HD Ratio

- 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



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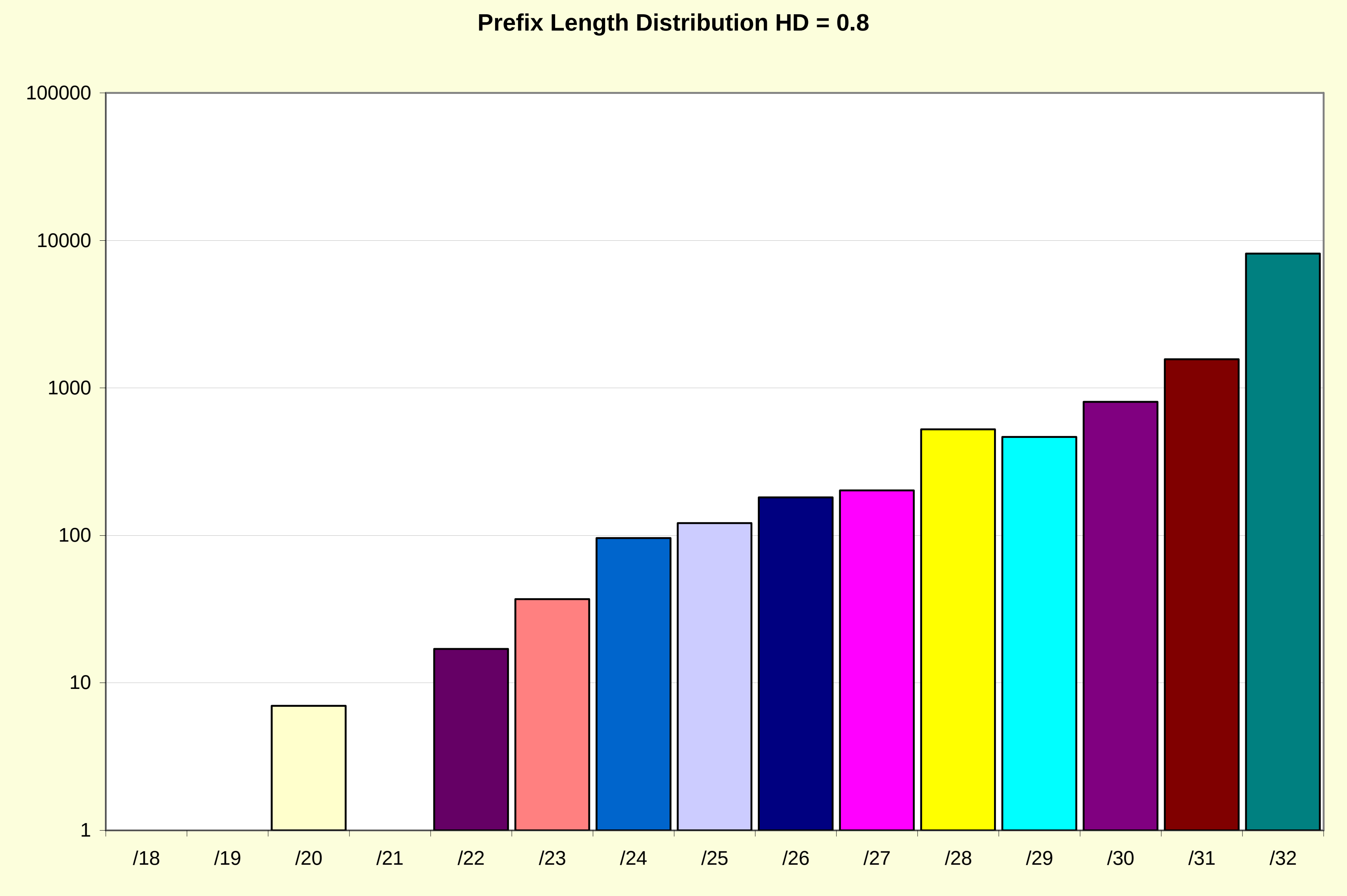
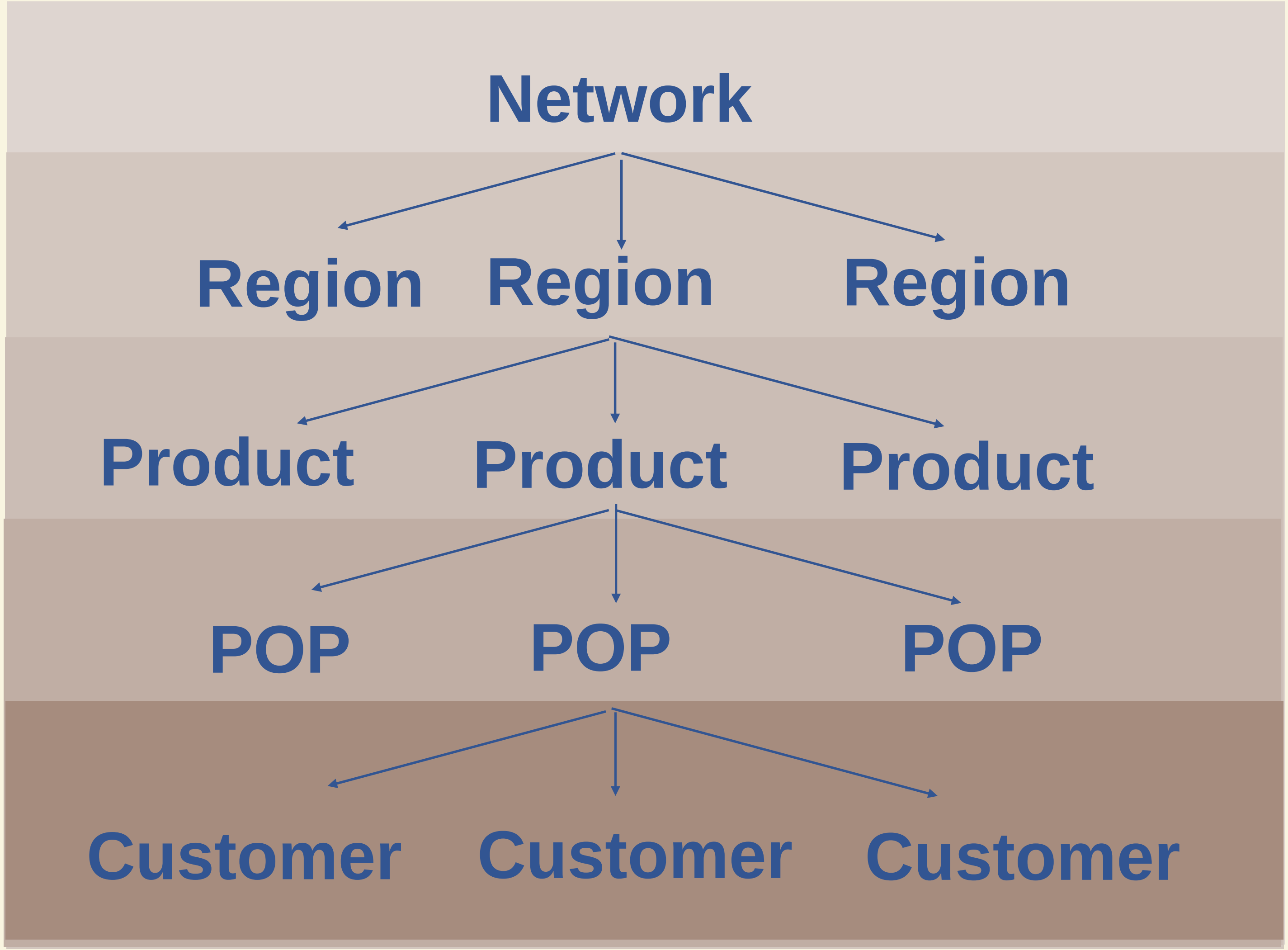
Prefix Distribution



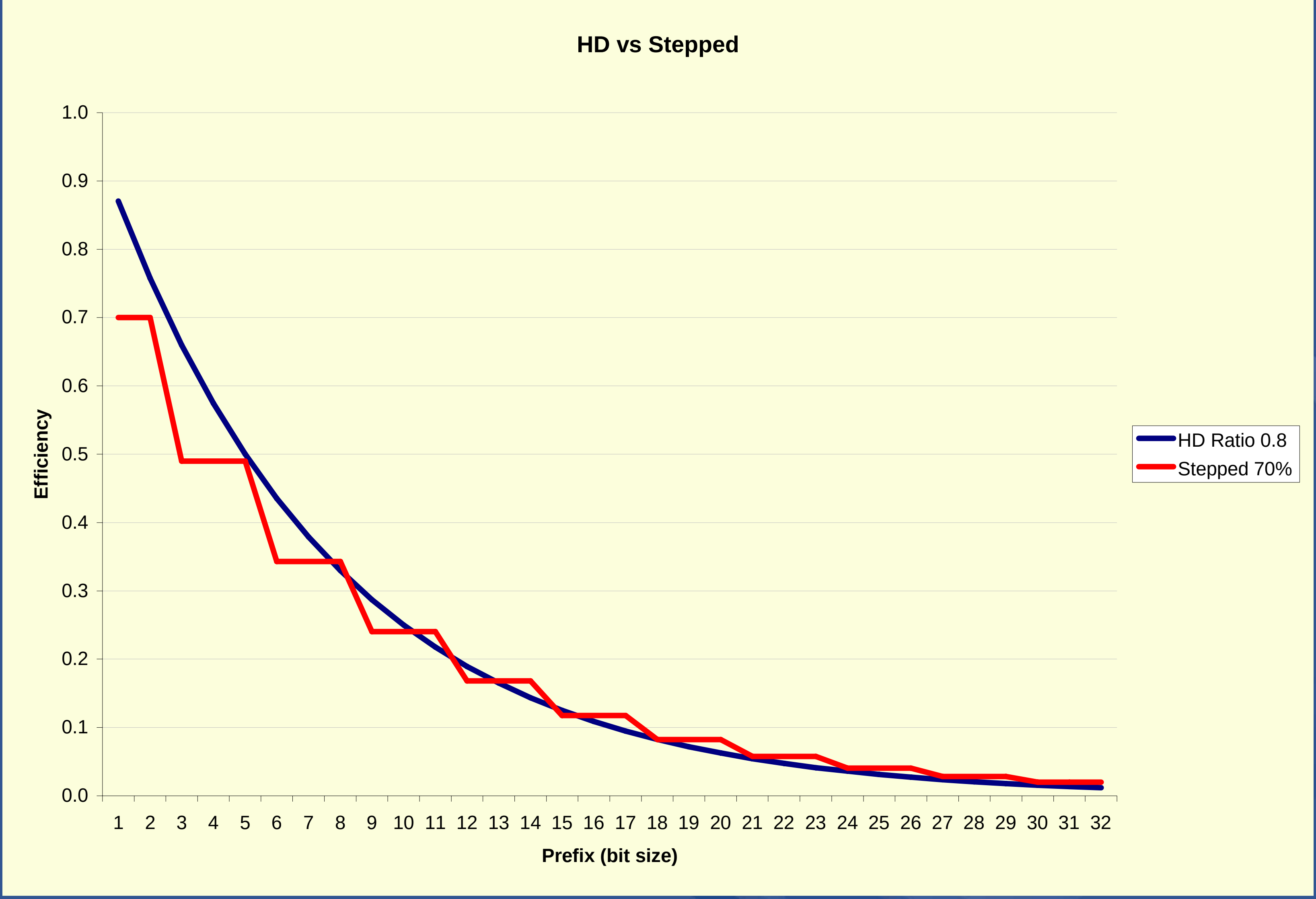
HD Ratio Observations

- 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



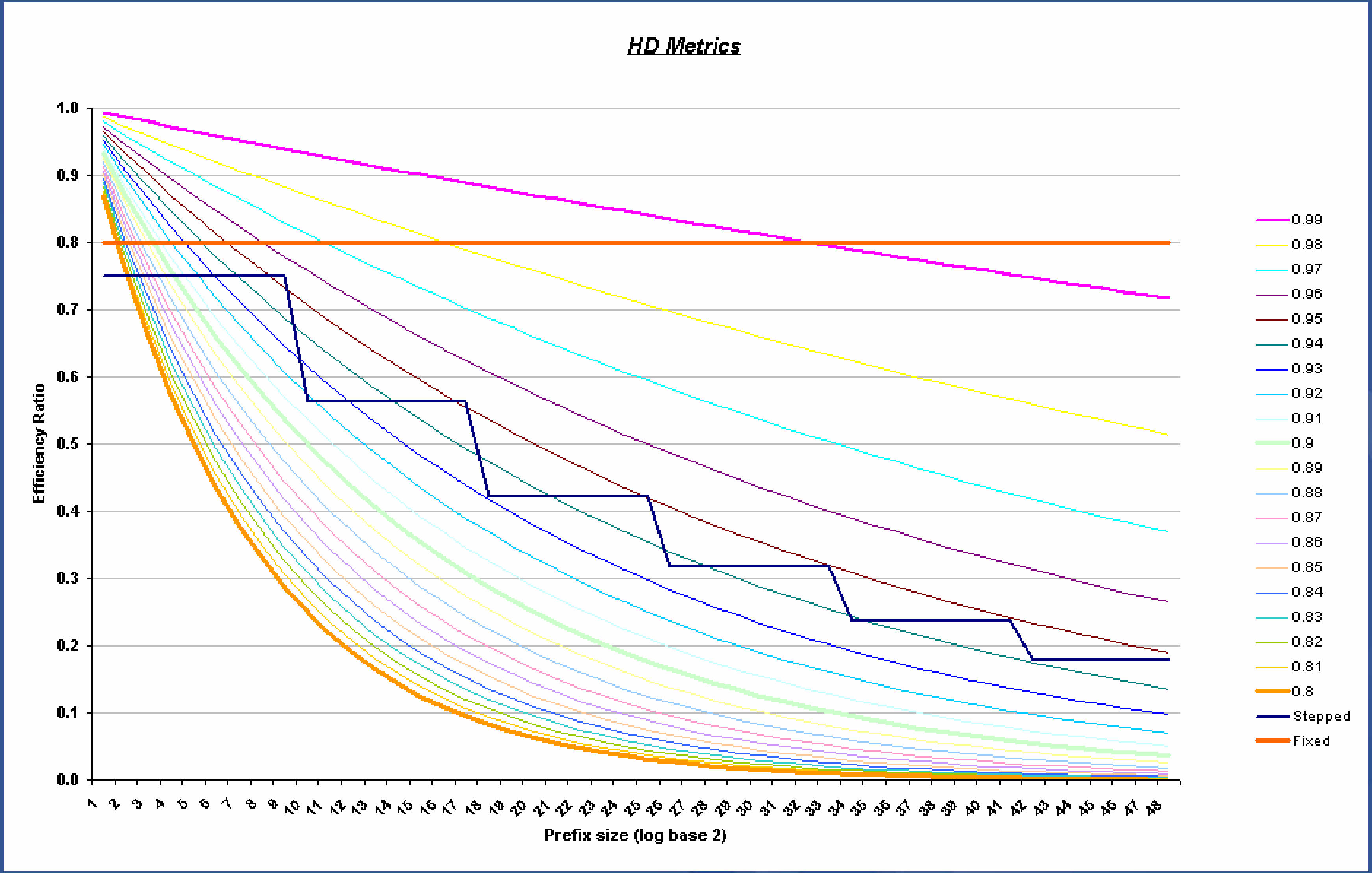
Interpreting the HD Ratio

- 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

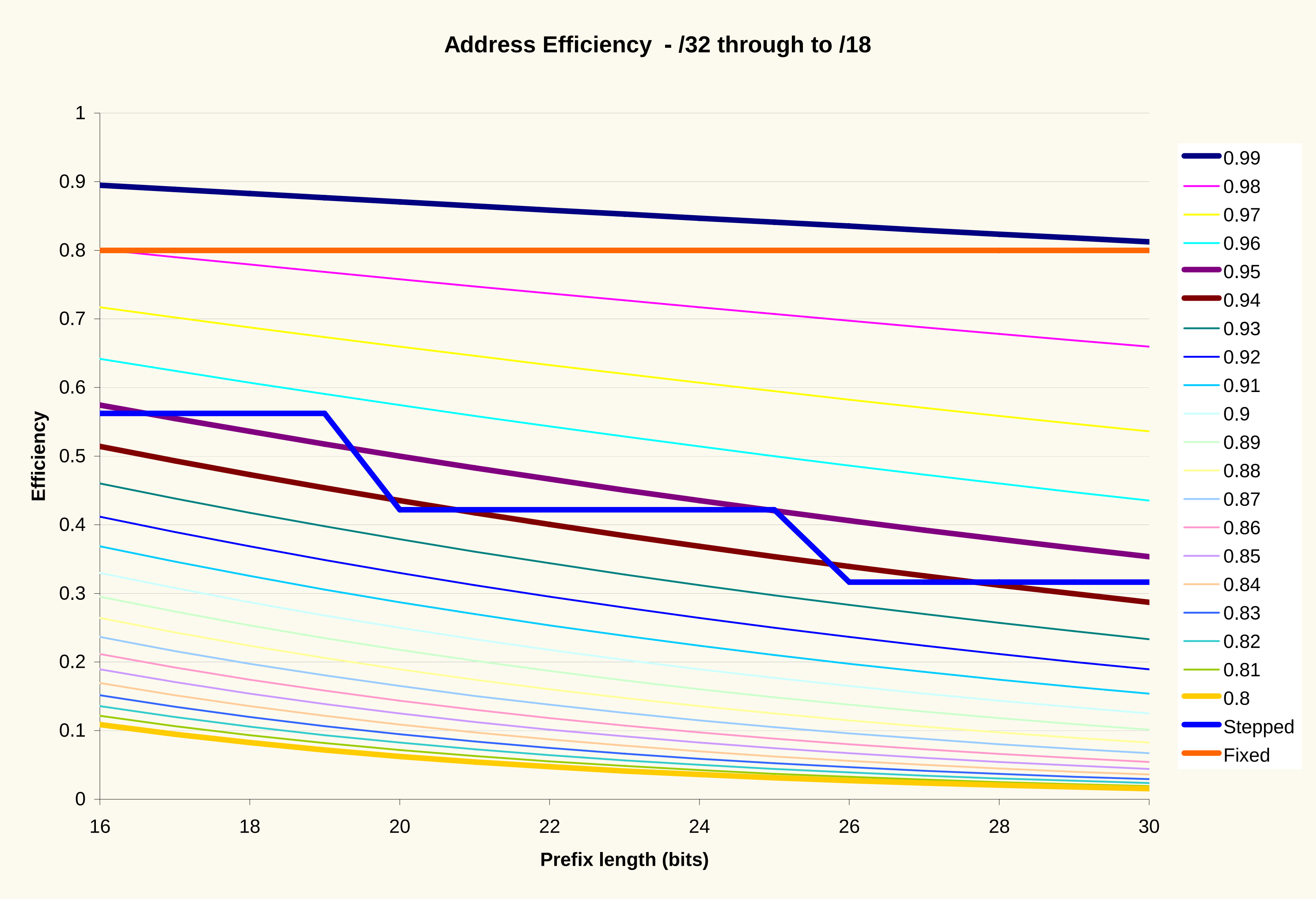
HD = 0.94

- 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)

Varying the HD Ratio



Varying the HD Ratio - Detail



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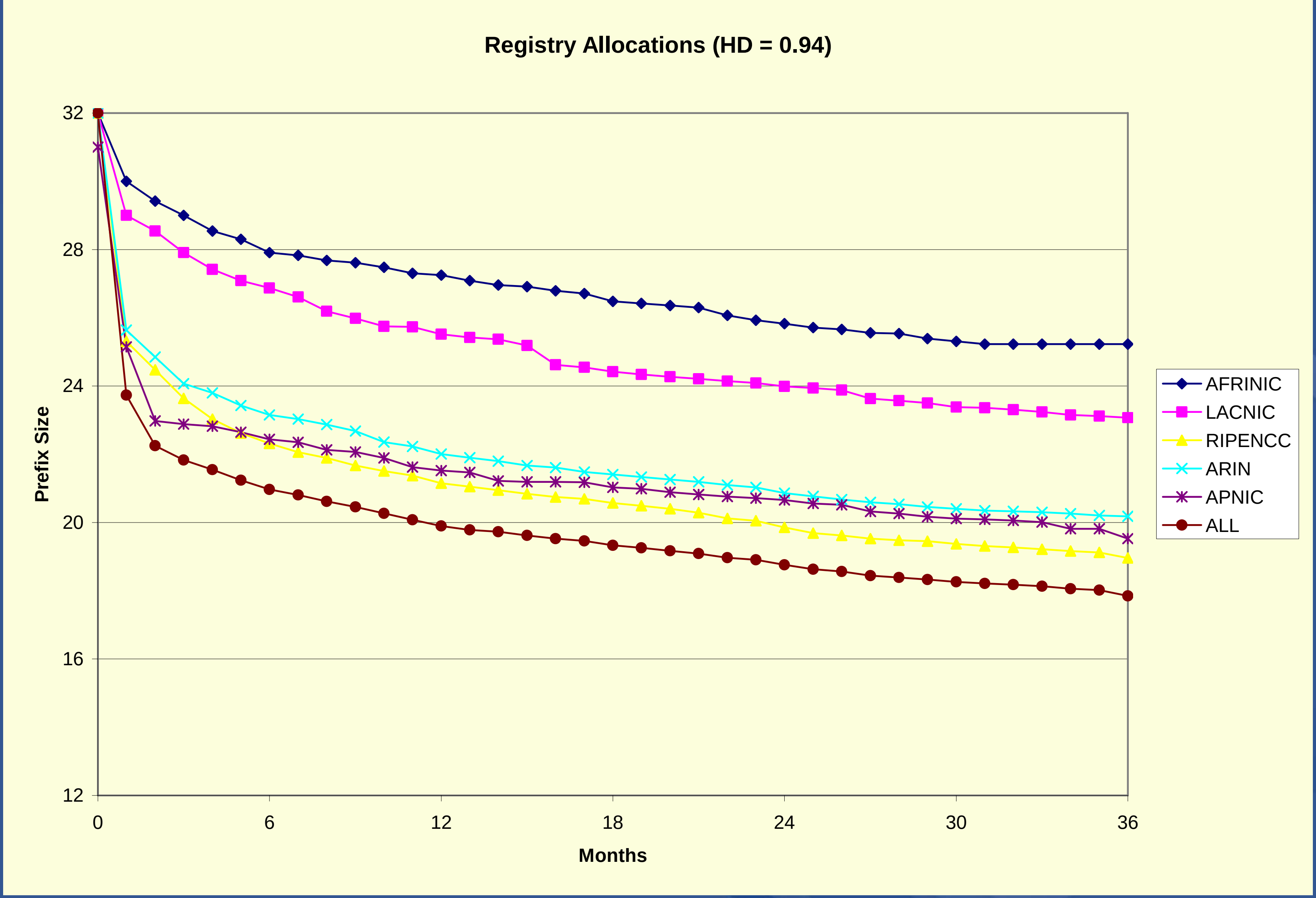
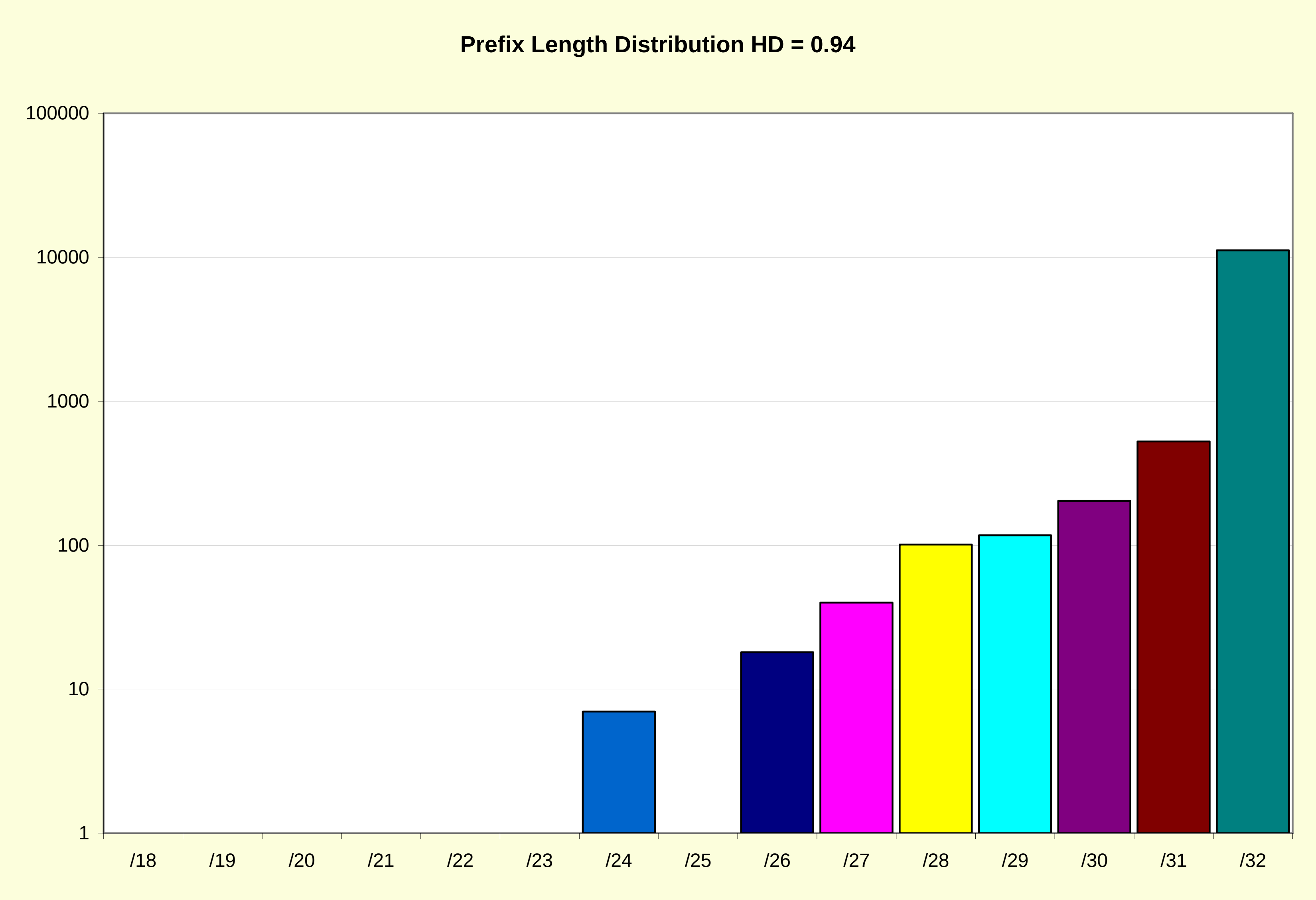
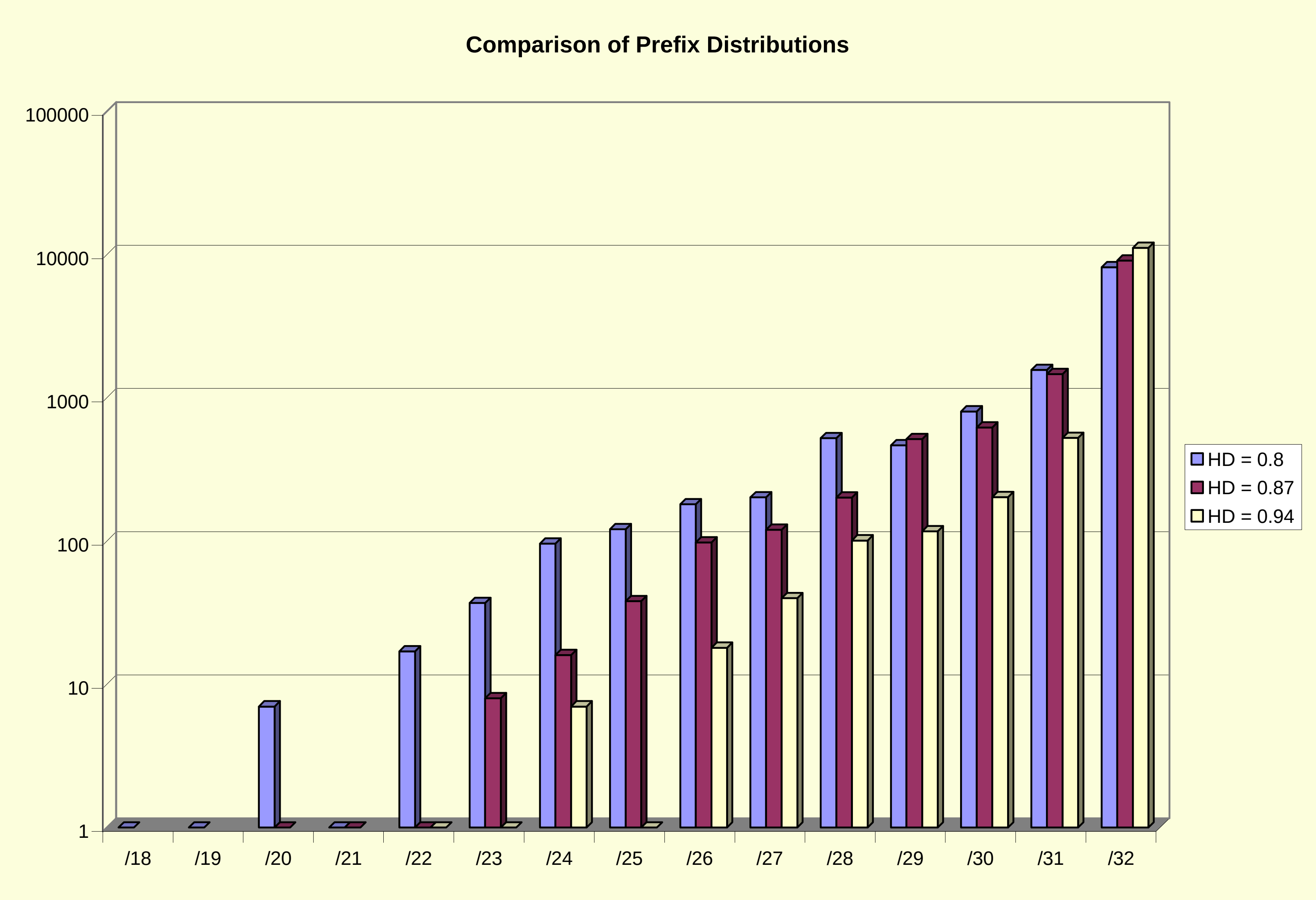
Allocation Simulation – HD = 0.94



Prefix Distribution – HD = 0.94



Comparison of prefix size distributions



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)
- 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?

- Need to consider what is common practice 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
- Need to define a common ‘baseline’ efficiency level rather than an average attainable level
  - What value would be readily achievable by large and small networks without resorting to renumbering or internal route fragmentation?
- Need to consider overall longer term objectives
  - Anticipated address pool lifetime
  - Anticipated size of the routing space

Thank you

Questions?