HD Ratio for IPv4

APNIC16 - Address Policy SIG
Seoul, Korea
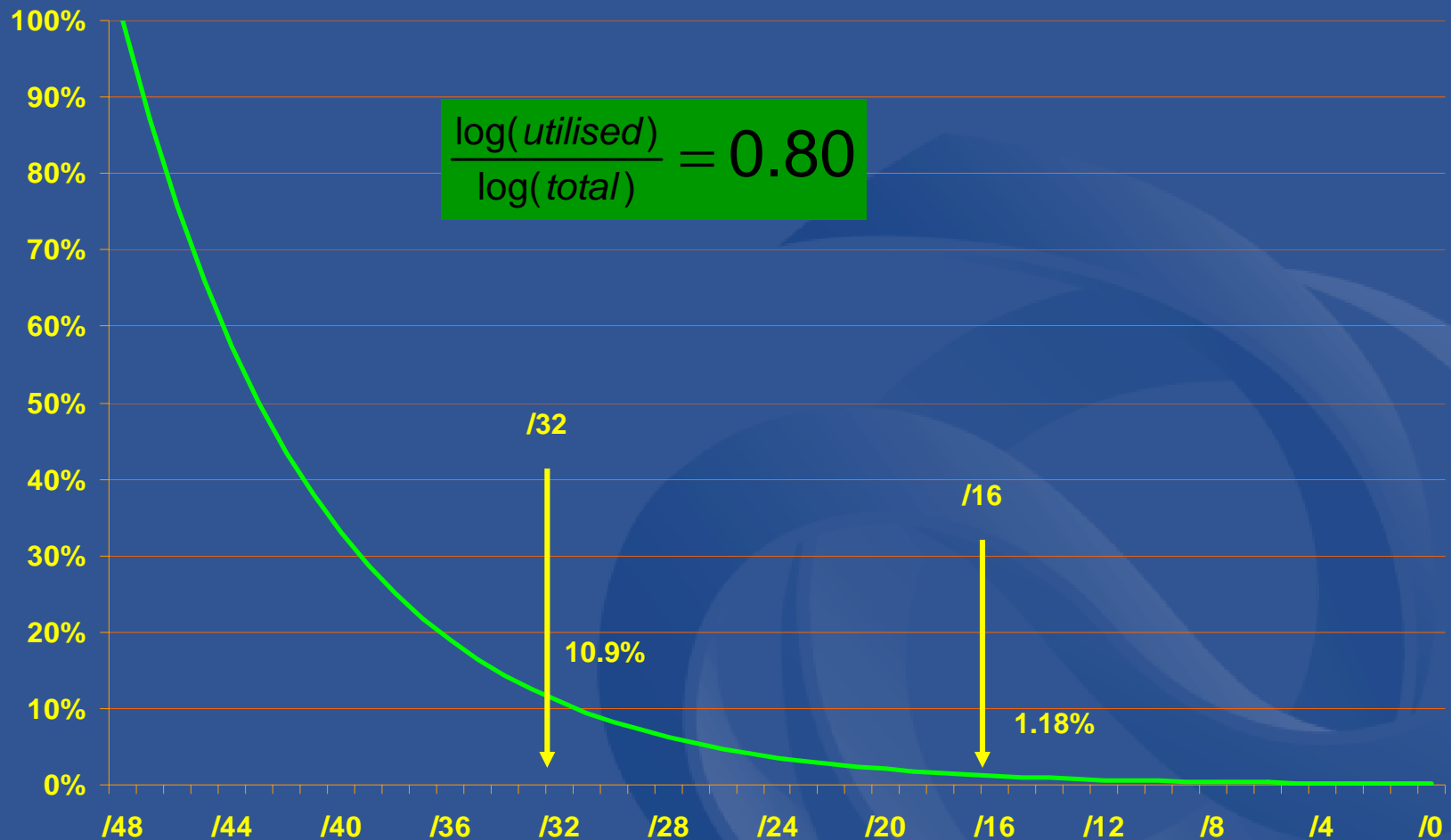## 20 August 2003

Background

- Host Density (HD) ratio
  - Measures utilisation in hierarchically managed address space (see RFC3194 and RFC1715)
  - An HD-ratio value corresponds to a percentage utilisation which decreases as the size of the address space grows

$$HD = \frac{\log(\textit{utilised host addresses})}{\log(\textit{total addresses})}$$

  - Note: calculation requires registration of individual site addresses (/48)
  - The HD-ratio has been adopted for IPv6
    - LIR may receive more IPv6 space when HD=0.80

Background - IPv6 (HD = 0.80)

$$\frac{\log(\textit{utilised})}{\log(\textit{total})} = 0.80$$

/32

10.9%

/16

1.18%

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%

/48 /44 /40 /36 /32 /28 /24 /20 /16 /12 /8 /4 /0

RFC3194 "The Host-Density Ratio for Address Assignment Efficiency"

Problem Summary

- IPv4 fixed utilisation requirement
  - Once 80% is sub-allocated or assigned, LIR can request additional block
  - Same requirement for all address blocks, regardless of size
- No allowance for hierarchical management
  - Address management efficiency decreases for large address blocks
 - Imposes unreasonable management overhead on larger LIRs

Proposal Summary

- HD-based IPv4 utilisation requirement
    - Lower % utilisation requirement for larger blocks
    - To make allowance for hierarchical management
- Variation of HD-Ratio proposed
    - Assignment Density (AD) Ratio
- Proposed value
    - Utilisation requirement AD=0.966
    - Calculated based on current 80% principle

Proposed IPv4 utilisation (AD 0.966)
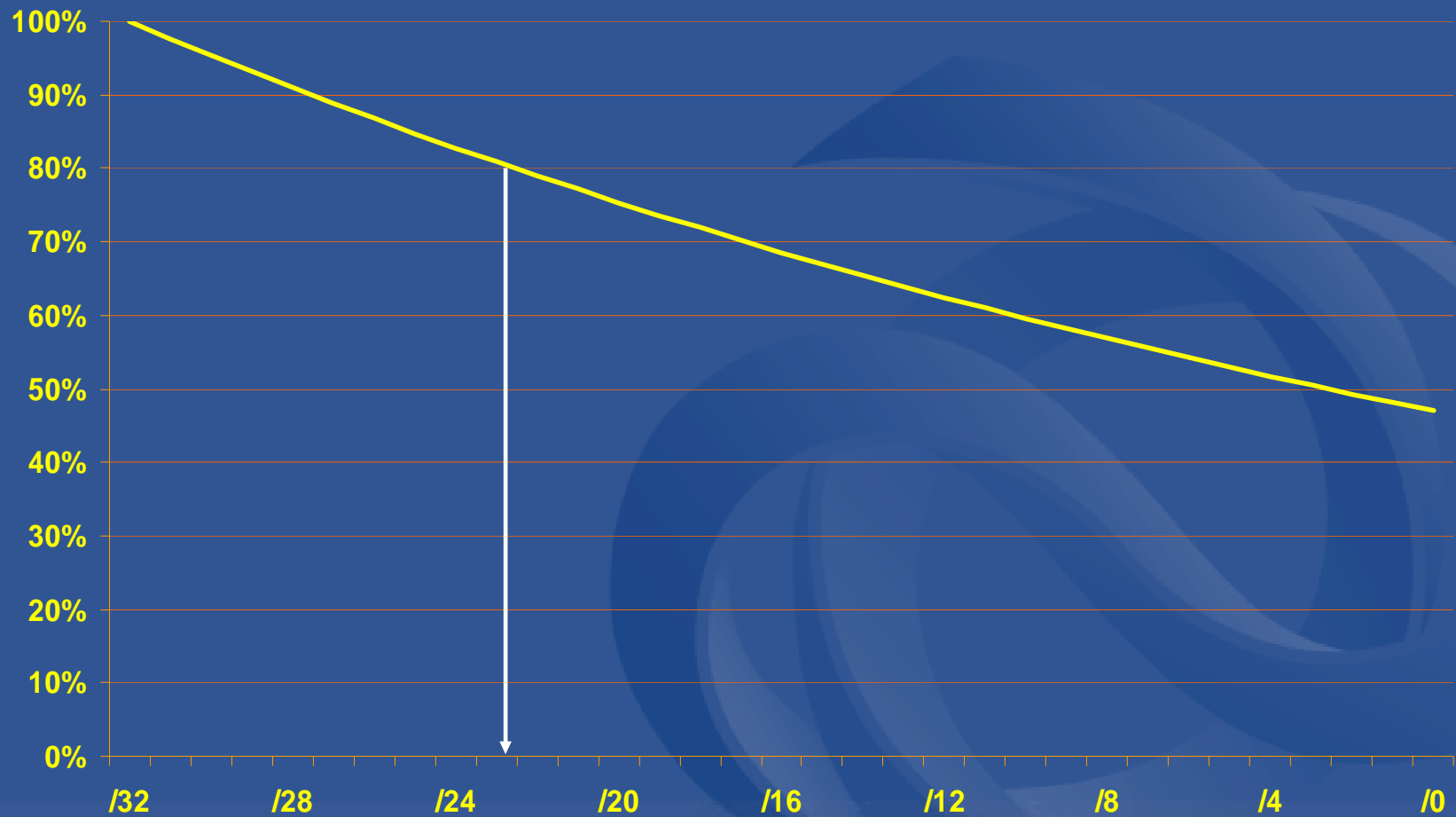
Proposed IPv4 utilisation (AD 0.966)

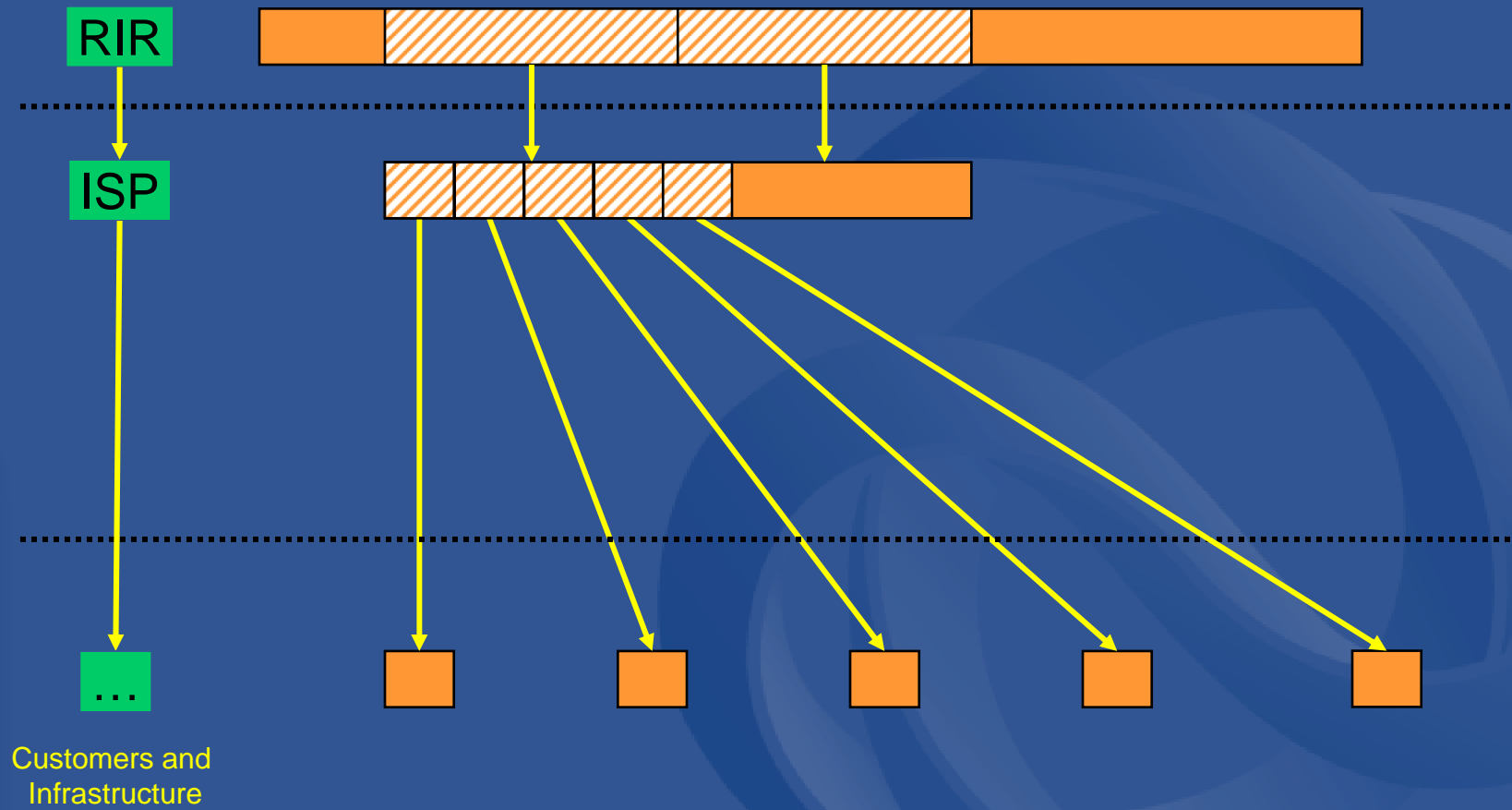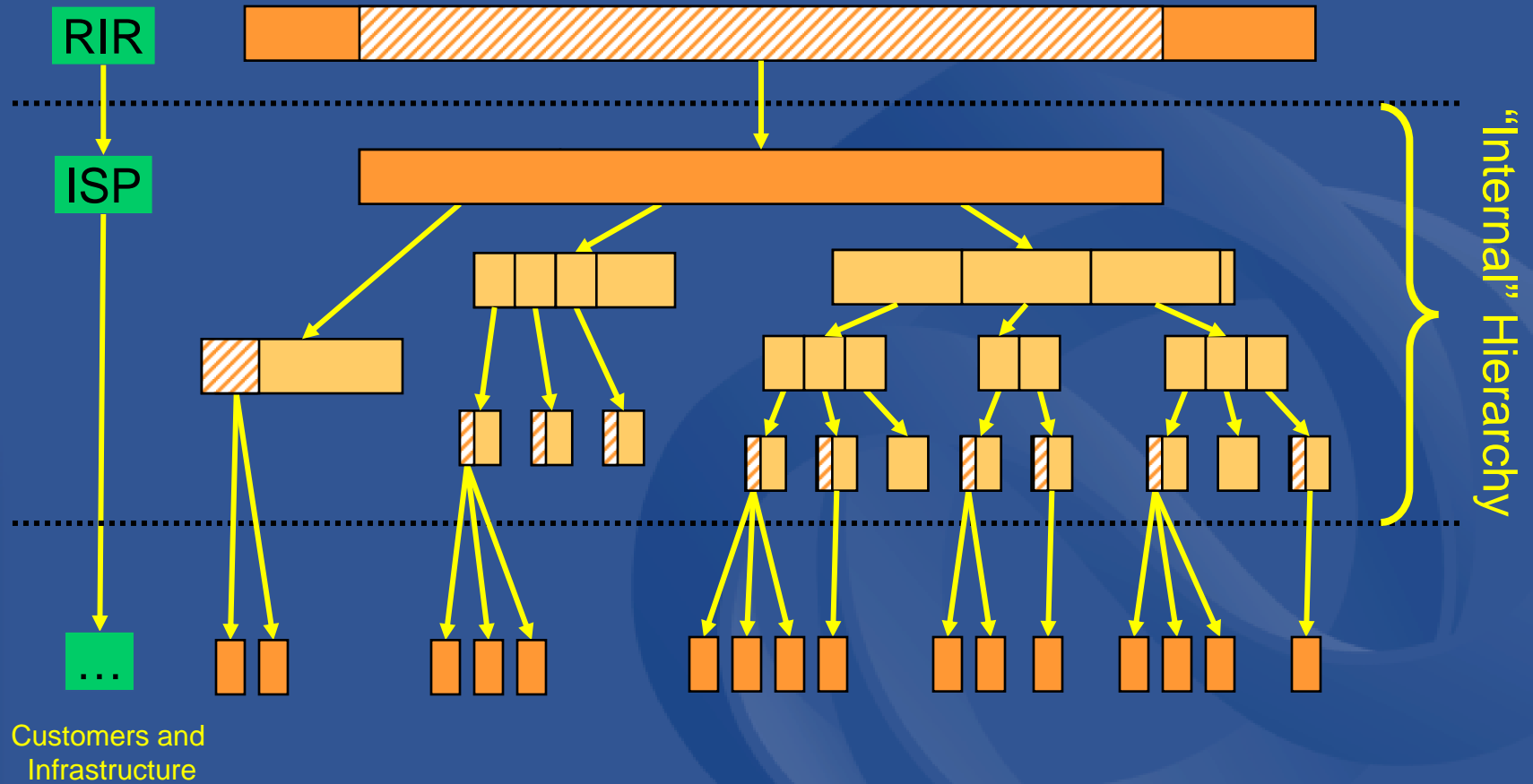| Prefix	Total addrs	Utilised addrs	%
/24	256	212	82.82%
/22	1024	809	79.00%
/20	**4096**	**3087**	**75.37%**
/18	16384	11780	71.90%
/16	65536	44949	68.59%
/14	262144	171518	65.43%
/12	1048576	654485	62.42%
/10	4194304	2497408	59.54%
/8	16777216	9529704	56.80%

Justification

Allocation Hierarchy - 1

Allocation Hierarchy - 2

RIR

ISP

…

Customers and
Infrastructure

"Internal" Hierarchy

Assignment Density (AD) Ratio

- Variation of HD ratio
  - Instead of measuring host addresses actually used, measures number of addresses assigned by LIR
   - For consistency with IPv4 policies, which do not track individual host address assignments

$$AD = \frac{\log(\textit{assigned addresses})}{\log(\textit{total addresses})}$$

- Propose to use AD Ratio as utilisation measure for IPv4
  - Need to determine appropriate value

Selecting an AD-Ratio value

- Principles
  - Accept 80% as reasonable utilisation limit for single-level hierarchy
  - Accept corresponding lower utilisation limits for deeper hierarchies
    - 64% for 2-level hierarchy (80% x 80%)
    - 51.2% for 3-level hierarchy (80% ** 3)
- Apply to ISP internal hierarchy
  - We assume likely useful depth of hierarchy according to size of address space
  - Select values which appear reasonable
    - Values are theoretical only

Allocation Hierarchy
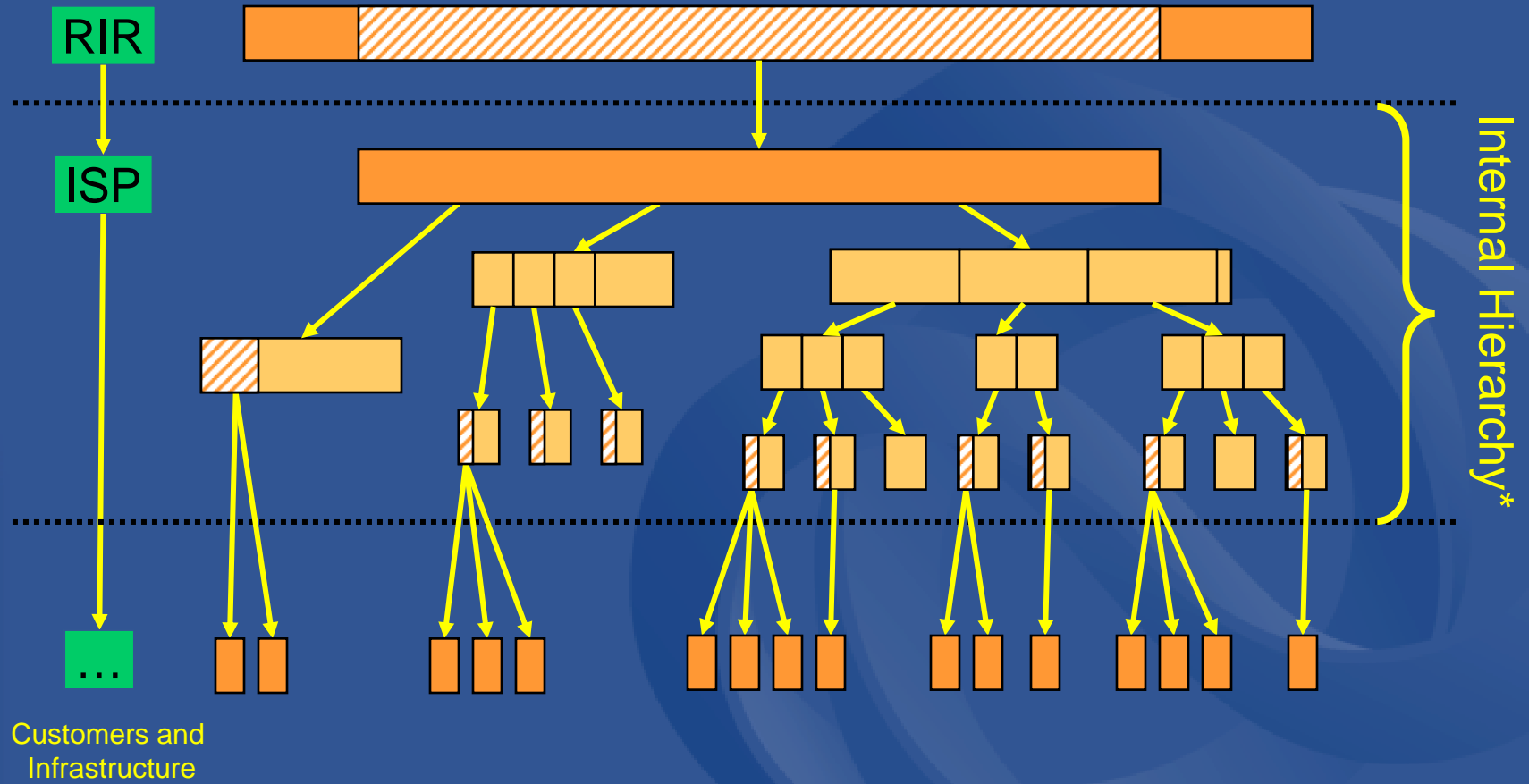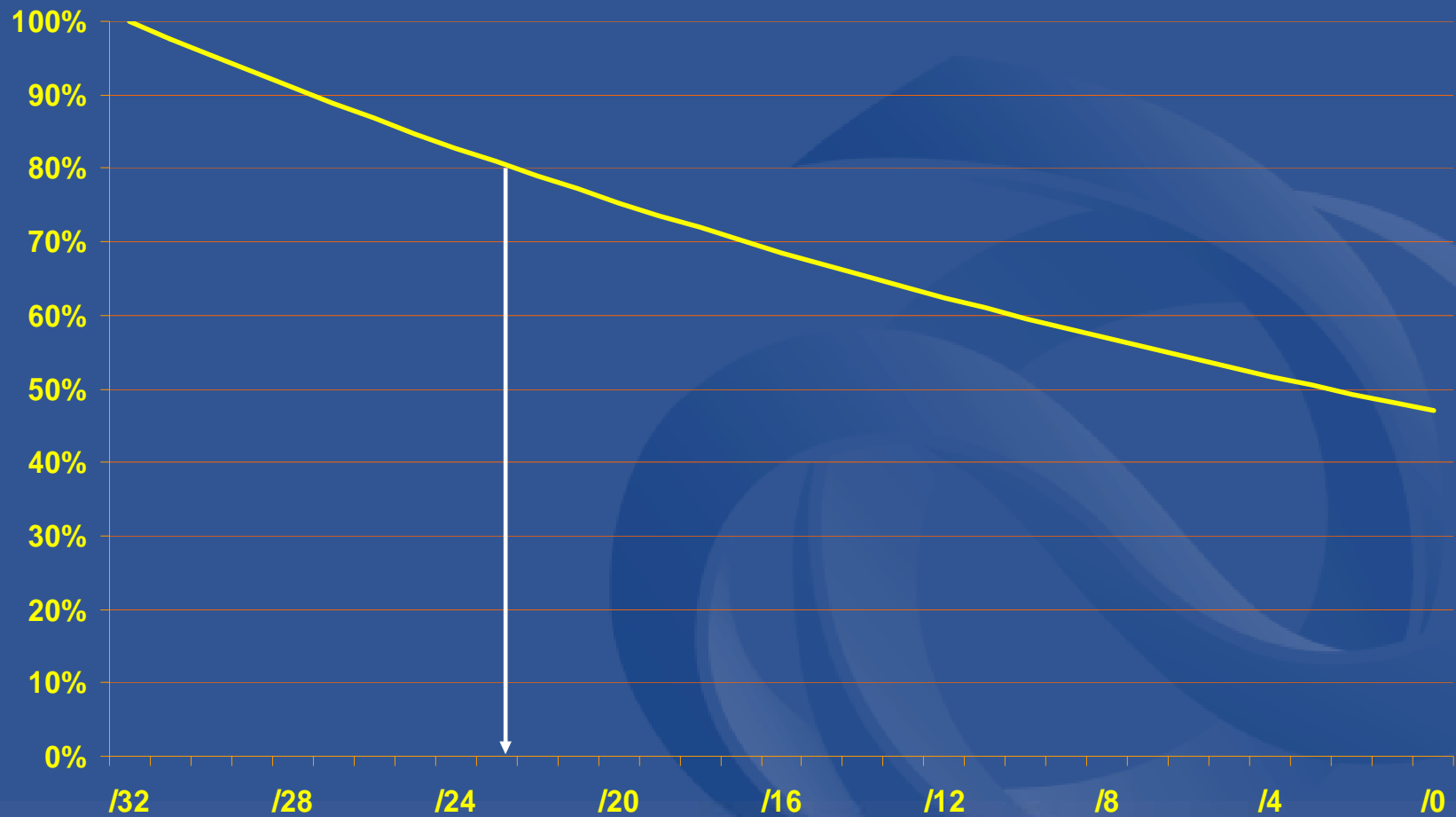
Selecting an AD-Ratio value

- Likely depth of ISP addressing hierarchy

Size Range (Prefix)	Depth (n)	Utilisation (0.80**n)	AD Ratio (calculated)
/24 to /20	1	80%	.960 to .973
/20 to /16	1.5	72%	.961 to .970
/16 to /12	2	64%	.960 to .968
/12 to /8	2.5	57.2%	.960 to .966
/8 to /4	3	51.2%	.960 to .966

- Common AD Ratio value
  - Most conservative: 0.966
  - Lease conservative: 0.961

IPv4 utilisation (AD = 0.966)

Impact

Impacts

- Administrative
  - LIR needs to incorporate new method of calculating utilisation in procedures
  - LIR would need to register infrastructure assignments/sub-allocations
  - APNIC Secretariat update internal policies, procedures and documentation
- Address space consumption
  - Initial impact
  - Ongoing impact

Impact - Address Consumption

- Initial impact
  - Maximum impact (address "wastage") can be calculated as difference in utilisation expectation for all allocated address space

Total LIRs in sample	788
Total address space held (actual)	4.17 (/8s)
Utilised addresses (80%)	3.32
Utilised addresses (AD 0.966)	2.53*
Extra "wasted" space	0.81
Extra "wastage" as proportion of total	19%

* Figure calculated from sample of 788 APNIC LIRs, according to actual address space holdings

Impact - Address Consumption

- Ongoing impact
  - Calculated by modeling the distribution of an additional /8 proportionally to all LIRs

Total LIRs in sample	788
Initial address space held (actual)	4.17 (/8s)
Additional address space allocated	1.00
Total address space now held	5.17
Utilised addresses (AD 0.966)	3.11
Additional addresses utilised	0.58
Additional addresses utilised (80%)	0.80
Extra "wasted" space	0.22
Extra "wastage" as proportion of total	22%

APNIC

Implementation

- RIR-LIR procedures
  - Replace 80% utilisation with 0.966 AD ratio

- Assignment procedures
  - Calculations rely on assignment and sub-allocation registration information
    - Preferably including infrastructure

Summary

- HD-Ratio based utilisation requirement is accepted for hierarchical address management
  - Propose to apply to IPv4 as AD-Ratio
  - Proposed utilisation requirement 0.966
- Benefit impacts larger ISPs
  - Improves address manageability
- Address space consumption impact
  - Initial impact - up to 19% additional space required (maximum eventual impact)
  - Ongoing impact - up to 22% increase in consumption rate (maximum)

Questions? Feedback?