IP Version 6

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IP Version 6

- Background
- What is IPv6
- Why IPv6

- And a few IPv6 myths as well

Background 1991

- January 1991 – IAB Architecture Review

  “If we assume that the Internet Architecture will continue in use indefinitely then we need additional [address] flexibility”

  - Two problems:
    - **Routing** and **Addresses**

      Growth in the inter-AS routing table

      Consumption of IP address space (noteably the Class B block)

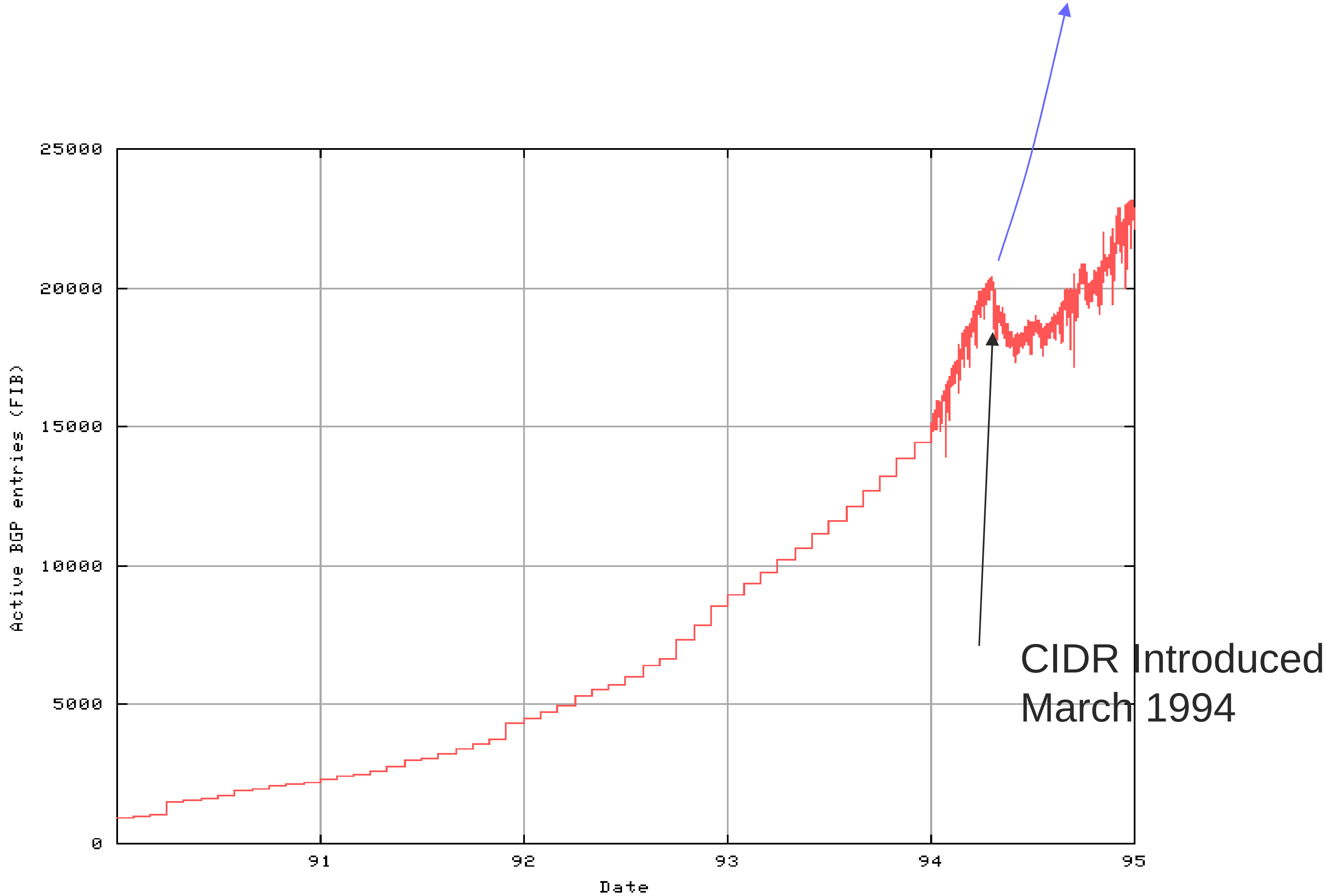
IETF Response – 1991 - 1992

- November 1991 – IETF ROAD Group
  - IETF **RO**uting and **AD**dressing Group set up to examine the consumption of address space and the exponential growth in inter-domain routing entries and propose scalable solutions

Routing = CIDR - 1993

- September 1993 – RFC1519 Classless Inter-Domain Routing
  - ROAD outcome
  - Routing refinements intended to alleviate pressure on B space
  - Short term alleviation of address consumption through improved potential for address utilization

CIDR Outcomes:….



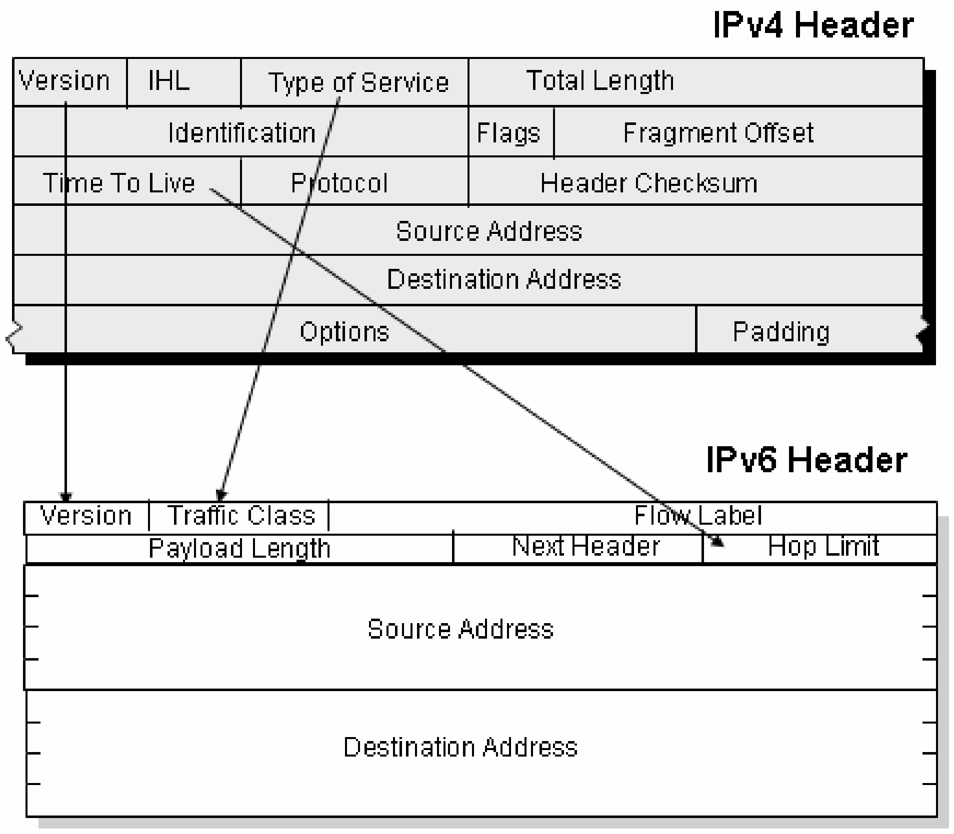
IPv? - 1993

- June 1992 – IAB recommends adoption of the OSI CLNS as the base start point for the successor protocol to IPv4
- July 1992 – IETF Plenary decides otherwise (both in terms of the choice of protocol and the IAB itself!)
- 1992 – 1994 – IETF undertakes an evaluation of a collection of potential next generation IP protocols
  - TUBA, SIP, PIP, SIPP, ….
- 1994 – IETF design team defines core IPv6 protocol

IPv6 is…

- IP with:
  - Larger address fields (128 bits)
    - Yes, that's a VERY big number!
  - Smaller number of header fields
  - Altered support for header extensions
  - Addition of a flow label header field

IPv6 Header



IPv4 Header
Version
IHL
Type of Service
Total Length
Identification
Flags
Fragment Offset
Time To Live
Protocol
Header Checksum
Source Address
Destination Address
Options
Padding
IPv6 Header
Version
Traffic Class
Flow Label
Payload Length
Next Header
Hop Limit
Source Address
Destination Address

IPv6

- What has **<u>not</u>** changed

  Almost everything!

  IPv6 is a connectionless datagram delivery service, using end-to-end address identifiers and end-to-end signaling, with TCP and UDP transport services.

  So is IPv4.

IETF IPv6 Specifications

- There are 90 RFCs that describe aspects of IPv6, including:

  RFC2460

  Internet Protocol, Version 6 (IPv6) Specification [December 1998]

  RFC2373

  IP Version 6 Addressing Architecture [July 1998]

  RFC3177

  IAB/IESG Recommendations on IPv6 Address [September 2001]

- And many more that reference application to IPv6

IETF Working Groups

- IPv6
  - Core protocol specification
  - L2 adaptations
  - MIBs
  - Mobility
  - Address Architecture
  - Routing interaction
  - Multi-homing
  - …

IETF Working Groups

- V6ops
  - Operational considerations
  - Transition mechanisms
  - Service management
  - …

IETF Working Groups

- Multi6
  - Multi-homing in V6
- MIP6
  - IP Mobility in V6
- PANA
  - Network Authentication
- …..
  - Almost every other WG has V6 activity streams

IETF IPv6 Working Group

Request For Comments:

- An Architecture for IPv6 Unicast Address Allocation (RFC 1887)
- Internet Protocol, Version 6 (IPv6) Specification (RFC 1883)
- Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) (RFC 1885)
- DNS Extensions to support IP version 6 (RFC 1886)
- IP Version 6 Addressing Architecture (RFC 1884)
- IPv6 Testing Address Allocation (RFC 1897)
- Path MTU Discovery for IP version 6 (RFC 1981)
- OSI NSAPs and IPv6 (RFC 1888)
- A Method for the Transmission of IPv6 Packets over Ethernet Networks (RFC 1972)
- Neighbor Discovery for IP Version 6 (IPv6) (RFC 1970)
- Transmission of IPv6 Packets Over FDDI (RFC 2019)
- IP Version 6 over PPP (RFC 2023)
- An IPv6 Provider-Based Unicast Address Format (RFC 2073)
- Basic Socket Interface Extensions for IPv6 (RFC 2133)
- TCP and UDP over IPv6 Jumbograms (RFC 2147)
- Advanced Sockets API for IPv6 (RFC 2292)
- IP Version 6 Addressing Architecture (RFC 2373)
- An IPv6 Aggregatable Global Unicast Address Format (RFC 2374)
- IPv6 Multicast Address Assignments (RFC 2375)
- Neighbor Discovery for IP Version 6 (IPv6) (RFC 2461)
- IPv6 Stateless Address Autoconfiguration
- Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification (RFC 2463)
- Transmission of IPv6 Packets over Ethernet Networks (RFC 2464)
- Internet Protocol, Version 6 (IPv6) Specification (RFC 2460)
- IP Version 6 Management Information Base for the Transmission Control Protocol (RFC 2452)
- IP Version 6 Management Information Base for the User Datagram Protocol (RFC 2454)

IETF IPv6 Working Group

Request For Comments: (cont)

- Management Information Base for IP Version 6: Textual Conventions and General Group (RFC 2465)
- Management Information Base for IP Version 6: ICMPv6 Group (RFC 2466)
- Proposed TLA and NLA Assignment Rules (RFC 2450)
- Transmission of IPv6 Packets over FDDI Networks (RFC 2467)
- Transmission of IPv6 Packets over Token Ring Networks (RFC 2470)
- IPv6 Testing Address Allocation (RFC 2471)
- IP Version 6 over PPP (RFC 2472)
- Generic Packet Tunneling in IPv6 Specification (RFC 2473)
- Transmission of IPv6 Packets over ARCnet Networks (RFC 2497)
- IP Header Compression (RFC 2507)
- Reserved IPv6 Subnet Anycast Addresses (RFC 2526)
- Transmission of IPv6 over IPv4 Domains without Explicit Tunnels (RFC 2529)
- Basic Socket Interface Extensions for IPv6 (RFC 2553)
- IPv6 Jumbograms (RFC 2675)
- Multicast Listener Discovery (MLD) for IPv6 (RFC 2710)
- IPv6 Router Alert Option (RFC 2711)
- Format for Literal IPv6 Addresses in URL's (RFC 2732)
- DNS Extensions to Support IPv6 Address Aggregation and Renumbering (RFC 2874)
- Router Renumbering for IPv6 (RFC 2894)
- Initial IPv6 Sub-TLA ID Assignments (RFC 2928)
- Privacy Extensions for Stateless Address Autoconfiguration in IPv6 (RFC 3041)
- IP Version 6 Management Information Base for the Multicast Listener Discovery Protocol (RFC 3019)
- Extensions to IPv6 Neighbor Discovery for Inverse Discovery Specification (RFC 3122)
- IPv6 multihoming support at site exit routers (RFC 3178)
- Transmission of IPv6 Packets over IEEE 1394 Networks (RFC 3146)
- Unicast-Prefix-based IPv6 Multicast Addresses (RFC 3306)
- Recommendations for IPv6 in 3GPP Standards (RFC 3314)

IETF IPv6 Working Group

Internet-Drafts:

- IPv6 Node Information Queries
- Internet Control Message Protocol (ICMPv6)
- Well known site local unicast addresses for DNS resolver
- Default Router Preferences, More-Specific Routes and Load Sharing
- An analysis of IPv6 anycast
- IPv6 Flow Label Specification
- Link Scoped IPv6 Multicast Addresses
- IPv6 Node Requirements
- IP Forwarding Table MIB
- Management Information Base for TCP
- Management Information Base for IP
- Requirements for IPv6 prefix delegation
- IPv6 Global Unicast Address Format
- IPv6 Scoped Address Architecture

IETF NGTrans Working Group

Request For Comments:

- Transition Mechanisms for IPv6 Hosts and Routers (RFC 1933)
  Routing Aspects of IPv6 Transition (RFC 2185)
  6Bone Routing Practice (RFC 2546)
  Stateless IP/ICMP Translation Algorithm (SIIT) (RFC 2765)
  Network Address Translation - Protocol Translation (NAT-PT] (RFC 2766)
  Dual Stack Hosts using the Bump-In-the-Stack Technique (BIS) (RFC 2767)
  6Bone Backbone Routing Guidelines (RFC 2772)
  Transition Mechanisms for IPv6 Hosts and Routers (RFC 2893)
  6BONE pTLA and pNLA Formats (pTLA) (RFC 2921)
  IPv6 Tunnel Broker (RFC 3053)
  Connection of IPv6 Domains via IPv4 Clouds (RFC 3056)
  A SOCKS-based IPv6/IPv4 Gateway Mechanism (RFC 3089)
  An anycast prefix for 6to4 relay routers (RFC 3068)
  An IPv6-to-IPv4 transport relay translator (RFC 3142)

Internet-Drafts:

- An overview of the Introduction of IPv6 in the Internet
  Dual Stack Transition Mechanism (DSTM)
  Survey of IPv4 Addresses in Currently Deployed IETF Standards
  Connecting IPv6 Domains across IPv4 Clouds with BGP
  Support for Multicast over 6to4 Networks
  Intra-Site Automatic Tunnel Addressing Protocol (ISATAP)
  SMTP operational experience in mixed IPv4/IPv6 environements
  An IPv6/IPv4 Multicast Translator based on IGMP/MLD Proxying (mtp)
  Moving in a Dual Stack Internet
  Dual Stack Hosts using 'Bump-in-the-API' (BIA)
  NGtrans IPv6 DNS operational requirements and roadmap
  Teredo: Tunneling IPv6 over UDP through NATs
  Interaction of transition mechanisms
  MIME TYPE definition for tunnels
  Dual Stack Transition Mechanism (DSTM) Overview
  ISATAP Transition Scenario for Enterprise/Managed Networks
  Unmanaged Networks Transition Scope
  Transition Mechanisms for IPv6 Hosts and Routers

V6Ops Working Group

- Transition Scenarios for 3GPP Networks
- Analysis on IPv6 Transition in 3GPP Networks
- Unmanaged Networks IPv6 Transition Scenarios
- Survey of IPv4 Addresses in Currently Deployed IETF Application Area Standards
- Survey of IPv4 Addresses in Currently Deployed IETF Operations & Management Area Standards
- Internet Area: Survey of IPv4 Addresses Currently Deployed
- Introduction to the Survey of IPv4 Addresses in Currently Deployed IETF Standards
- Survey of IPv4 Addresses in Currently Deployed IETF Routing Area Standards
- Survey of IPv4 Addresses in Currently Deployed IETF Security Area Standards
- Survey of IPv4 Addresses in Currently Deployed IETF Sub-IP Area Standards
- Survey of IPv4 Addresses in Currently Deployed IETF Transport Area Standards
- Basic Transition Mechanisms for IPv6 Hosts and Routers
- Evaluation of Transition Mechanisms for Unmanaged Networks

IPv6 Strengths

- Larger Addresses
  - Allows billions of devices to be interconnected

*for example….. The Sony IP video camera**

Network Function

- Bluetooth Standard: Ver 1.1
- Email: SMTP, POP3
- Web Browser
- HTML: HTML3.2, Frame. JavaScript, SSL (V2/3)
- Image: GIF, JPEG, XBM, PNG

IPv6 Strengths

- Larger Address pool means no forced Network Address Translators in many future deployment scenarios
  - Eliminate NAT architectures as a means of address compression
  - Allow coherent end-to-end packet delivery
  - Improve the potential for use of end-to-end security tools for encryption and authentication
  - Allow for widespread deployment peer-to-peer applications
    - SIP, IMM, …

IPv6 Strengths

- No NATS (cont)
  - Regain fundamental leverage of IP as a network architecture
    - Simple interior service requirement
    - Service environment defined as end-to-end application
  - This is considered by many to be a VERY GOOD THING
    - Complex network architectures scale very poorly!

IPv6 – Transition and Coexistence

- V6 will not take over all data networking requirements in a working future timeframe
  - i.e. V4 is not disappearing anytime soon
- About the most likely scenario is a dual stack world for some years to come
- Dual stack transitional worlds present many complex issues in terms of referential integrity of identity, reachability, gateway functionality, security and application functionality
  - These are current activities

Public Network IPv6 Status

- Increasing level of experimentation and trials within the ISP provider sector
  - some commercial services are appearing, but in restricted niche areas
- BUT still no overwhelming commercial impetus to immediately deploy V6 services in many markets

  Widespread “wait and see” attitude

Marketing IPv6

- There is a body of opinion that states that without some degree of “push” the path of least resistance will be IPv4 + NATs
  - So there is a certain amount of “push” about the merits of IPv6.
  - Unfortunately many of these claims of superior functionality enter into the space of technical mythology….

IPv6 Myths

- **IPv6 is “more secure” than V4**
  - **Not Really**

    IPv6 is no more or less secure than V4

    Both IPv6 and IPv4 offer stronger potential security than “IP with header mangler” architectures simply because the original IP source and destination address header fields can be included in the packet authentication space

IPv6 Myths

- **Only IPv6 supports mobility**
  - **Not Really**

    Both V4 and V6 support mobility equally well (or equally poorly!)

    The problem is the overloaded semantic of an IP address which duals as identity and network location

    This is the subject of ongoing efforts – but no clear understanding of the role of identification at the various levels of the protocol stack is apparent to date

IPv6 Myths

- **IPv6 offers “bundled” QoS**
  - **Nothing has changed**.

    The TOS field in V4 is the TOS field in V6

    The Flow-ID field has no practical application in large scale networks

    QoS deployment issues are neither helped nor hindered by V4 or V6

    Packet-based and stream-based QoS signalling is one type of approach to resource management of a shared network. It is not obvious that this particular form of signaling is the right approach to resource management in large scale public IP networks, let alone whether V6 is the only way to achieve this.

IPv6 Myths

- **Only V6 offers plug and play autoconfiguration**
  - **Not Really**

    V4 networks these days are DHCP-equipped

    There is an increasing issue over the desire for “plug and play simplicity”, which invariably leads to solutions of stateless auto-configuration, and a desire to associate a constant “identity association” with a device. It was anticipated that the low order 64 bits of the V6 address space would be an identity field. There are, however, complications here….

IPv6 Myths

- **IPv6 allows rapid renumbering**
  - **Not really**

    Define “rapid”:

    10^{-3} seconds? No!

    10^{6} seconds ? Possibly

    This is no different from V4 + DHCP

“Pretending that renumbering is never a significant cost in large scale networks isn't going to get us anywhere other than NATsville”
David Conrad, posting to the routing_discussion@ietf mailer.

“One of the big selling points of v6 was that renumbering was gonna be easy, right? So we didn't have to do funky addressing... Are you telling me that one of the selling points of v6 is bunk?
Tony Li, posting to the routing_discussion@ietf mailer.

IPv6 Myths

- **IPv6 supports multi-homing and provider choice**
  - **Not really**

    See rapid renumbering

    Multi-homing is a tough technical topic

    V6 makes multi-homing no harder and no easier

    The core problem is attempting to dis-associate end-point identifiers from locator-identifiers (splitting apart the overloaded semantics of an IP address defining ‘who’, ‘where’ and ‘how’)

IPv6 Myths

- **IPv6 solves Routing Scaling issues**
  - **If only it could!**

    Routing is a cross-product of topology, policy and dynamic behaviour

    V6 does not make routing easier or more scaleable – it's the same problem with a larger sandpit to play havoc in!

IPv6 Myths

- This is solid technology and the IETF has stopped tinkering with it
  - Define ‘tinkering’

    Site-Local Addresses are being removed from the standard specification

    The interpretation of the flow label is still under consideration

    Dynamic service discovery is unfinished

    No one wants to declare mobile IPv6 ‘done’

IPv6 Myths

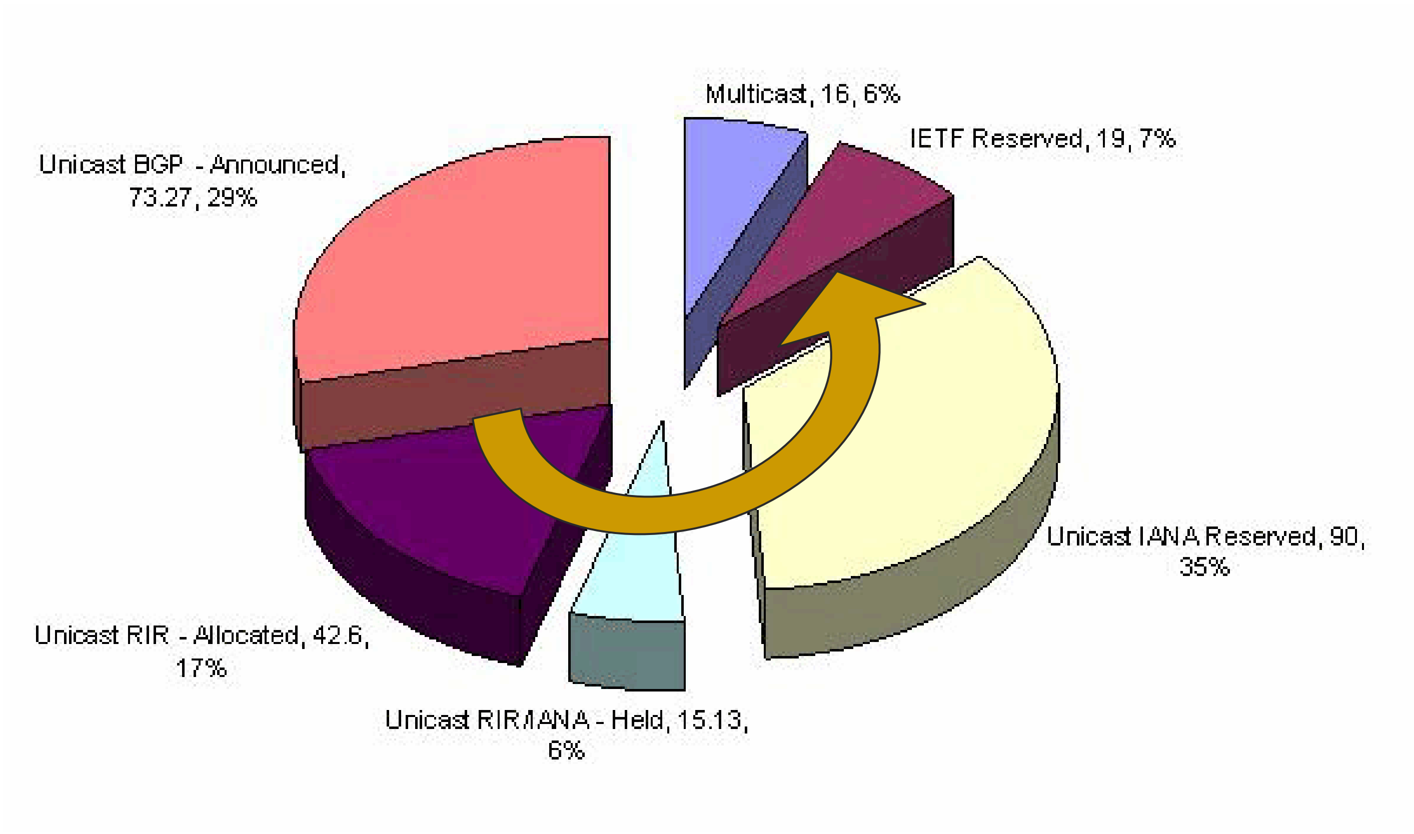
- **All IPv4 space has been exhausted**
  - **NO**

    29% of the total IPv4 space is routed

    46% of the available IPv4 space has been allocated to LIRs and End Users

    Widespread use of NATs in corporate deployments and some types of public deployments has reduced pressure on address consumption. Its likely that exhaustion is more than a decade away!

IPv4 Address Space



IPv6 vs IPv4

- There is no compelling “feature” or aspect of V6 that does not have a functional counterpart in V4.
- Any industry adoption of V6 cannot be based on superior functionality of V6 over V4 as a protocol platform

The IPv6 community got into the corner it's in now because it took the path of least technical resistance: IPv6 looks a lot like IPv4 because we "know“ that IPv4 "works". Well, guess what, IPv4 *doesn't* work, and IPng needed to look really different, and those of us who tried to tell the rest of the IETF that didn't get very far - although I think we gave it a pretty good try.

So if the IPv6 community again takes the path of least technical resistance, having not learned the first time around that that's really not the answer, G-d help you all.

Noel Chiappa, *Posting to IETF multi6 WG, 26 Feb 2003*

IPv6 vs IPv4

- The fundamental difference is the larger address fields used in V6. There is really nothing else in IPv6 that represents a basic departure from the IPv4 architecture.

- **But this single difference might well be enough to propel V6 adoption in a ‘smart device’ world.**

But Don’t Forget Economics…

- In a world of hundreds of billions of communicating devices, one can expect that each device will cost cents
- One can also expect that the total amount of money spent on communications services will remain, in terms of total GDP, roughly constant.

- This implies that each device will be able to spend fractions of cents on its communications needs
  - Either every device will be limited to sending a few bits per month
  - Or the cost of communications will need to drop still further

- The implication is that the network will need to service a massively larger number of devices with a larger total traffic load within a relatively constant revenue base.

- This then implies that a such a world of ubiquitous V6 devices is economically viable only if we can leverage transmission and switching costs down by 3 or 4 orders of magnitude over current costs.
  - And this may take some time to achieve

Thank You

- Some V6 Resources:
  - http://www.ipv6forum.com
  - http://www.6bone.net
  - http://www.kame.net

  - And by the presenter:
    - To Nat or V6? That is the question…
      http://www.potaroo.net/ispcolumn/2001-01-ipv6.html
    - Waiting for IPv6
      http://www.potaroo.net/papers/isoc/2003-01/Waiting.html