



APNIC

Asia Pacific Network Information Centre

IPv6 Addressing and Address Management

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Director General
APNIC



Overview

- IPv6 address architecture
- Why IPv6?
- Address management past and present
- Regional Internet Registries
- IP address policies
- Global policy coordination
- What's next



What is an IP Address?

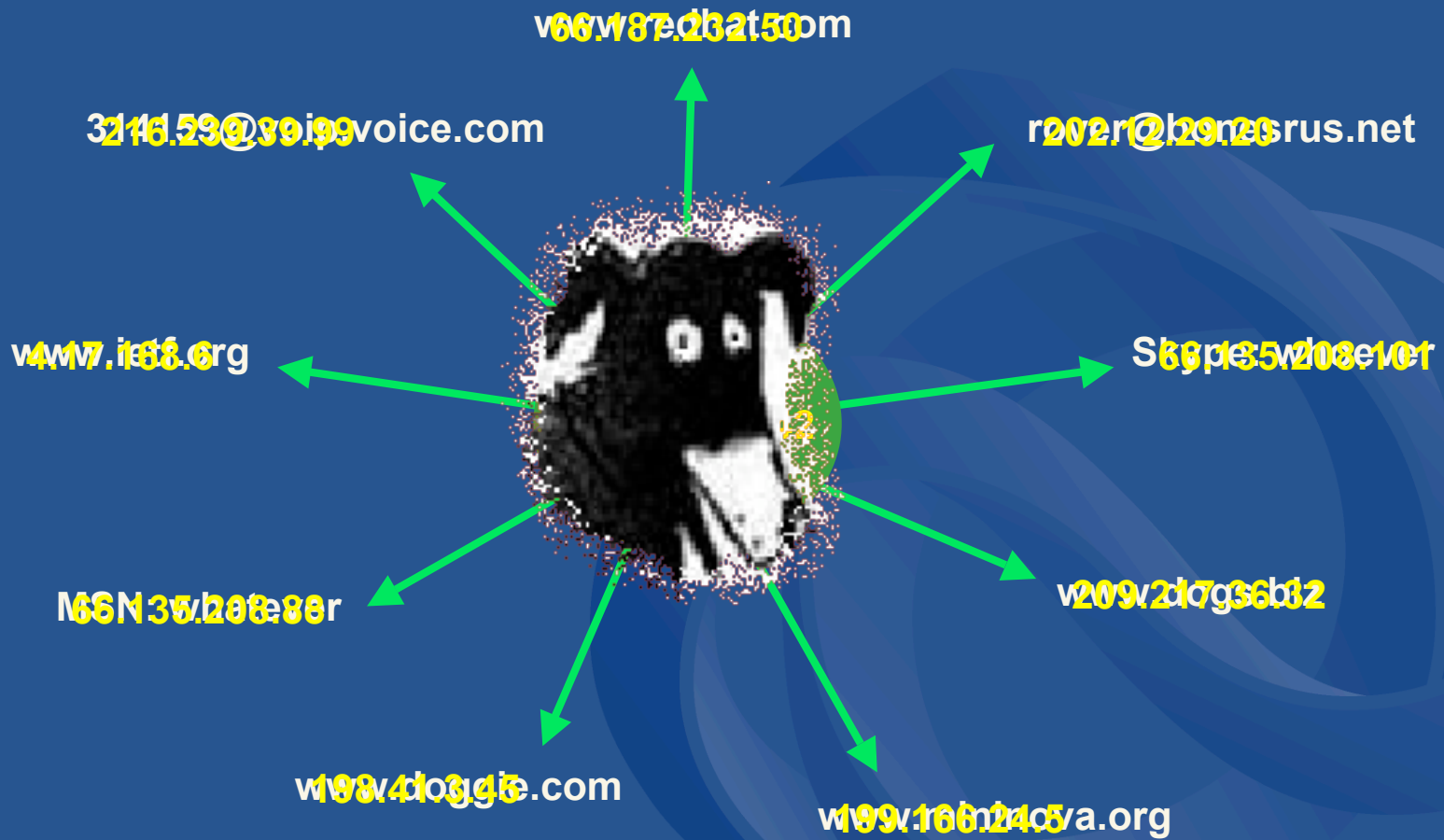


“On the Internet,
nobody knows you’re a dog...”



by Peter Steiner, from The New Yorker, (Vol.69 (LXIX) no. 20)

“On the Internet...” you are nothing but an IP Address!



What is an IP Address?

IPv4: 32 bits

e.g. 202.12.29.142 (host address)
202.12.29/24 (network address)

2^{32} = 4,294,967,296 addresses
= 4 billion addresses

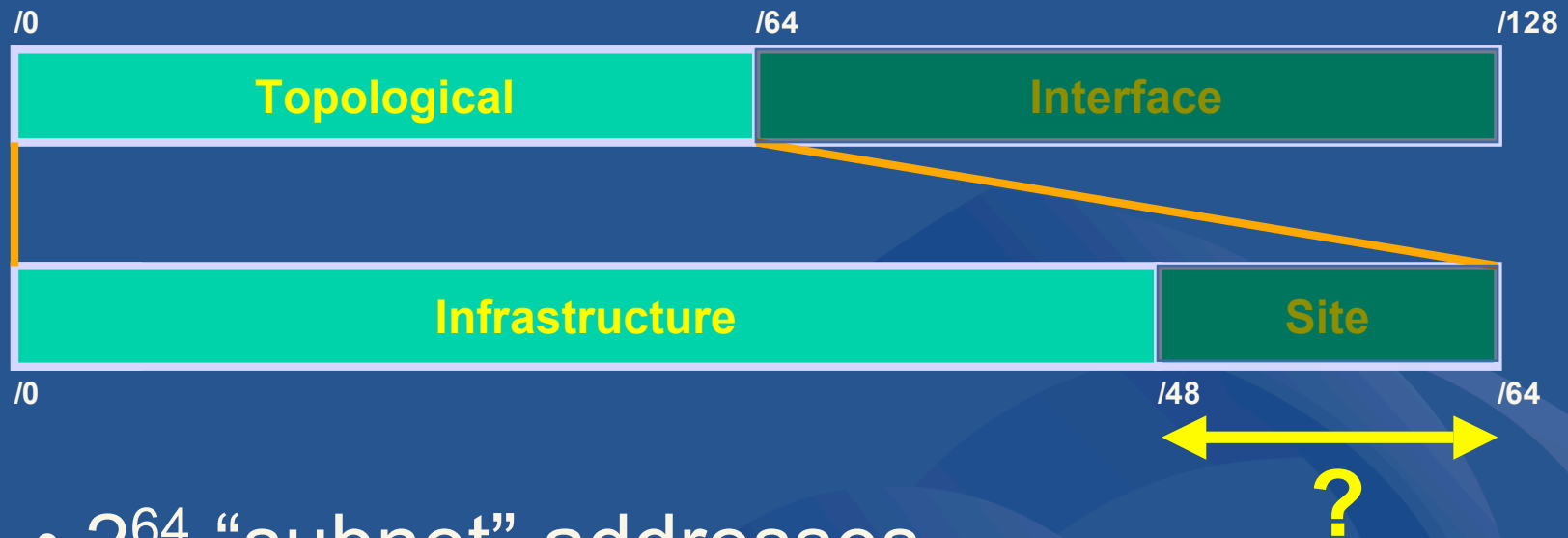
IPv6: 128 bits

e.g. 2001:400:3c00:af92:: (host address)
2001:0400::/32 (network address)

2^{128} = 340,282,366,920,938,463,463,374,607,431,770,000,000
= 340 billion billion billion billion addresses ?



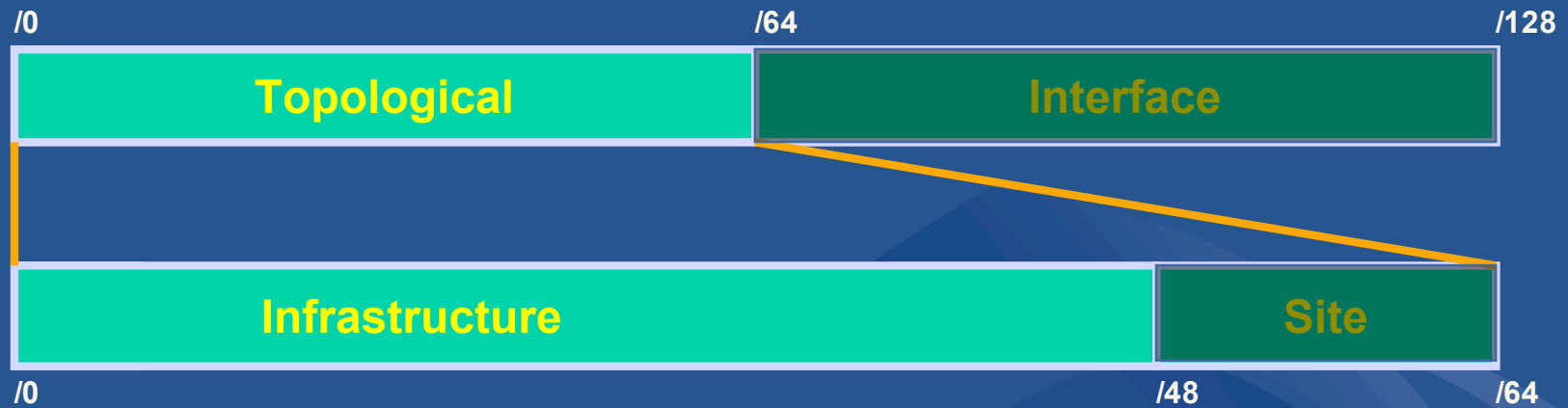
IPv6 address architecture



- 2^{64} “subnet” addresses
 - = 18,446,744,073,709,551,616
 - = 18 billion billion subnet addresses
- 2^{48} site addresses
 - = 281,474,976,710,656
 - = 281 thousand billion site addresses



One more thing...



RFC 2450 (1998), now deprecated!

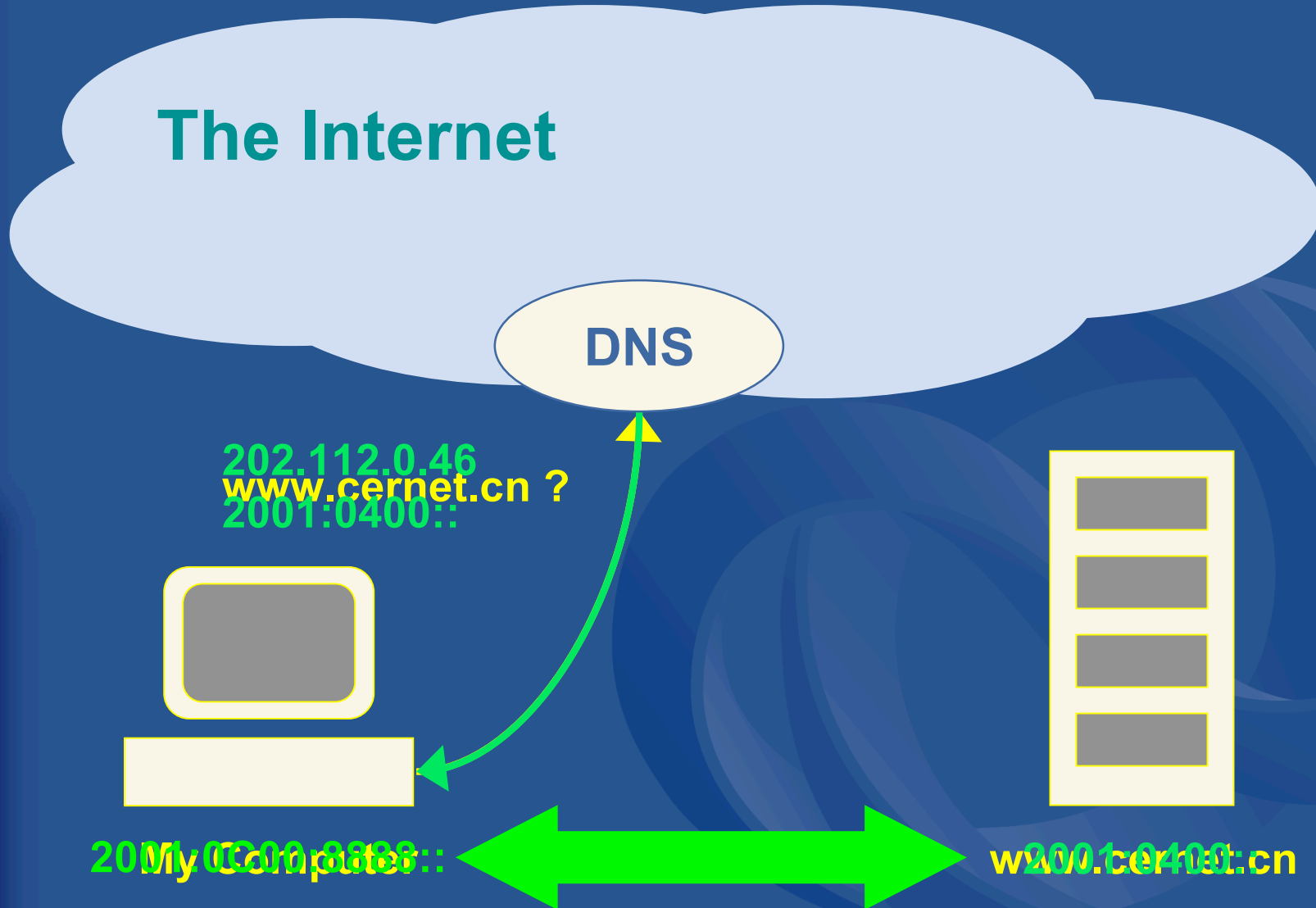


What else is an IP Address?

- Internet infrastructure addresses
 - Uniquely assigned to infrastructure elements
 - Globally visible to the entire Internet
- A finite “Common Resource”
 - Never “owned” by address users
- Managed globally under common policies
 - To ensure globally cohesive Internet
 - Policies developed by the Internet community
 - Implemented by cooperative RIR system
- Not dependent upon the DNS



IP addresses are not domain names...





Why IPv6?

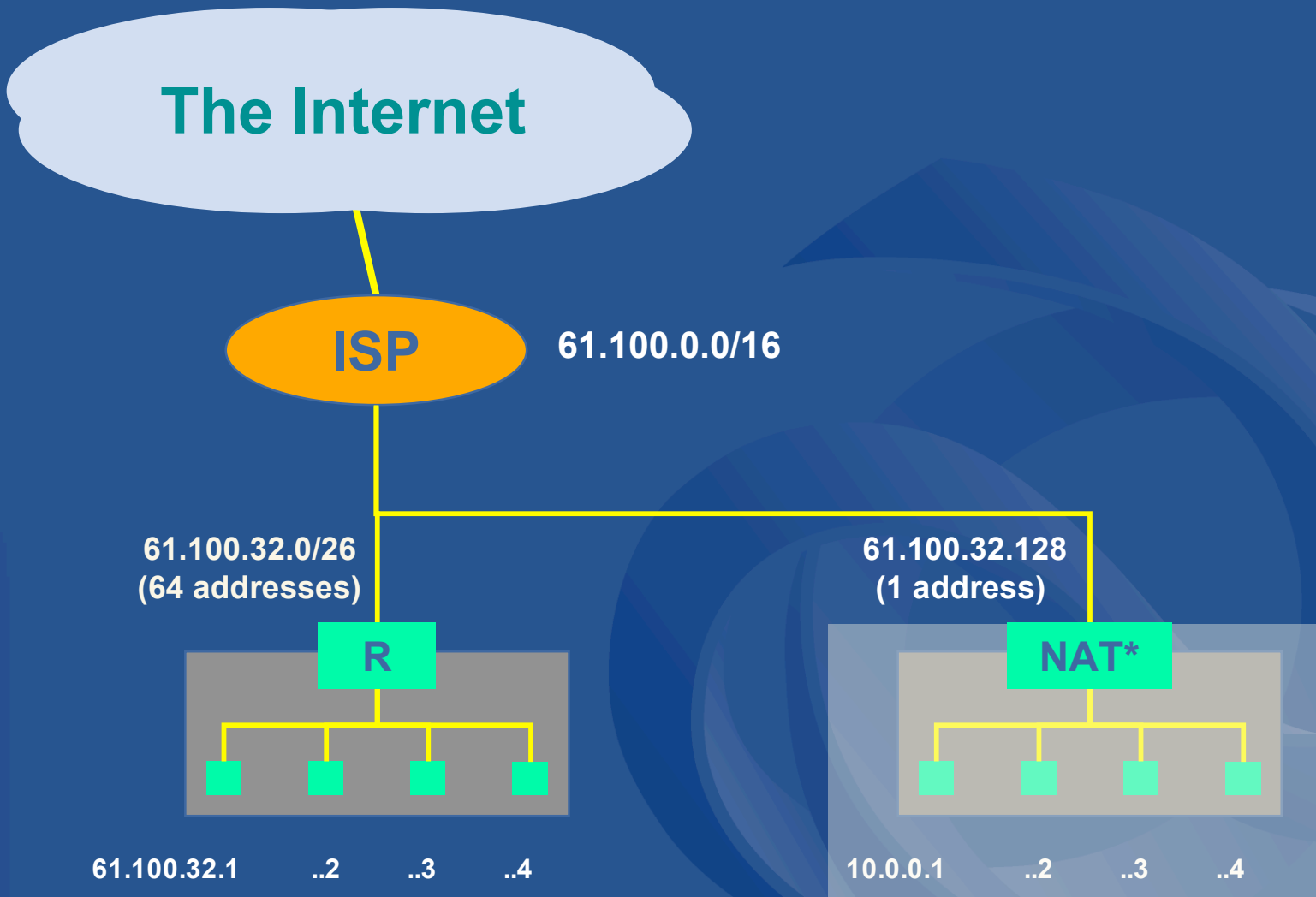


Rationale for IPv6

- IPv4 address space consumption
 - Now up to 10 years unallocated remaining
 - More if unused addresses can be reclaimed
 - ...or less if allocation rates increase
- Loss of “end to end” connectivity
 - Widespread use of NAT due to ISP policies and marketing
 - Additional complexity and performance degradation
 - “Fog on the Internet”
 - Brian Carpenter, IETF, RFC 2775



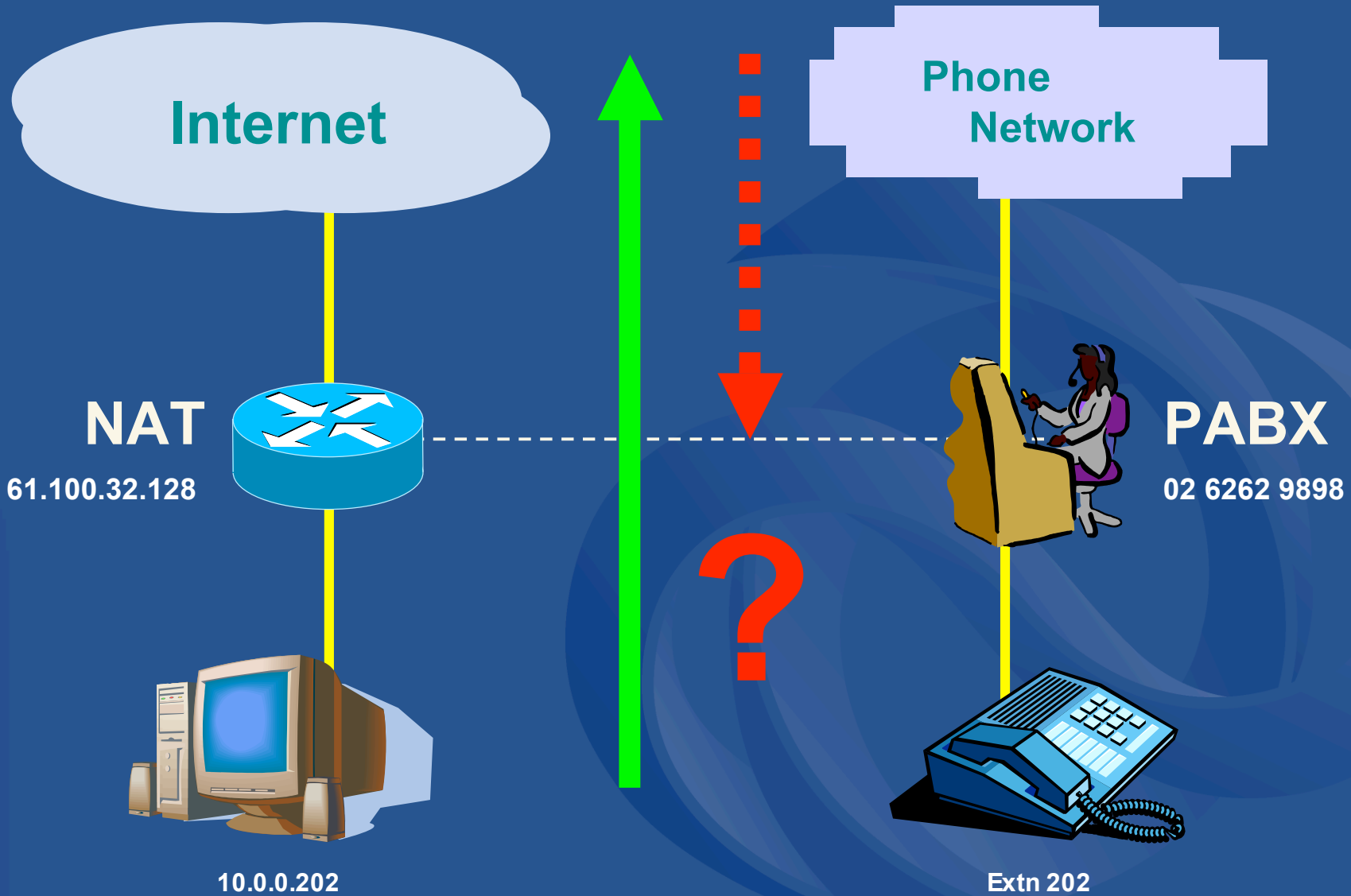
The NAT problem



*AKA home router, ICS, firewall



The NAT problem





Rationale for IPv6

- Other “features” ...
 - Security
 - QOS
 - Mobility?
 - Multihoming and routing table control?
- All available in some form in IPv4
 - Or yet to be solved



How are IP Addresses managed?

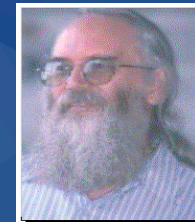


The early years: 1981 – 1992



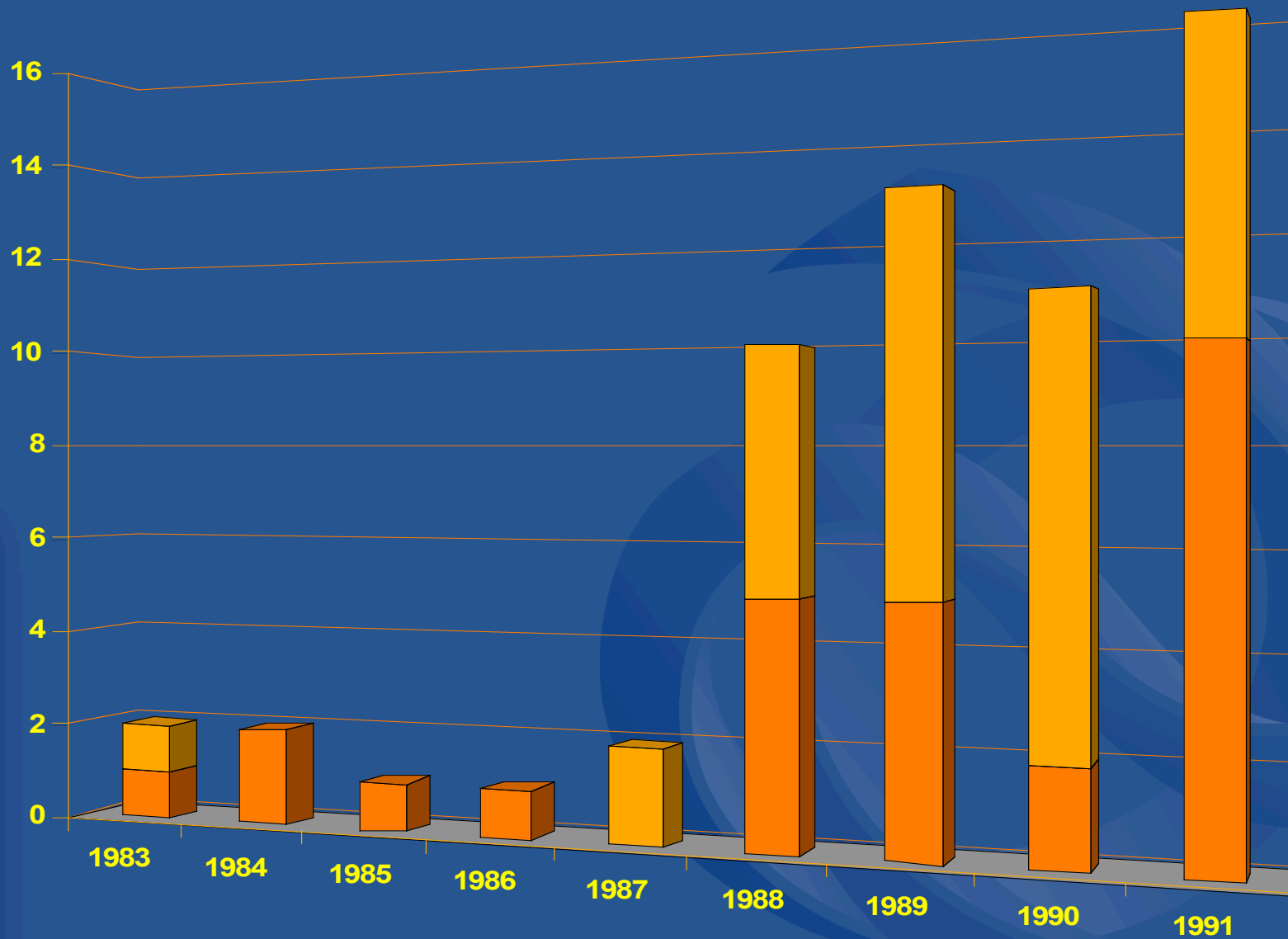
1981:

“The assignment of numbers is also handled by Jon. If you are developing a protocol or application that will require the use of a link, socket, port, protocol, or network number **please contact Jon to receive a number assignment.**” (RFC 790)



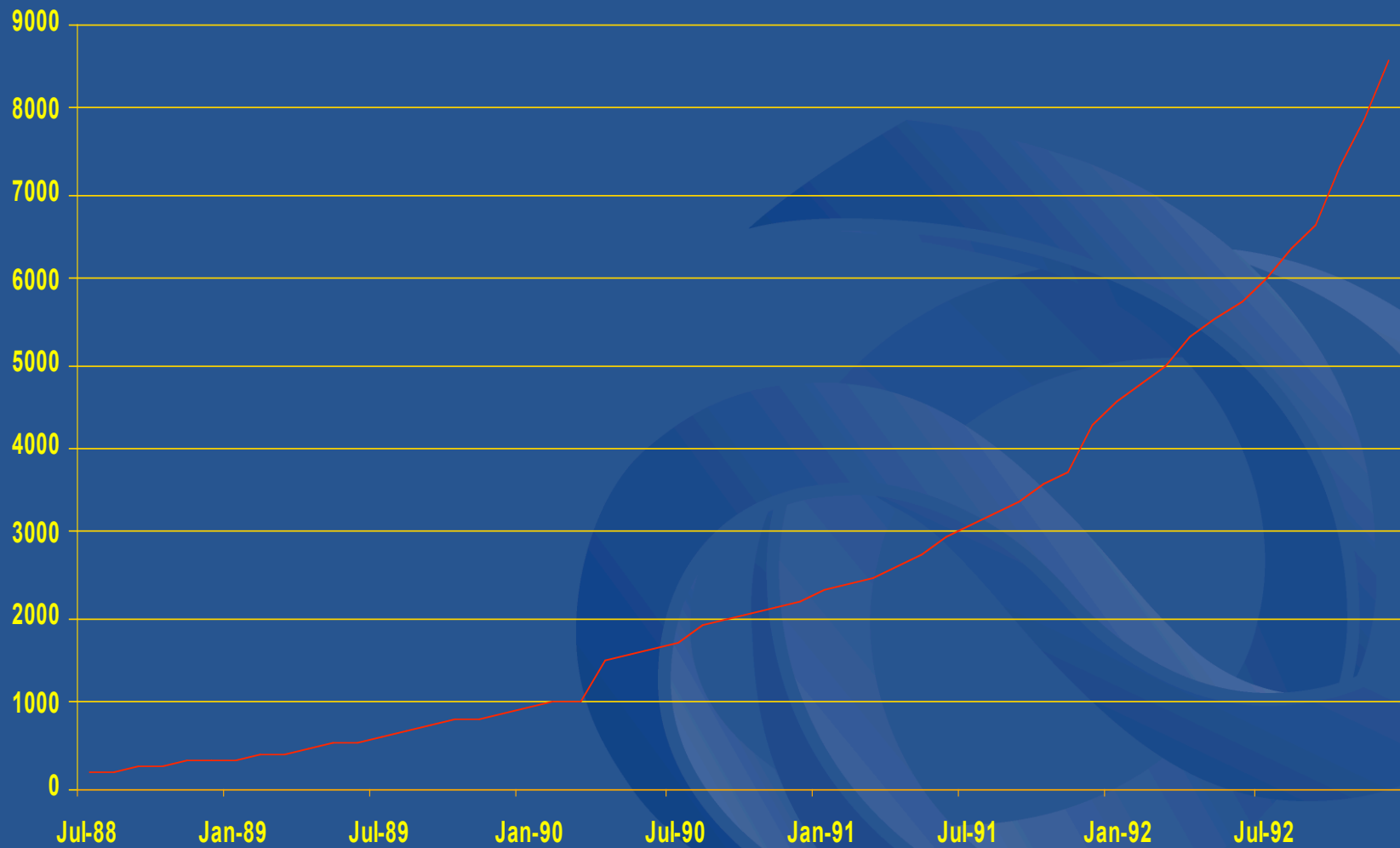


IANA address consumption



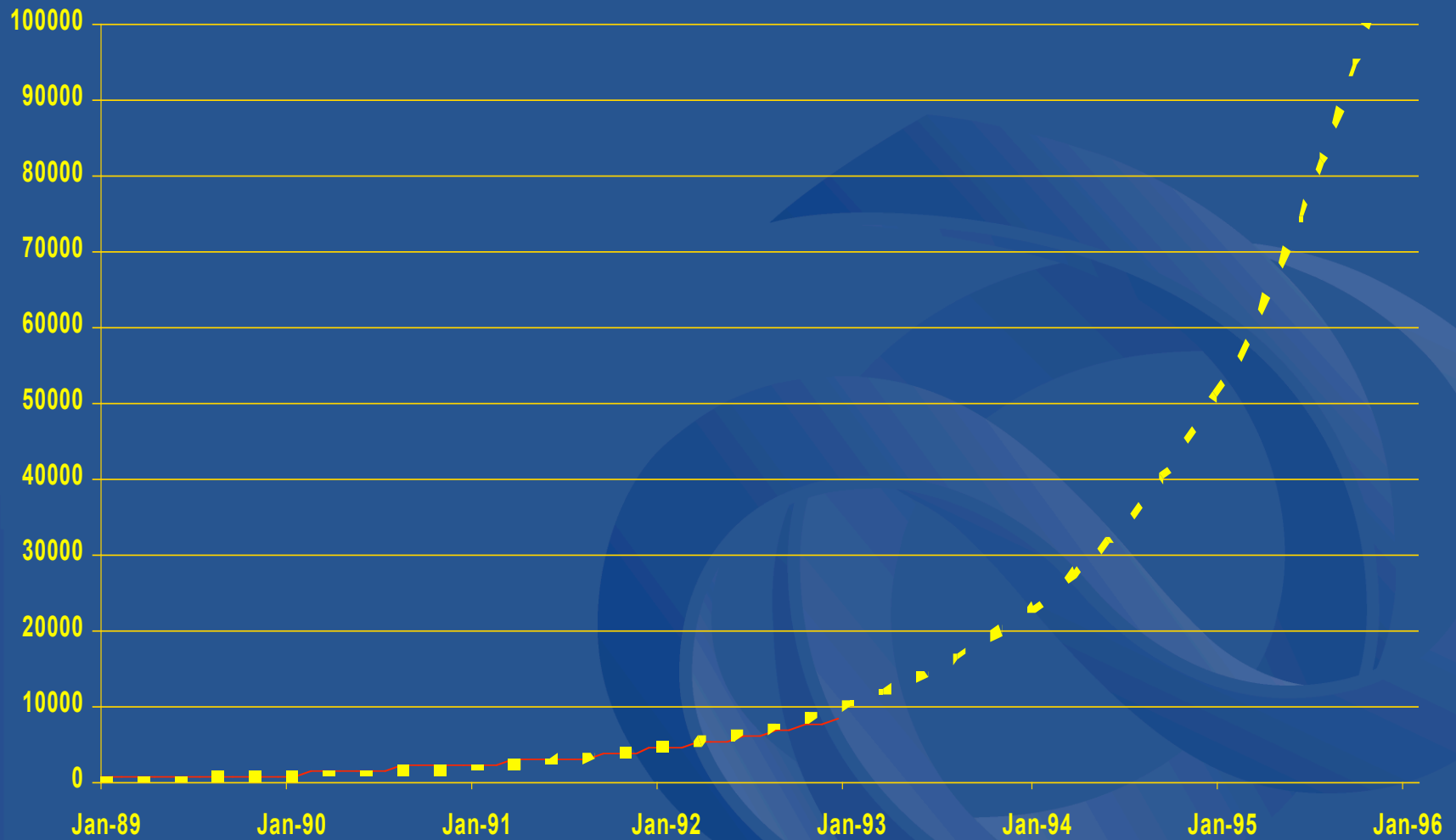


Global routing table: '88 – '92





Global routing table: Projection





The boom years: 1992 – 2001



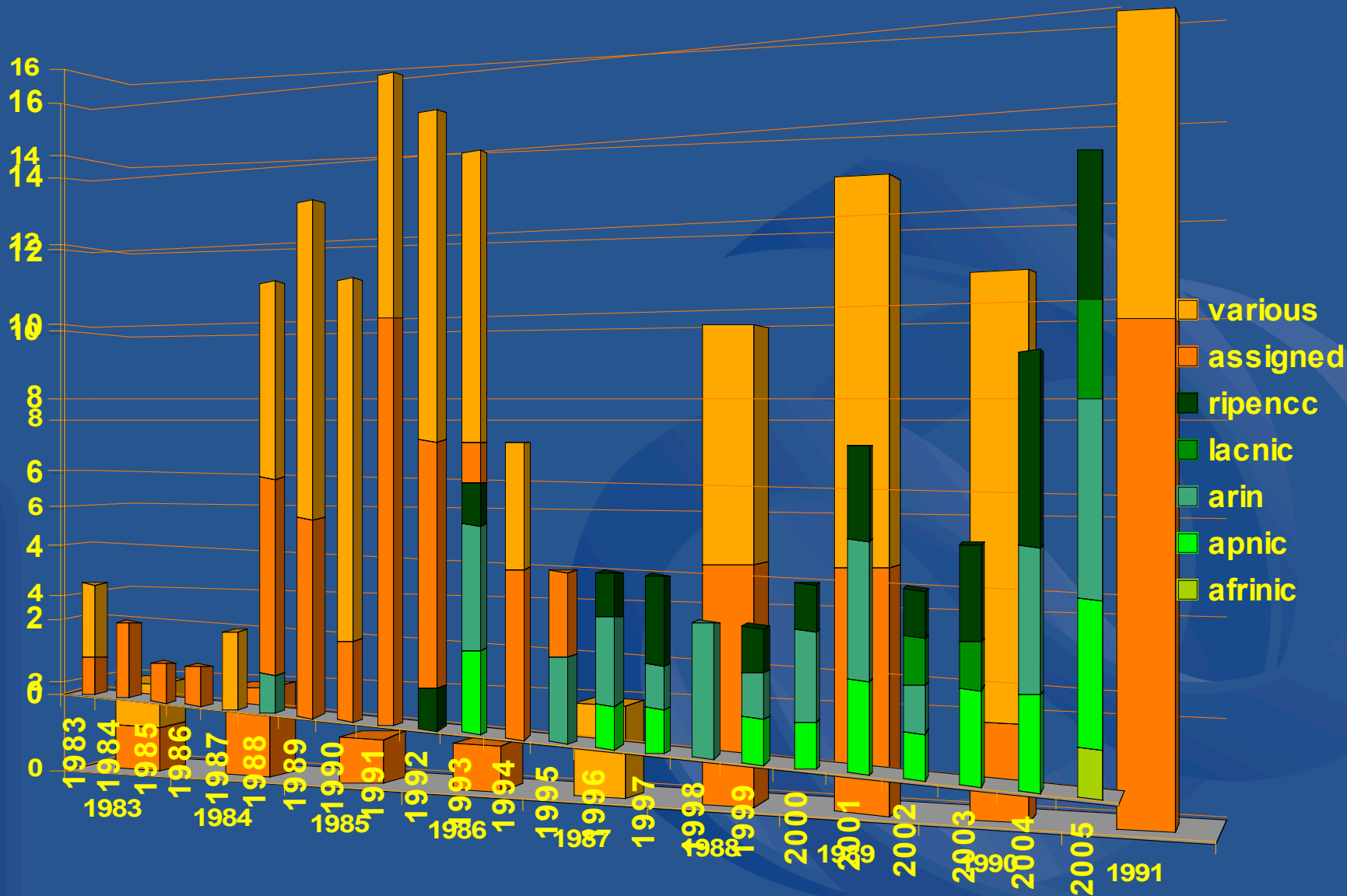
1992:

“It has become clear that ... these problems are likely to become critical within the next one to three years.” (RFC1338)

“...it is [now] desirable to consider delegating the registration function to an organization in each of those geographic areas.” (RFC 1366)

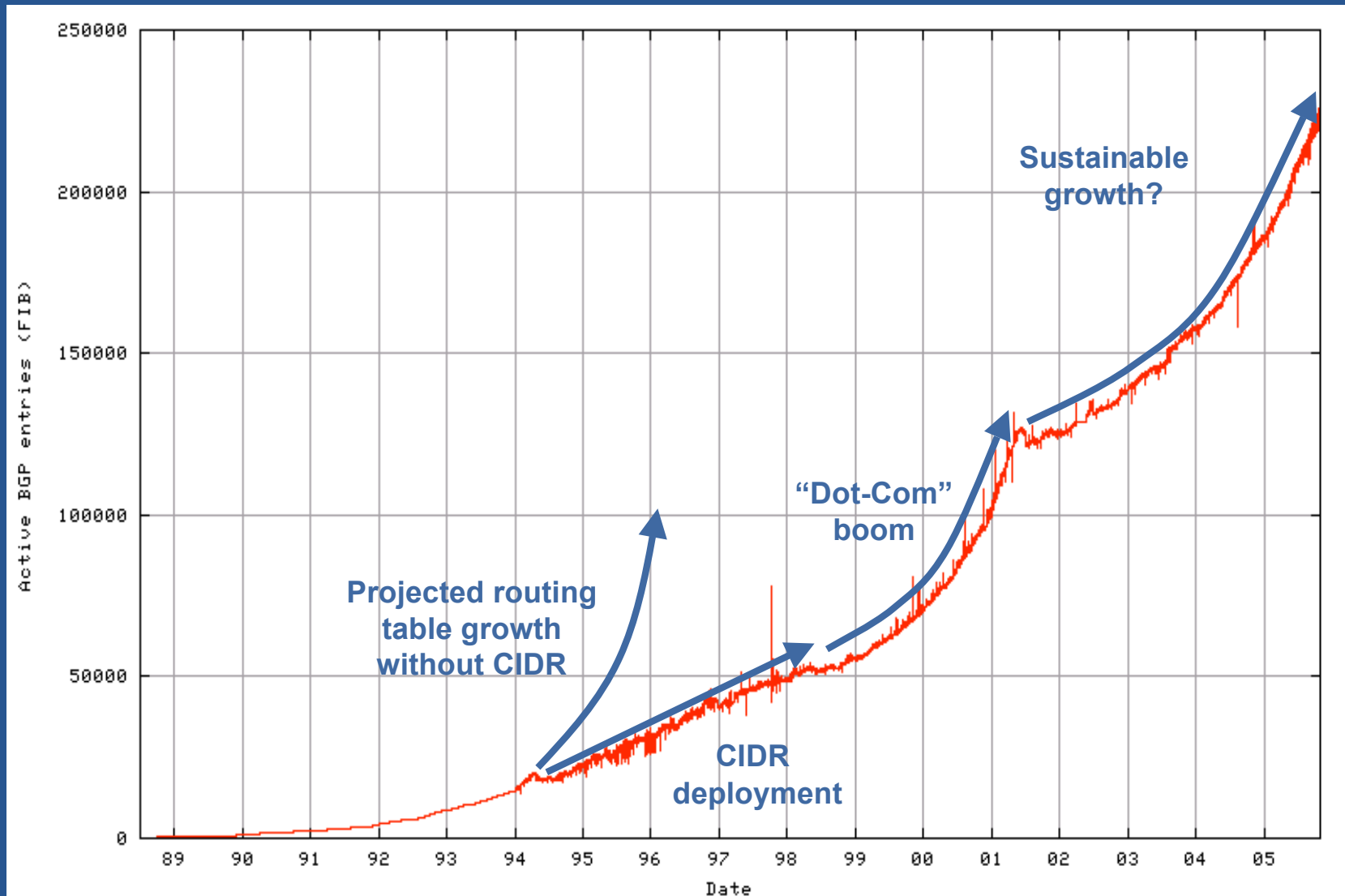


IANA address consumption



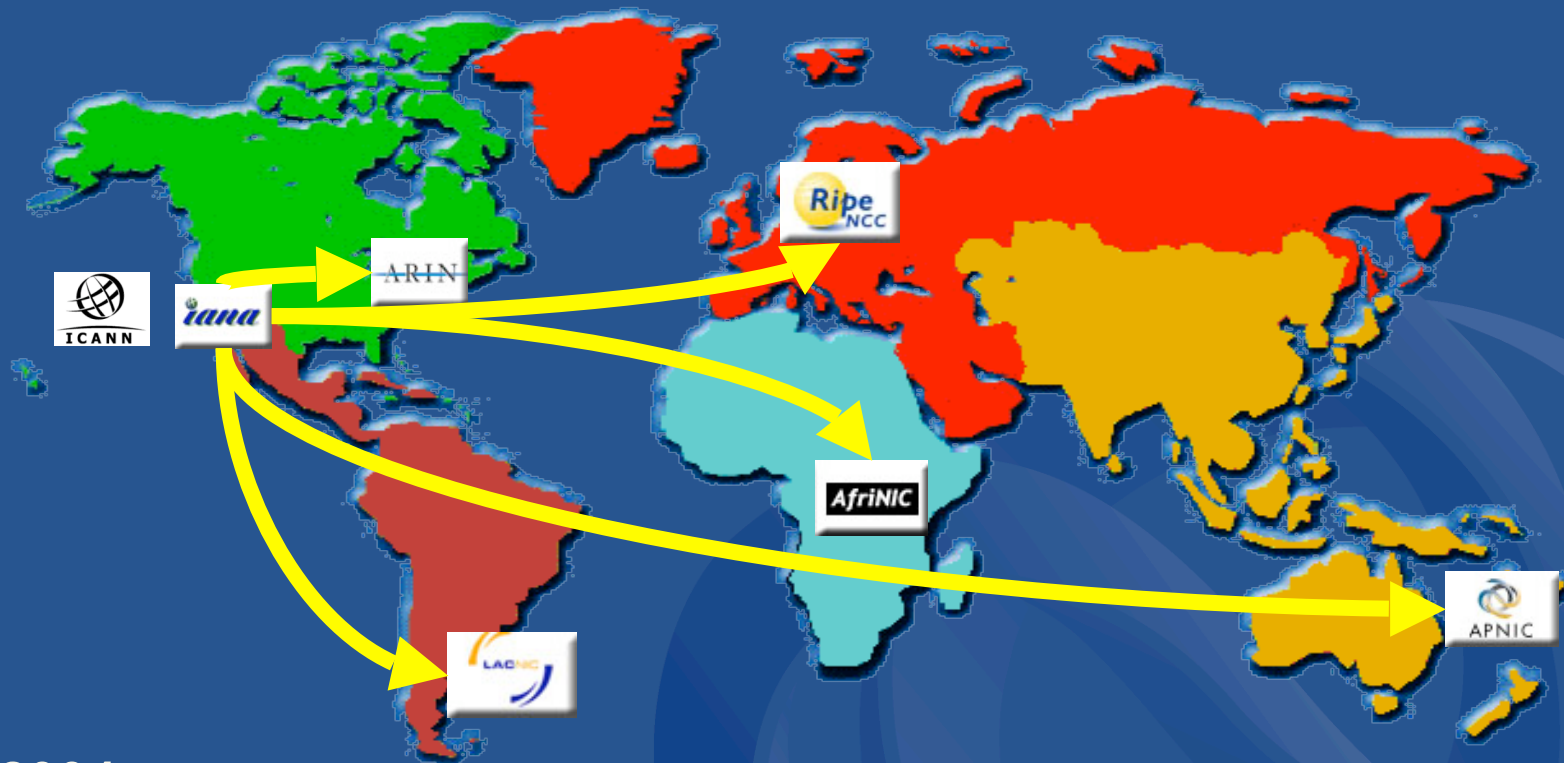


Global routing table (IPv4)





Recent years: 2002 – 2005



2004:

Establishment of the
Number Resource Organisation

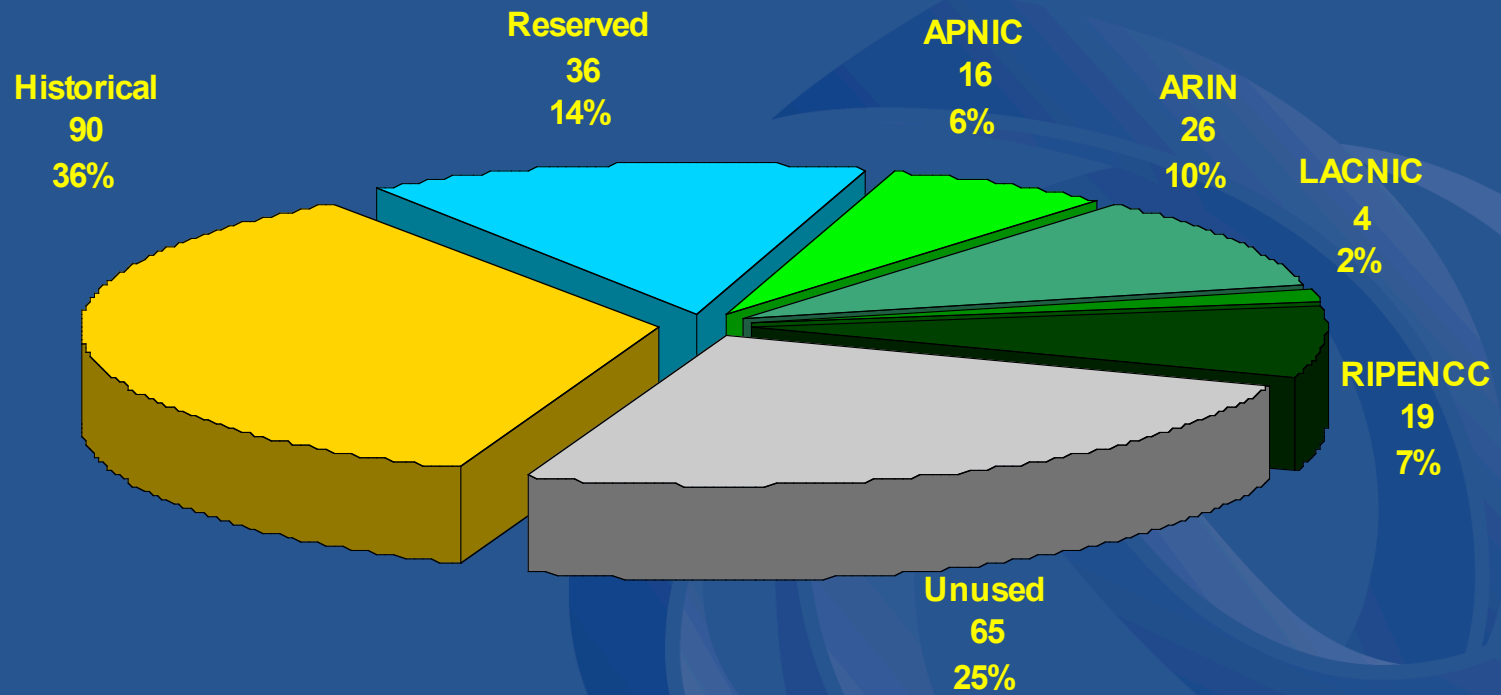




Where are the addresses?

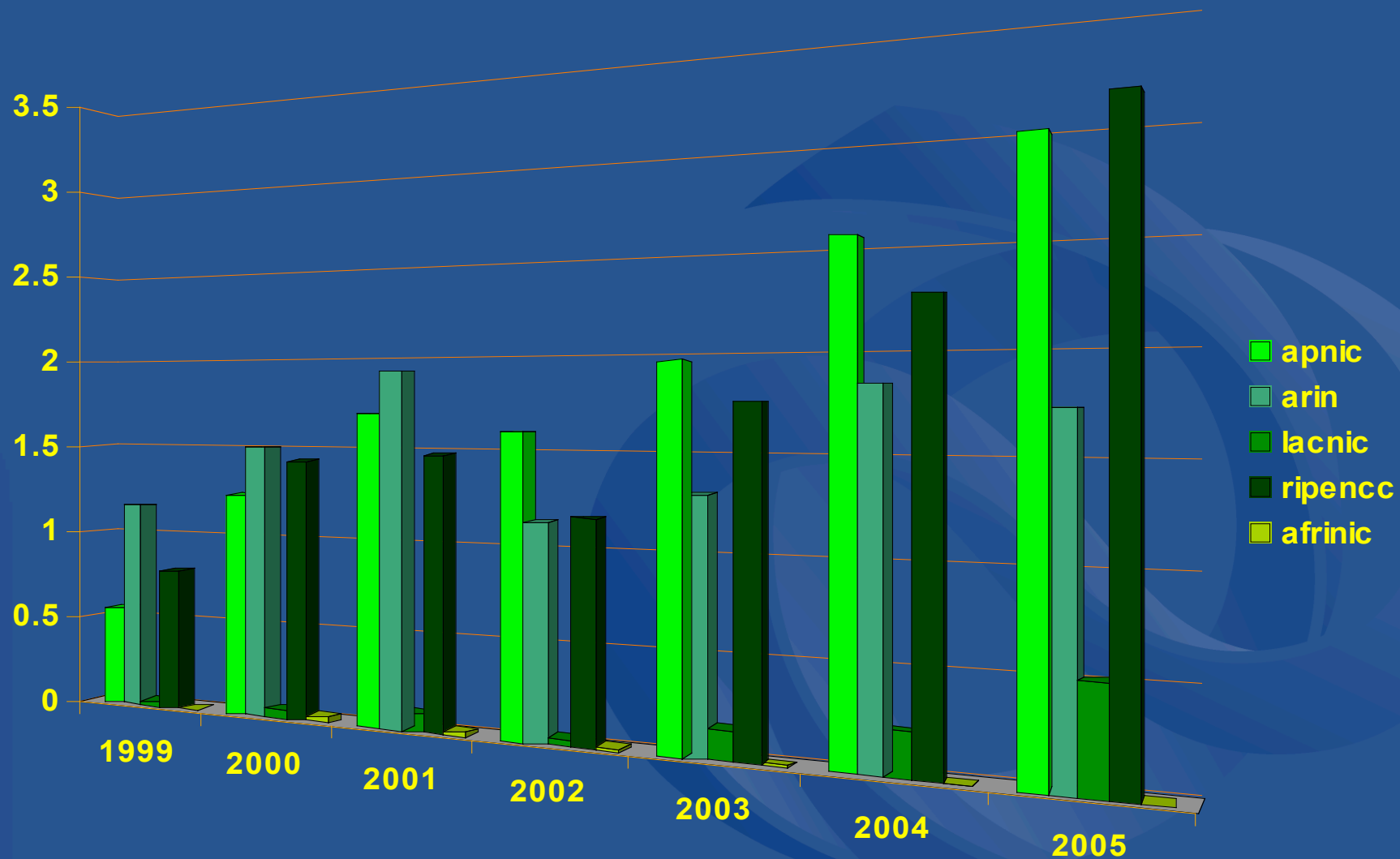


IPv4 distribution – Global



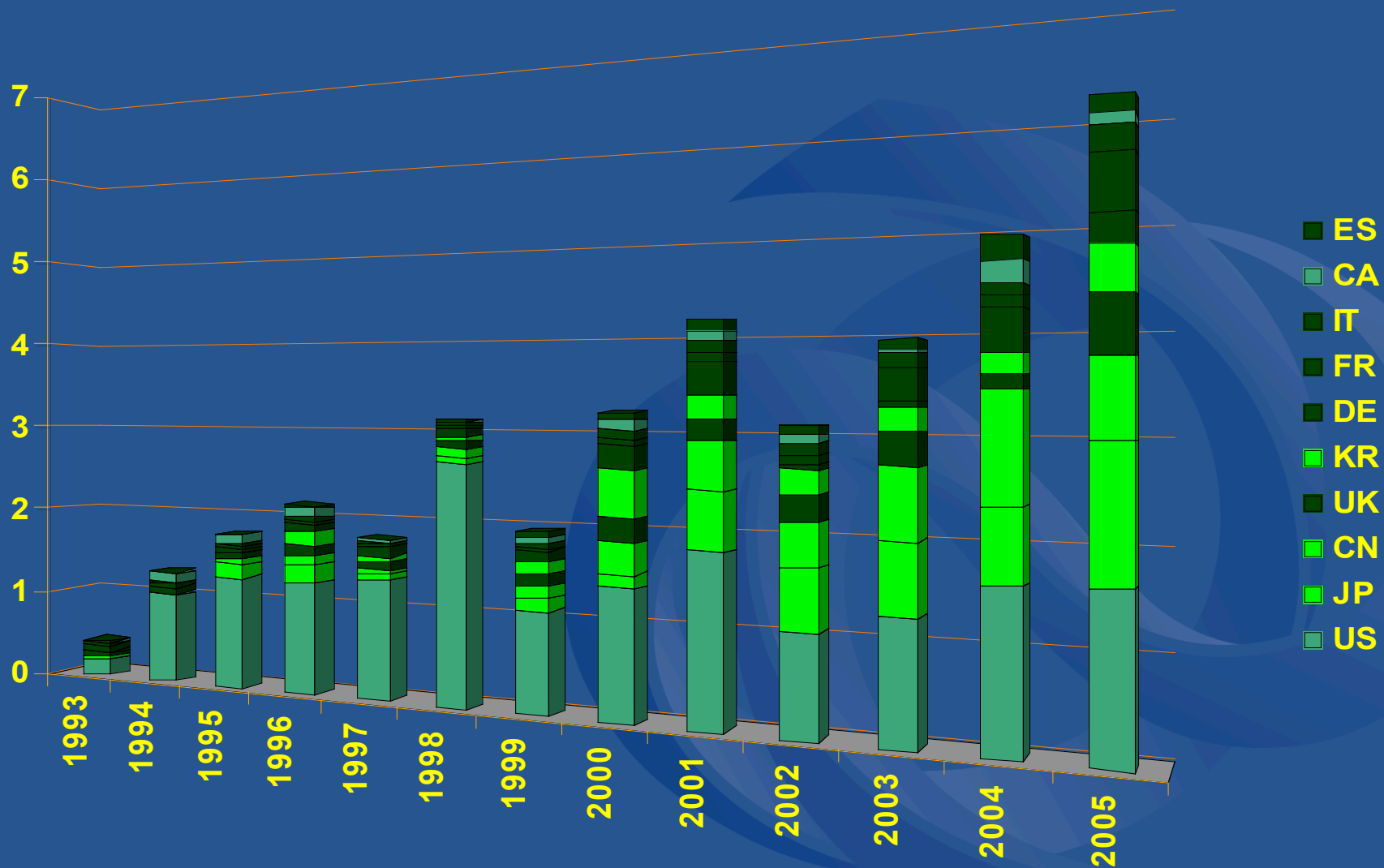


IPv4 distribution – Regional





IPv4 distribution – Top 10



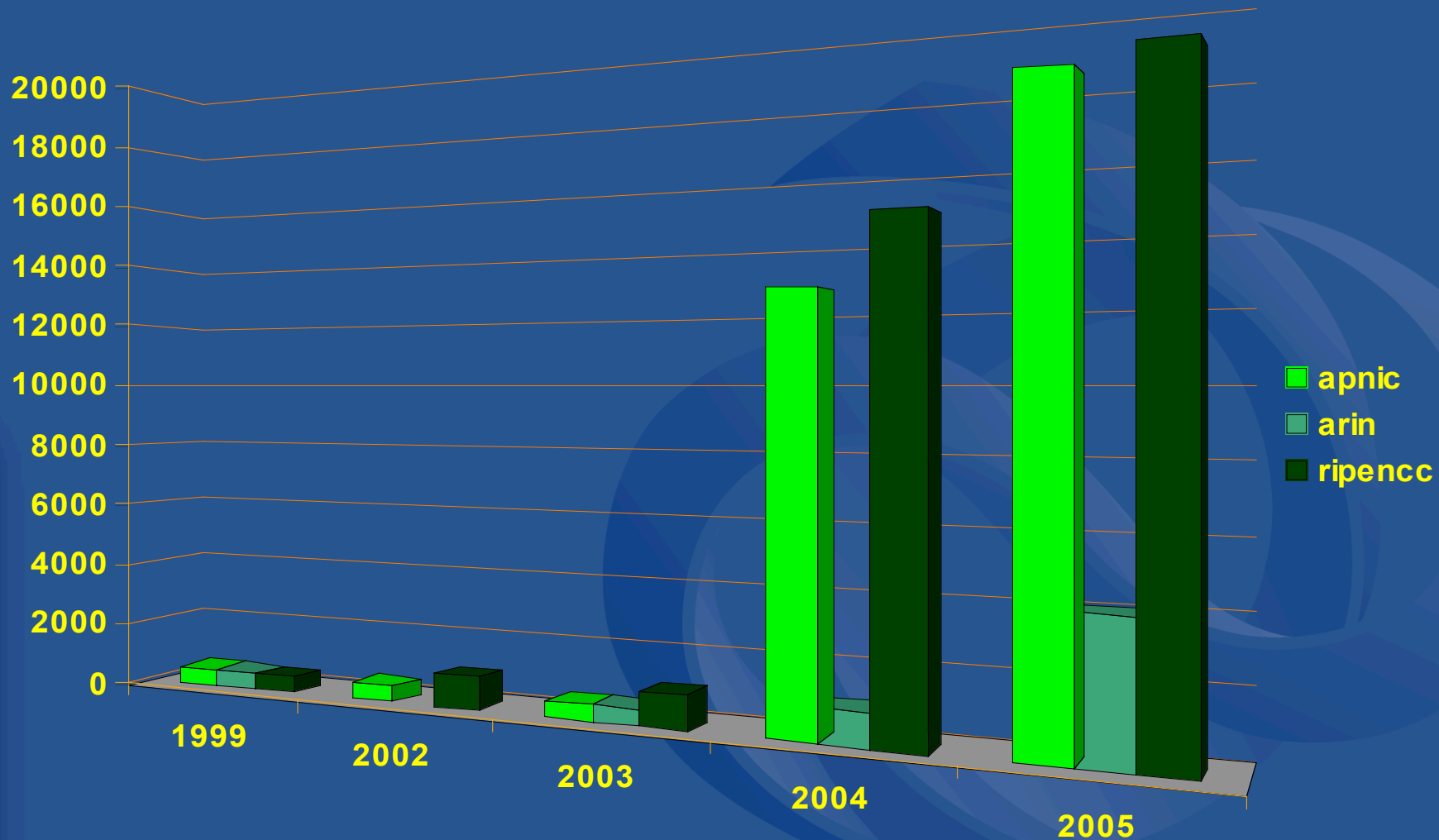


IPv6 distribution – Global

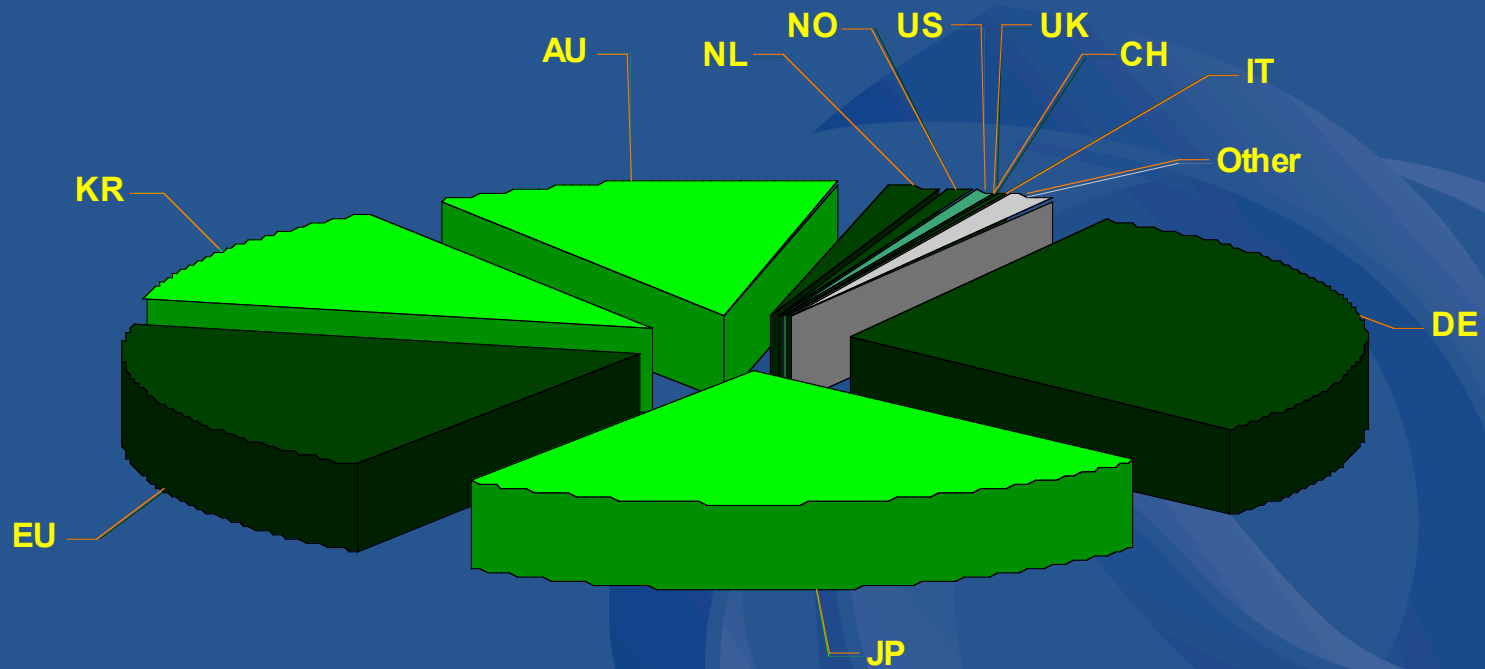




IPv6 distribution – Regional



IPv6 distribution – Top 10





APNIC

Asia Pacific Network Information Centre

Regional Internet Registries

What are RIRs?

- Regional Internet Registries
 - Industry self-regulatory bodies
 - Non-profit, neutral and independent
 - Open membership-based structures
- Internet resource allocation and registration
 - Primarily, IP addresses – IPv4 and IPv6
- Policy development and coordination
 - Open Policy Meetings and processes
- Supporting activities
 - Training courses, outreach
 - Newsletters, reports, web sites
 - Technical/operational services

What is APNIC?



What is APNIC?

- RIR for Asia Pacific region
 - Established 1993, Tokyo
 - 1100+ members in 45 of 62 AP economies
 - 45 staff, 18 nationality/language groups
- National Internet Registry structure
 - All NIRs follow same policies
 - Single regional address pool
- Other activities
 - Liaison: IETF, APT, PITA, APEC, ISP-A's
 - ITU Sector Member
 - UN ECOSOC consultative status
 - Operational services and support...



Rootservers





icons.apnic.net

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http://icons.apnic.net/

APNIC

Home 12 October 2005

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SEARCH

Search...

USER LOGIN

Hello, pwilson
[Logout](#)

VISITORS BY ECONOMY

Welcome to ICONS!

Welcome to the Internet Community of Online Networking Specialists (ICONS). The main objective of this site is to provide the Internet community in the Asia Pacific region with an opportunity to share information on networking topics that affect ISPs today. The ICONS site contains a wide variety of features such as an online forum, documents, presentations, and links to interesting external material.

This site is for the community. We encourage you to contribute anything interesting that you think may be of benefit to others. You can participate in the forum and upload documents such as training or presentation materials.

You can browse the existing contents as a guest user, however, to add content to ICONS, you simply need to register as an ICONS member.

Feel free to invite friends and colleagues to join the ICONS community.

Enjoy the site!

Newsflash

Last Modified: Monday, Sep 19/2005 15:12

Back on 14 January 2004, we provided notification that the "B" root server address was being renumbered. This renumbering occurred 28 January 2004. We have continued to run root service on the old address since then to ease transition for those who might have needed more time to make the change.

Please ensure that you have a current "root.hints" or "cache.db" file. The current version may be downloaded from

MOST RECENT

- [NOGs](#)
- [Internet organisations](#)
- [IXP](#)
- [DNS](#)
- [Routing](#)

POPULAR

- [Index of topics](#)
- [DNS](#)
- [IPv6](#)
- [Security](#)
- [IXP](#)

ONLINE POLLS

What is the next topic you would like to see on this site?

WIMAX
 WiFi
 GSM/GPRS
 VoIP

[Vote](#) [Results](#)

WHO'S ONLINE

Done

Adblock



Other activities

- Certification Authority
 - Member authentication
 - RFC 3779 implementation
 - Test resource certificates available at
 - <ftp://ftp.apnic.net/pub/test-certs>
- Internet “governance”
 - Dialog with governments
 - ORDIG - Open Regional Dialog on Internet Governance (UNDP)
 - ICANN, WSIS, WGIG etc etc



IP Address Policies

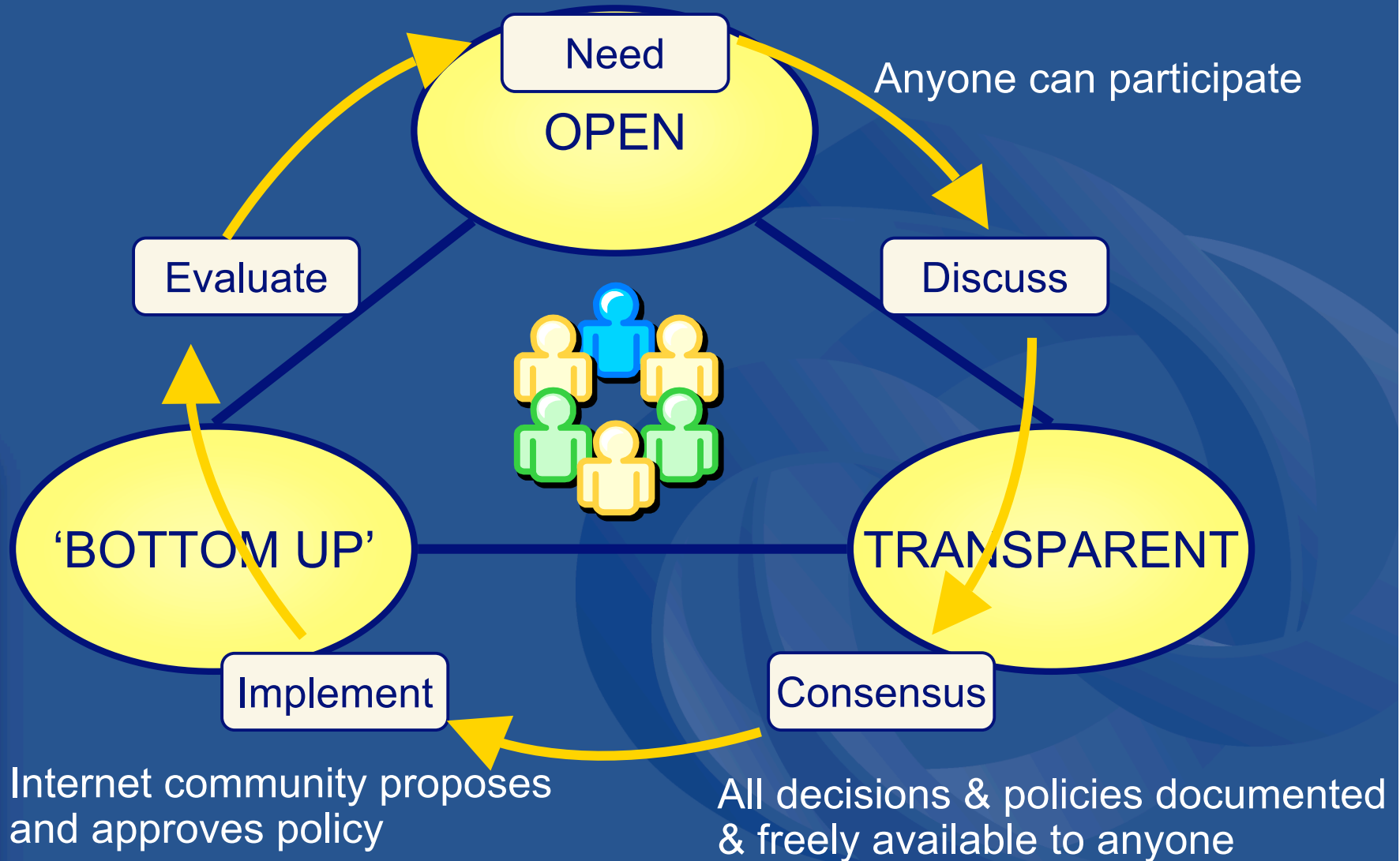


IP address management policies

- Fundamental technical principles
 - Provider-based addressing
 - Objective demonstrated need
 - Conservation, aggregation and registration
- Administrative policies
 - “Common resources” – not owned
 - Management in common interest
 - First-come-first-served allocation
- Constantly evolving through policy process
 - By consensus of Internet operator community
 - Process is open to all interested parties



RIR policy coordination



IPv6 management policies

- Utilisation metric
 - HD Ratio rather than percentage
 - Specific value 0.8 initially
 - Change currently under discussion
- Assignment size
 - /48 initially suggested by IETF
 - May be changed to /56 or other
- Initial/minimum allocation size
 - /32 for all ISP allocations



IPv6 utilisation – HD Ratio

- Under IPv4, address space utilisation measured as simple percentage:

$$Utilisation = \frac{assigned}{available}$$

- IPv4 utilisation requirement is 80%
 - When 80% of address space has been assigned or allocated, LIR may receive more
 - E.g. ISP has assigned 55,000 addresses from /16

$$\frac{assigned}{available} = \frac{55,000}{65,536} = 84\%$$



IPv6 utilisation – HD Ratio

- Under new IPv6 policy utilisation is determined by HD-Ratio (RFC 3194):

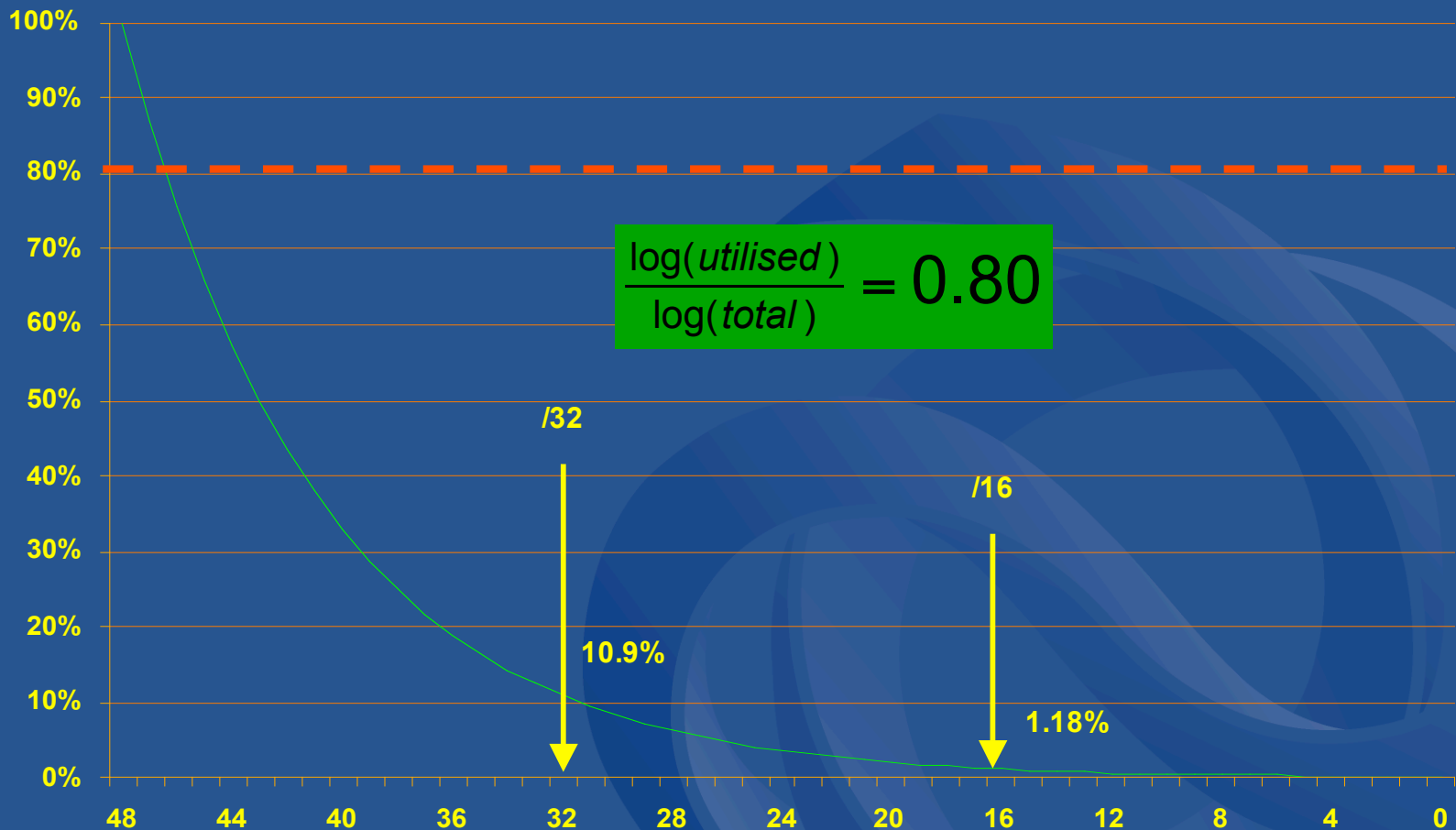
$$Utilisation_{HD} = \frac{\log(\textit{assigned})}{\log(\textit{available})}$$

- IPv6 utilisation requirement is HD=0.80
 - Measured according to end-site assignments only (intermediate allocations are ignored)
 - E.g. ISP has assigned 10,000 addresses from /32

$$\frac{\log(\textit{assigned})}{\log(\textit{available})} = \frac{\log(10,000)}{\log(65,536)} = 0.83$$



IPv6 utilisation (HD = 0.80)



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



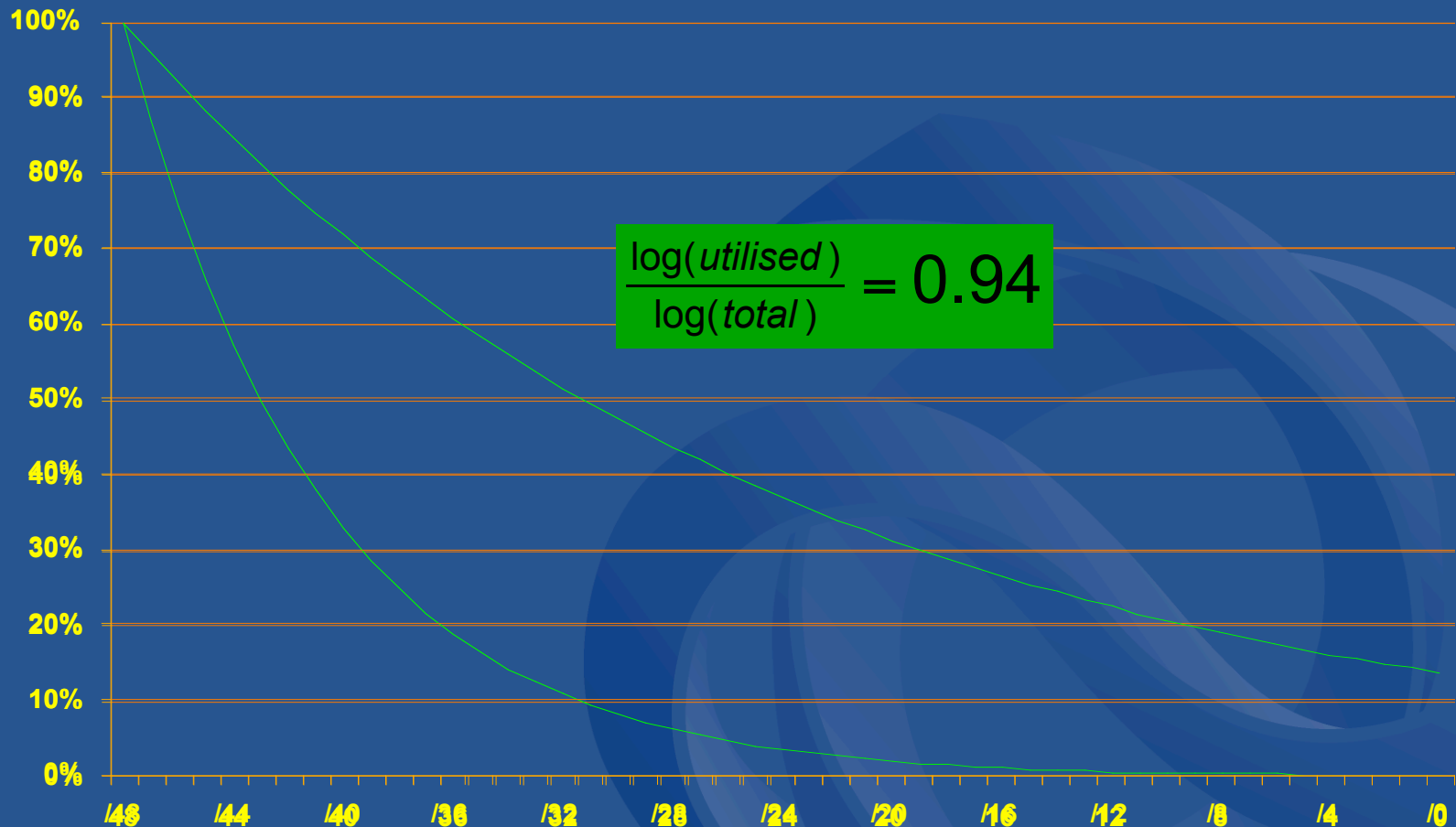
IPv6 utilisation (HD = 0.80)

- Percentage utilisation calculation

IPv6 Prefix	Site Address Bits	Total site address in /48s	Threshold (HD ratio 0.8)	Utilisation %
/42	6	64	28	43.5 %
/36	12	4096	776	18.9 %
/35	13	8192	1351	16.5 %
/32	16	65536	7132	10.9 %
/29	19	524288	37641	7.3 %
/24	24	16777216	602249	3.6 %
/16	32	4294967296	50859008	1.2 %
/8	40	1099511627776	4294967296	0.4 %
/3	45	35184372088832	68719476736	0.2 %



IPv6 utilisation (HD = 0.94)



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



IPv6 utilisation (HD = 0.94)

- Proposed utilisation measures

IPv6 Prefix	Site Address Bits	Total site address in /48s	Threshold (HD ratio 0.8)	Utilisation %
/42	6	64	50	77.9 %
/36	12	4096	2487	60.7 %
/35	13	8192	4771	58.2 %
/32	16	65536	33689	51.4 %
/29	19	524288	237901	45.4 %
/24	24	16777216	6183533	36.9 %
/16	32	4294967296	1134964479	26.4 %
/8	40	1099511627776	208318498661	19.0 %
/3	45	35184372088832	5414630391777	15.4 %



Global Policy Coordination

Global policy coordination

- Local actions have global impact
 - Consumption or wastage of common resource
 - Global routing table growth
- Bad behaviour can isolate entire networks and countries
 - E.g. Spam and hacking, router overload
- Inconsistent policies also cause global effects
 - E.g. Fragmentation of IP address space
 - If widespread, Internet routing is fragmented
 - End of global end-end routability
- Address policies must be globally consistent
 - RIRs work hard to ensure this



NRO

- Number Resource Organisation (2003)
 - “Coalition” of all RIRs
- For carriage of joint RIR activities
 - Technical coordination and services
 - DNS, ERX, whois, 6to4, IPv6 unique local addresses...
 - RIR point of contact and representation
 - Global policy coordination
 - Negotiation/liaison with other bodies
 - ICANN, IETF, UN/ITU/WSIS etc
- Independent of ICANN
 - Able to operate with or without ICANN
 - But intended to support and work with ICANN



ASO

- Address Supporting Organisation
 - Established 1999, reformed 2004
- ICANN function, performed by NRO
 - Under MoU between NRO and ICANN
 - Provides global policy coordination structure
- Address Council (AC)
 - Global policy coordination according to the ASO Policy Development Process (PDP)
 - Other roles: appointments, liaisons, etc
- Revised PDP
 - 15 step (max) process
 - NRO PDP suspended while ASO provides those functions



Summary

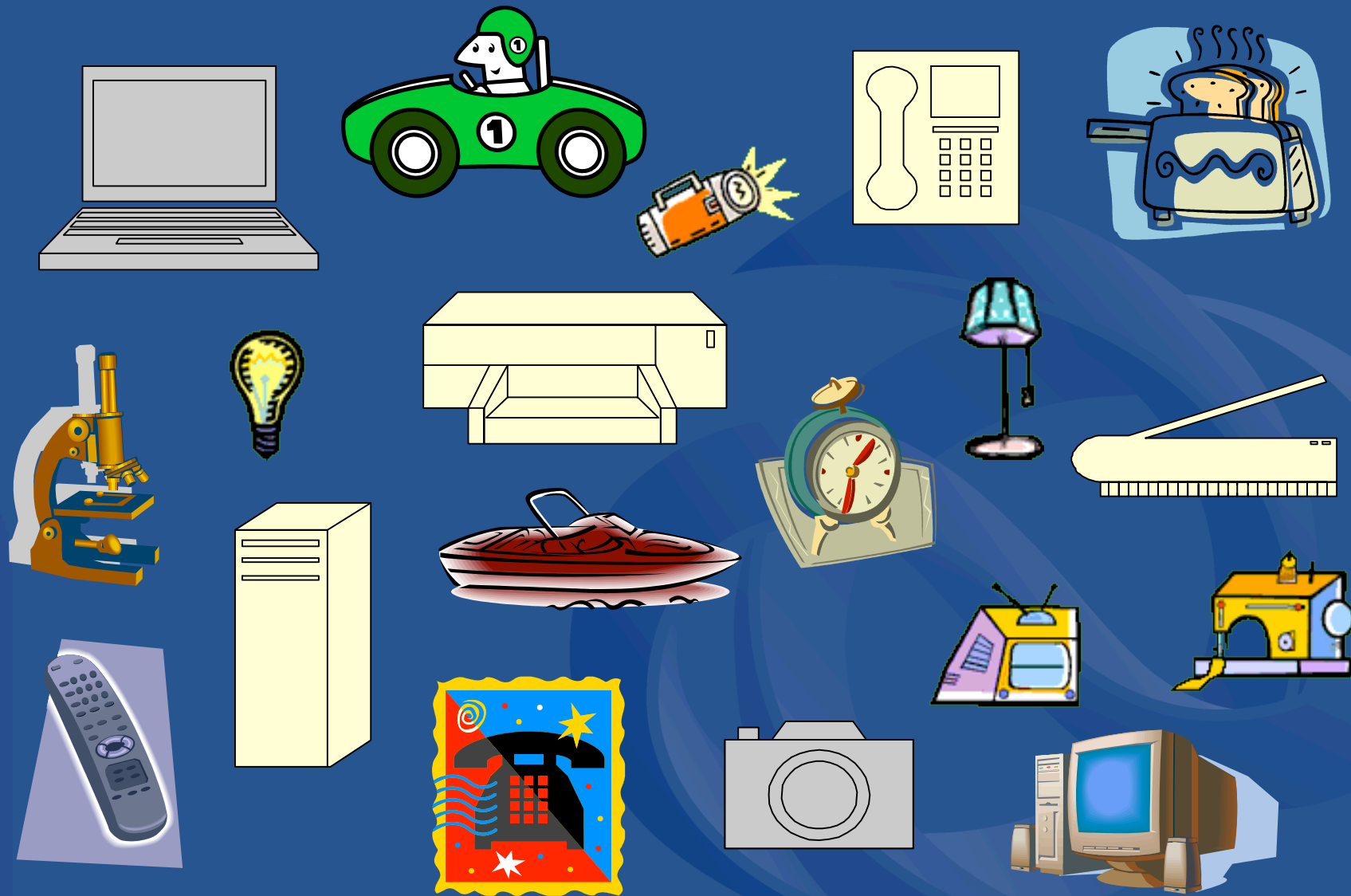


IP address policy

- A global internet needs global policy
 - RIRs and NRO achieve this
 - 10+ years of successful experience
- Policy fragmentation
 - Internet fragmentation, loss of global routing
- IPv4 has a long history
 - Result of early allocations is unfair distribution
 - RIRs have ensured that current allocation policies are fair to all
- IPv6 is being managed better from the start
 - RIR system is responsible and fair
 - Policy will continue to evolve with the Internet



IPv6 – Internet for everything!





IPv6 – Summary

- The good news...
 - IPv6 is available now
 - IPv6 addresses are very easy to obtain
- The not so good news...
 - Complexity: cost and learning curve
 - Demand? Do users want it? “Chicken and Egg”
- The reality: A long transition
 - “Changing engines mid-flight”
 - 10 years to complete?
- **The critical message: Start now!**



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Thank You