IPv4 Address Lifetime Expectancy - 2003

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Research activity
supported by APNIC
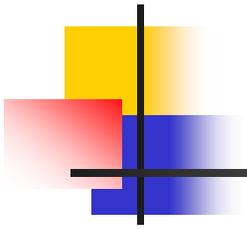
IPv4 Address Lifetime Expectancy

- This was an IETF activity starting as part of the Routing and Addressing (ROAD) activity in the early 1990's

- The objective was to understand the rate of allocation of IPv4 addresses and make some predictions as to the date of eventual exhaustion of the unallocated address pool

- This is a re-visiting of this activity with consideration of additional data derived from the characteristics of the BGP routing table
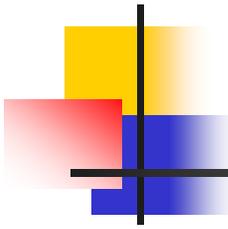
The IPv4 Address Space

- A 32 bit field spanning some 4.4B entries

- The IETF, through standards actions, has determined some space to be used for global unicast, some for multicast and some held in reserve

- IANA has allocated some unicast space to the RIRs for further allocation and assignment, assigned some space directly, and reserved some space for particular purposes

The IPv4 Top Level Structure

Reserved 7.5% 19 /8

Multicast 6.2% 16 /8

Unicast 86.3%
221 /8
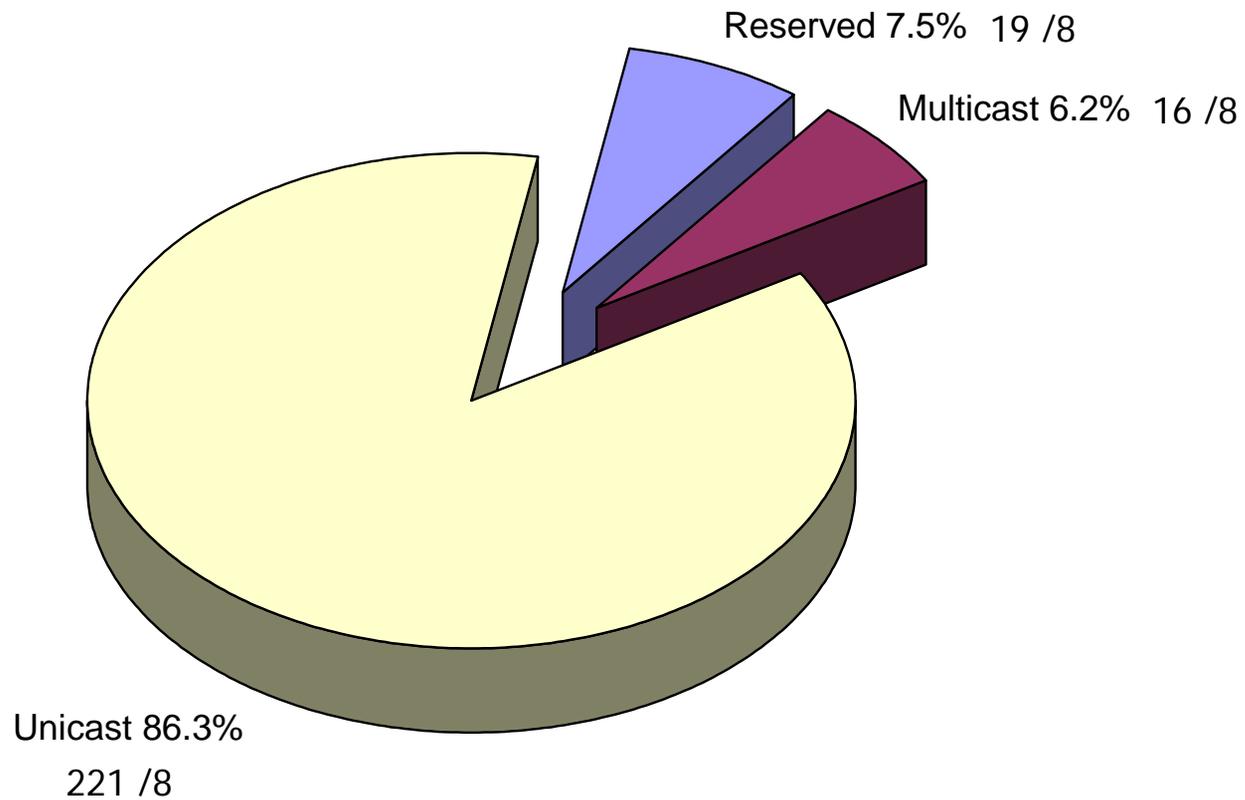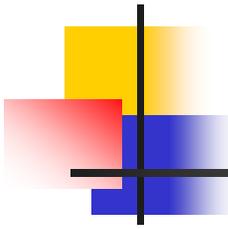
Modeling the Process

- A number of views can be used to make forward projections:
    - The rate at which IPv4 number blocks are passed from IANA to the RIRs
    - The rate at which RIRs undertake assignments of IPv4 address blocks to LIRs and end users
    - The growth of the number of announced addresses in the BGP routing table
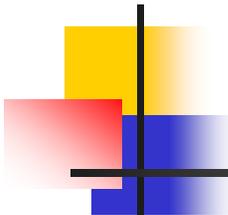
Data Sets

- IANA IPv4 Address Registry
  - Allocation of /8 blocks to RIRs and others
- RIR Stats files
  - Allocation of blocks to LIRs
- BGP Routing table
 - Amount of address space advertised as reachable
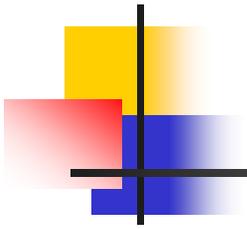
IANA Allocations

- The IPv4 address registry records the date of each /8 allocation undertaken by the IANA

- This data has some inconsistencies, but is stable enough to allow some form of projection
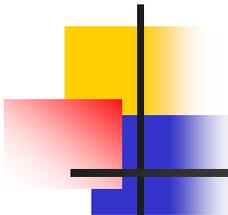
IANA Registry Comments

- The allocation dates for those address blocks prior to 1995 are inaccurate
  - The earliest date is 1991, and a large block has been recorded as allocated in 1993.
  - This is inconsistent with dates recorded in the RIR stats files, which record allocations back to 1983
  - It would appear that there was a revision of the IANA registry in the period 1991 – 1993, and the IANA recorded dates are the revision dates
  - Useable dates appear to start from allocations from 1995 onwards
 - plus http://www.potaroo.net/IPAddrs

IANA – Current Status

IETF Reserved 7.5%

Multicast 6.2%

Unicast - Allocated 51.1%

Unicast IANA Reserved 35.2%
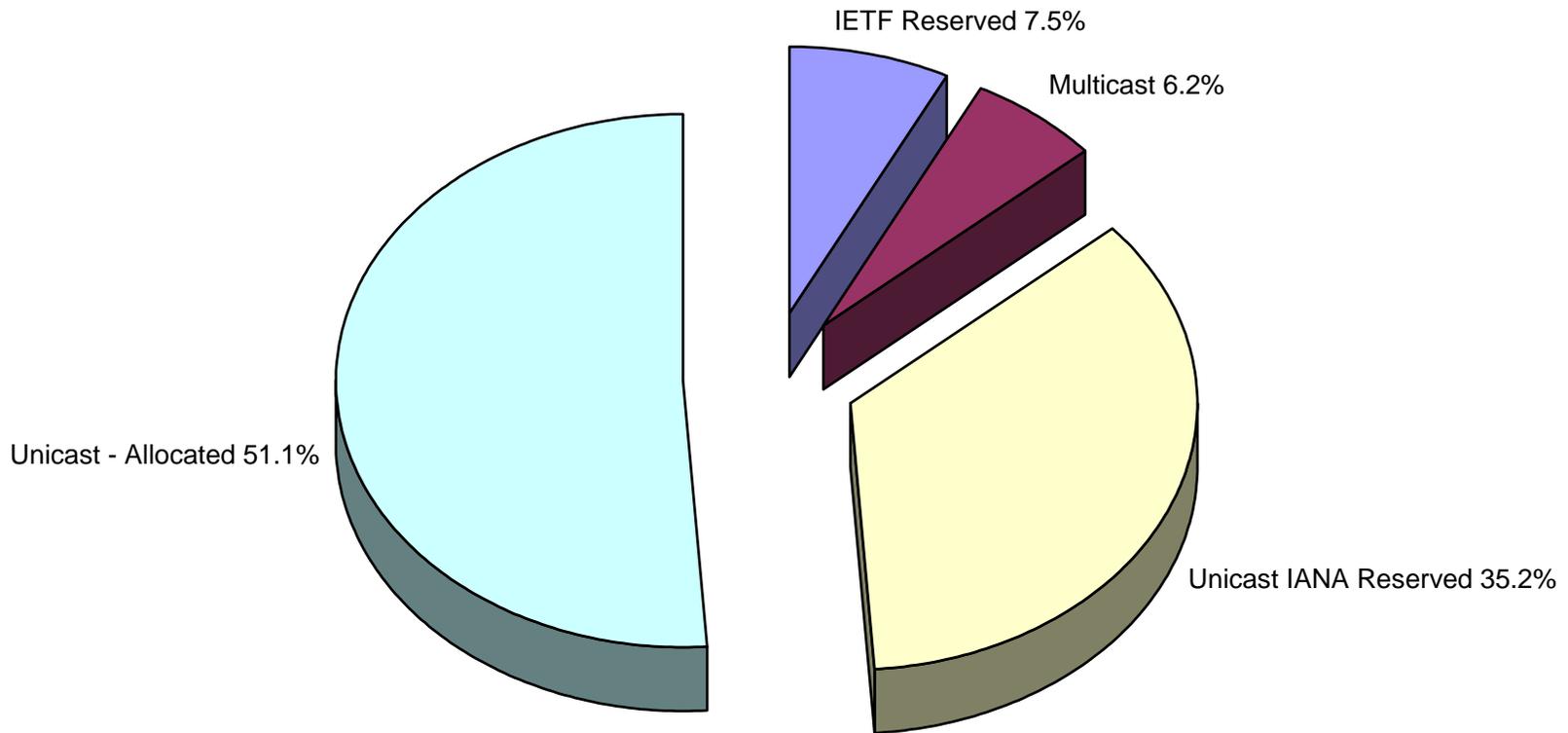
IANA Allocations

IANA Allocations (/8)
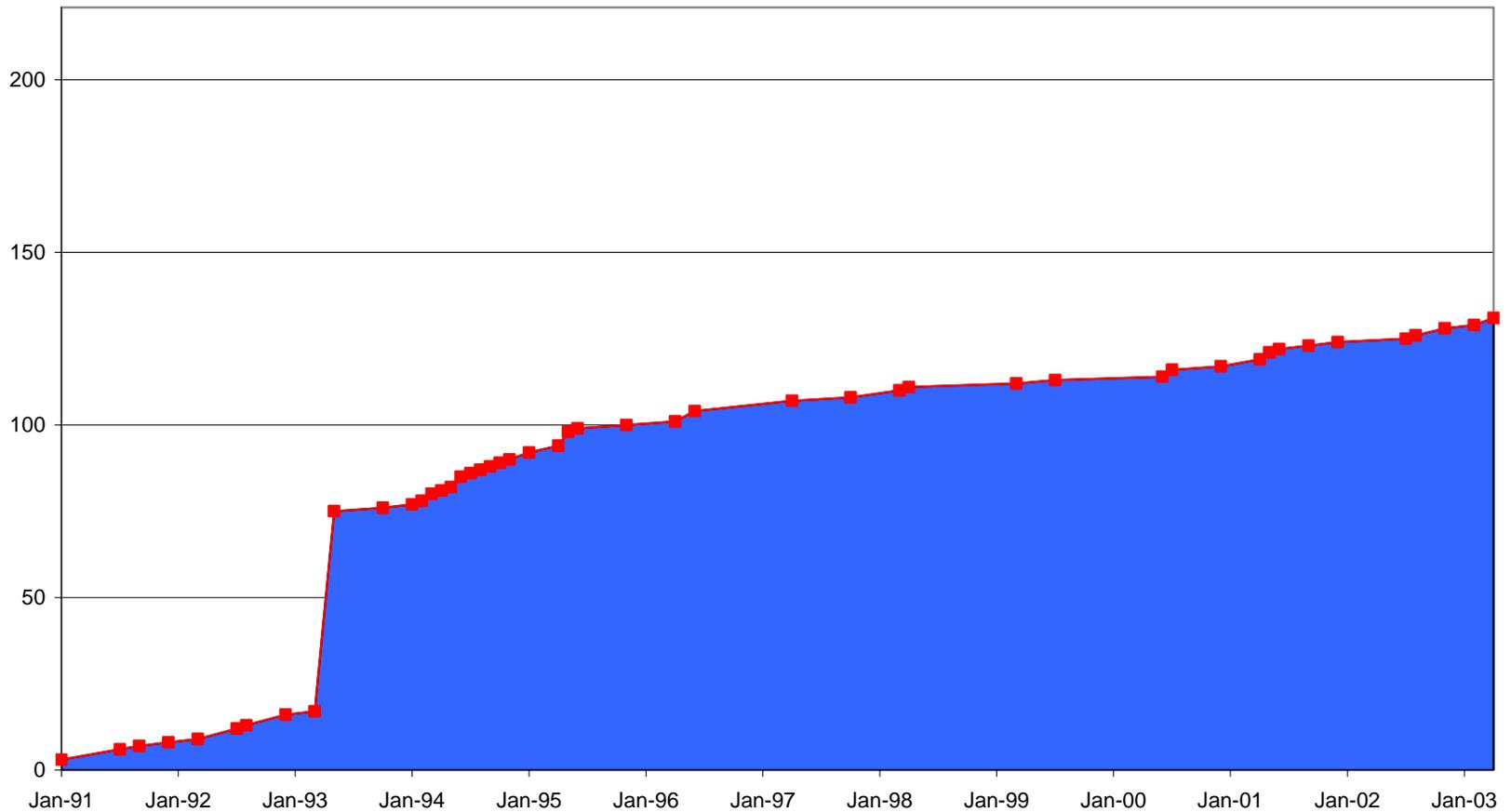
IANA Projections

**IANA Allocation Projection**
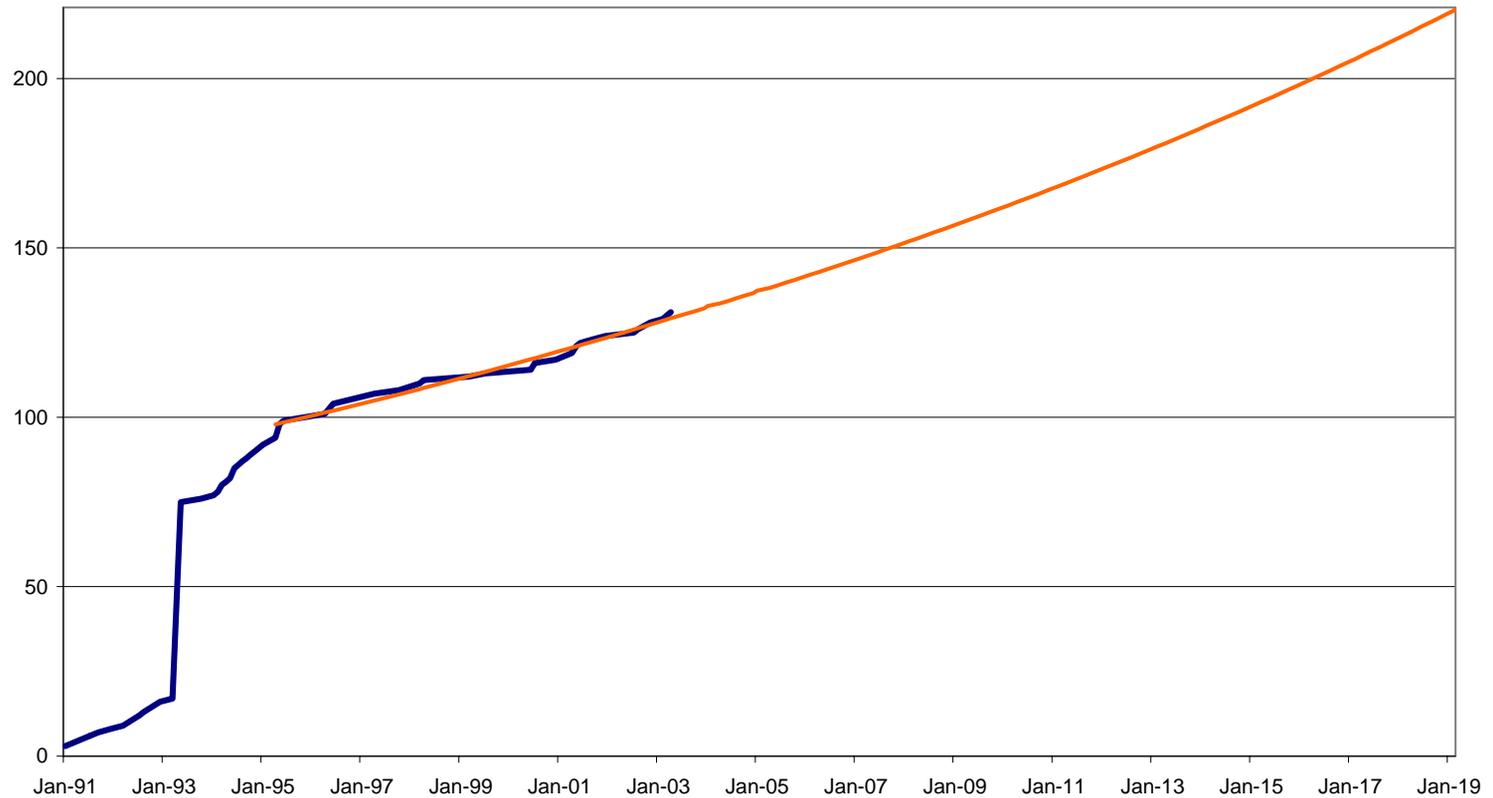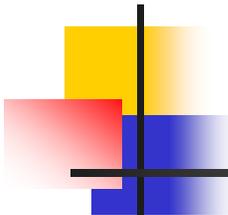
IANA Projections

- This projection of 2019 for IANA address pool exhaustion is very uncertain because of:
  - Sensitivity of allocation rate to prevailing RIR assignment policies
  - Takeup of applications that require end-to-end IP addressing vs use of NATs
  - Potential use of a further 16 /8s currently reserved by the IETF
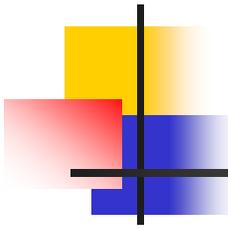
RIR Allocations

- The RIR stats files records the date of each allocation to an LIR, together with the allocation details

RIR Allocations – Current Status

Multicast, 16, 6%

IETF Reserved, 19, 7%

Unicast RIR - Allocated, 115.87, 46%

Unicast IANA Reserved, 90, 35%

Unicast RIR/IANA - Held, 15.13, 6%
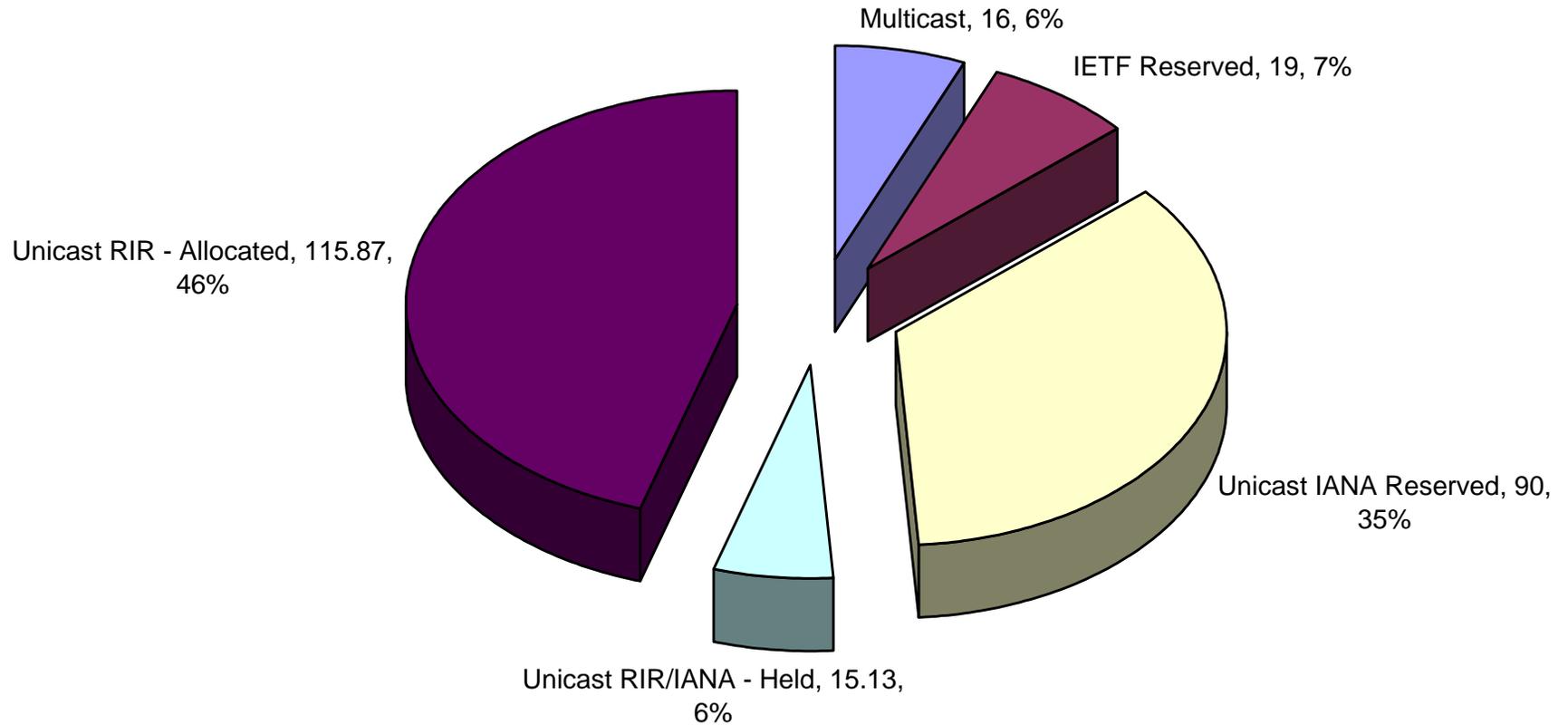
RIR Allocations /8

Address Allocation Status - by /8
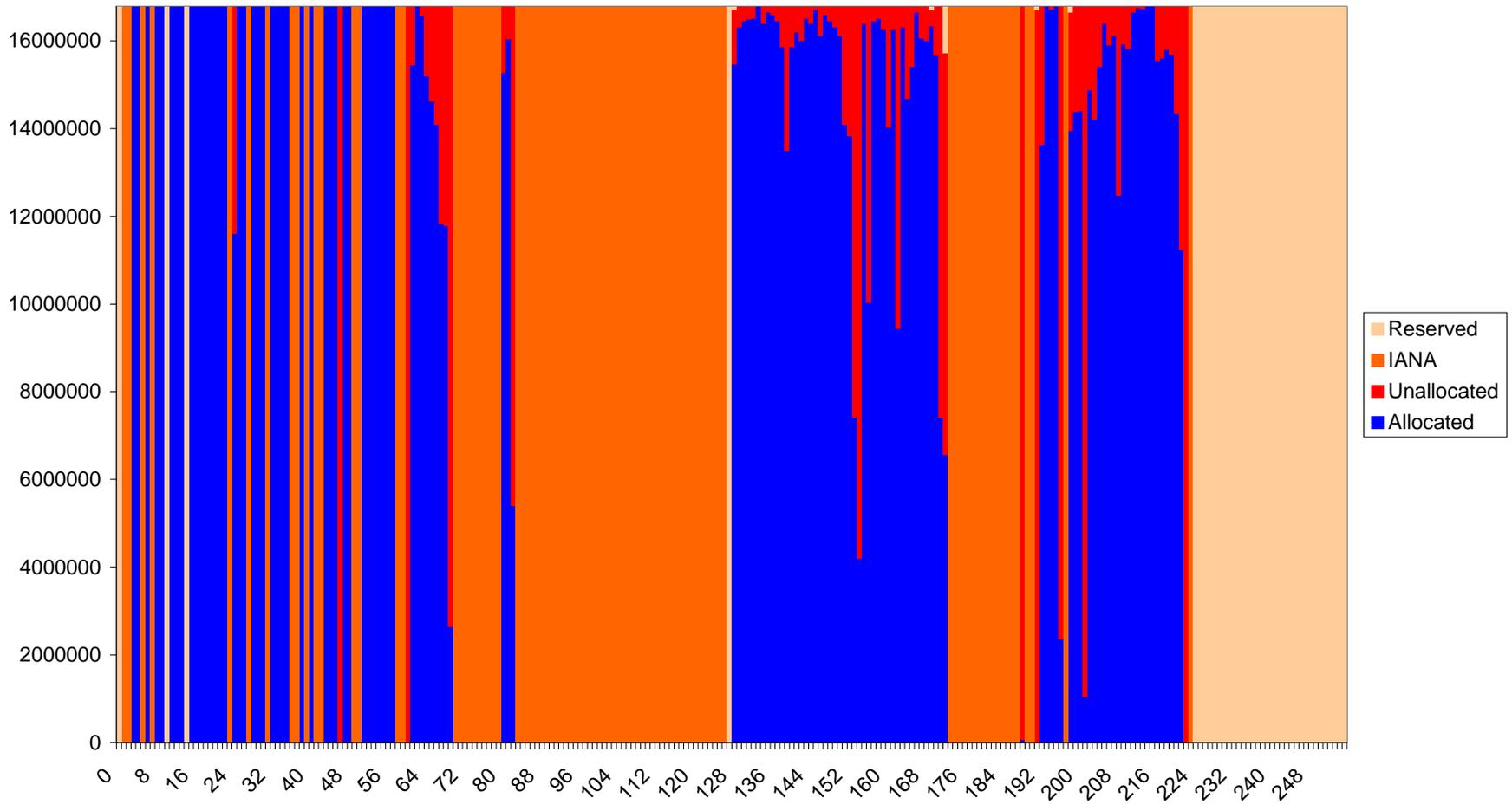
RIR Allocations

RIR Allocations
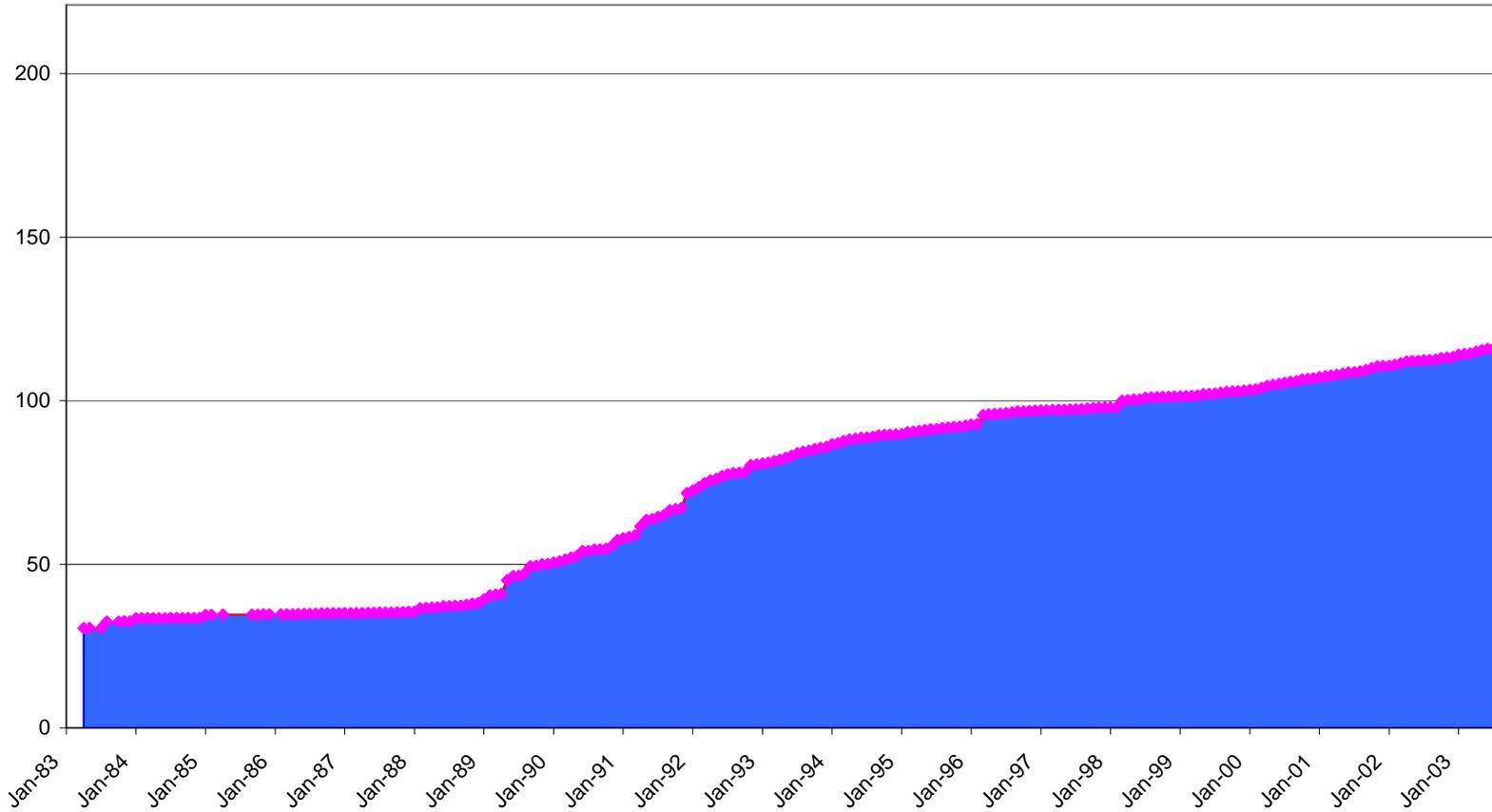
RIR Projections

RIR Allocations - Projection
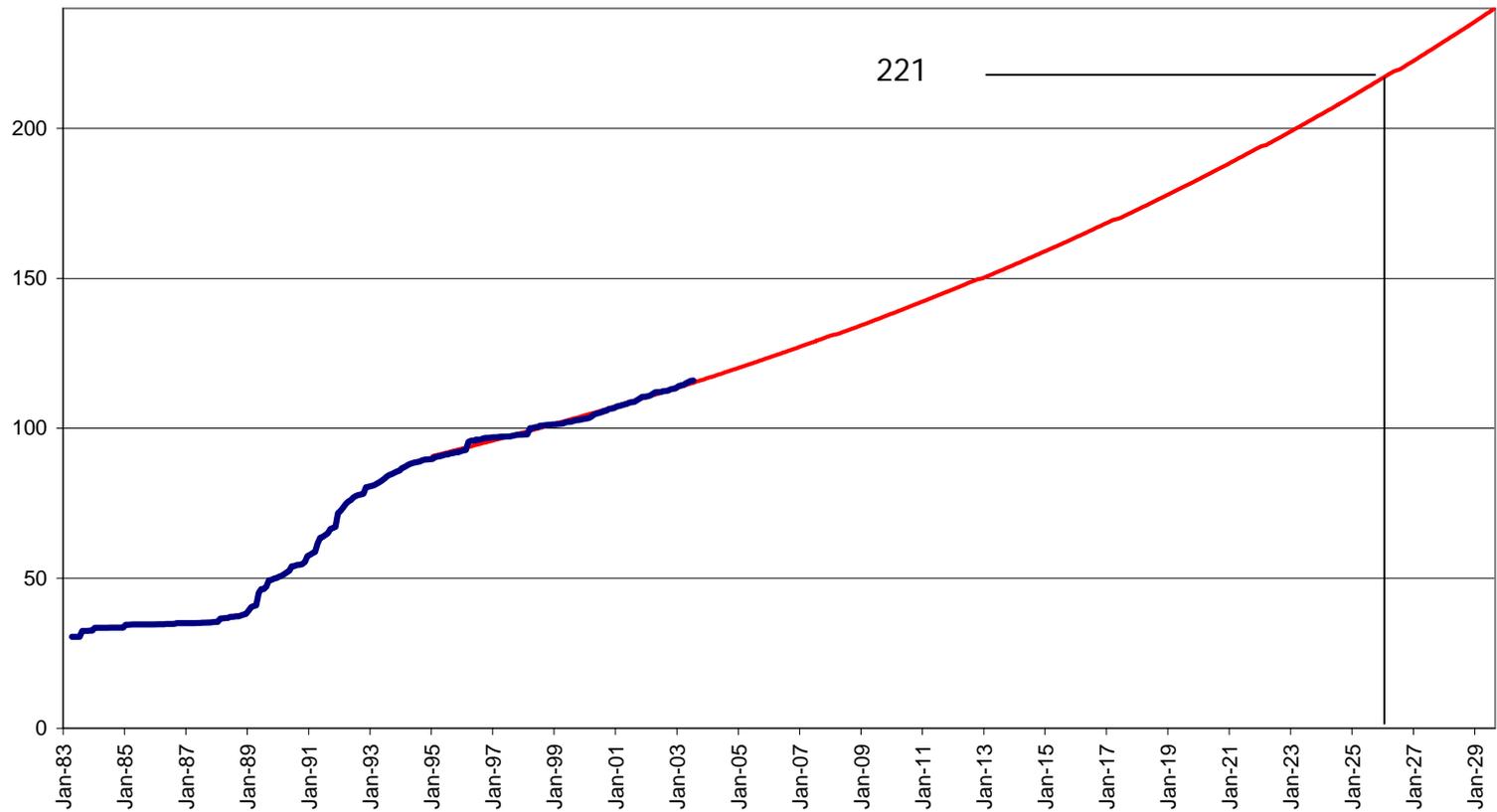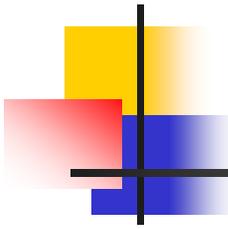
RIR Projections

- This projections of 2026 for 221 /8s and 2029 for 237/8s has the same levels of uncertainty as noted for the IANA projections
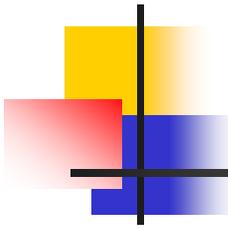
# BGP Routing Table

- The BGP routing table spans a set of advertised addresses

- A similar analysis of usage and projection can be undertaken on this date

The Route Views view
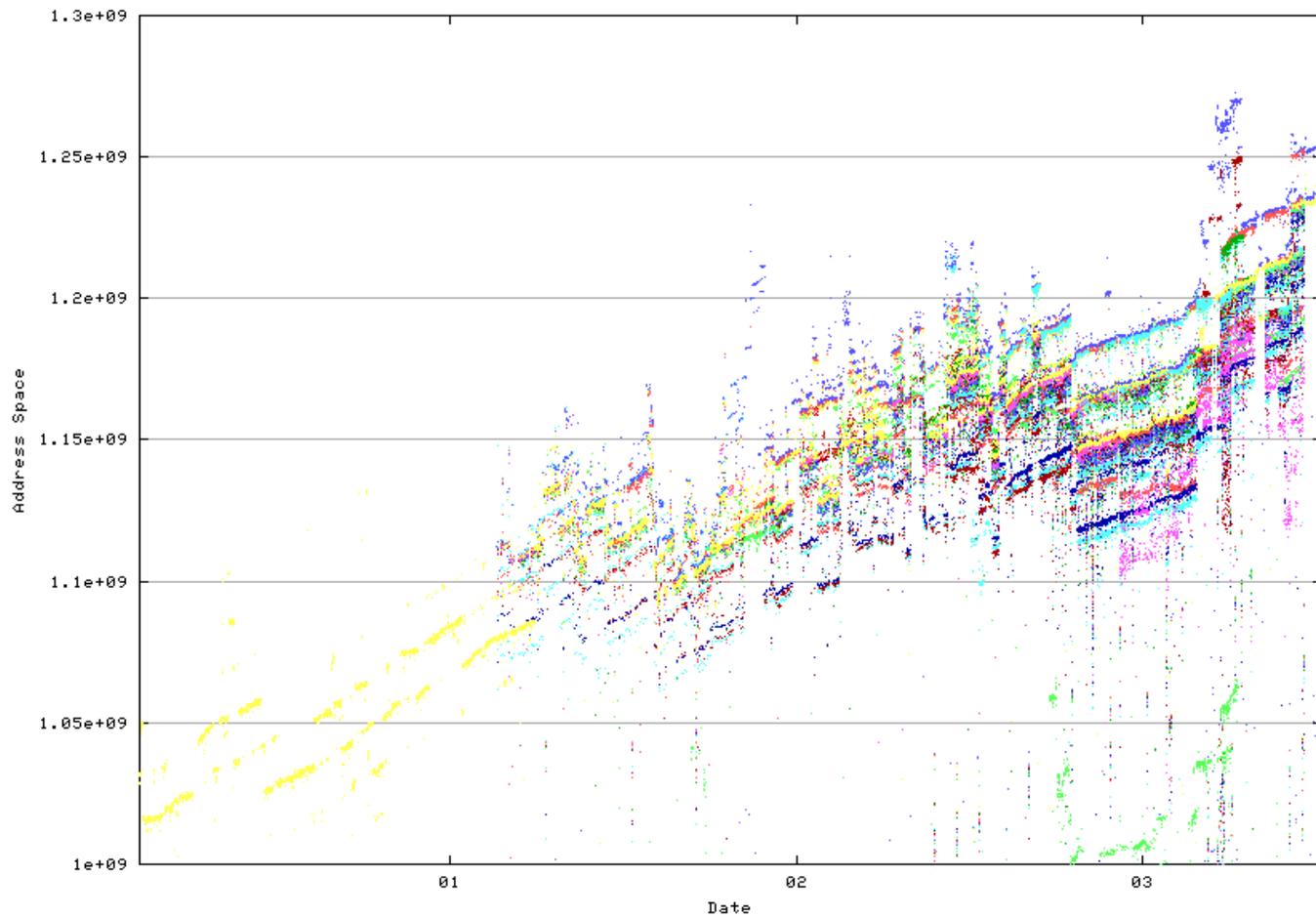
The AS1221 view

BGP Routing Table - Status

Multicast, 16, 6%

IETF Reserved, 19, 7%

Unicast BGP - Announced, 73.27, 29%

Unicast IANA Reserved, 90, 35%

Unicast RIR - Allocated, 42.6, 17%

Unicast RIR/IANA - Held, 15.13, 6%
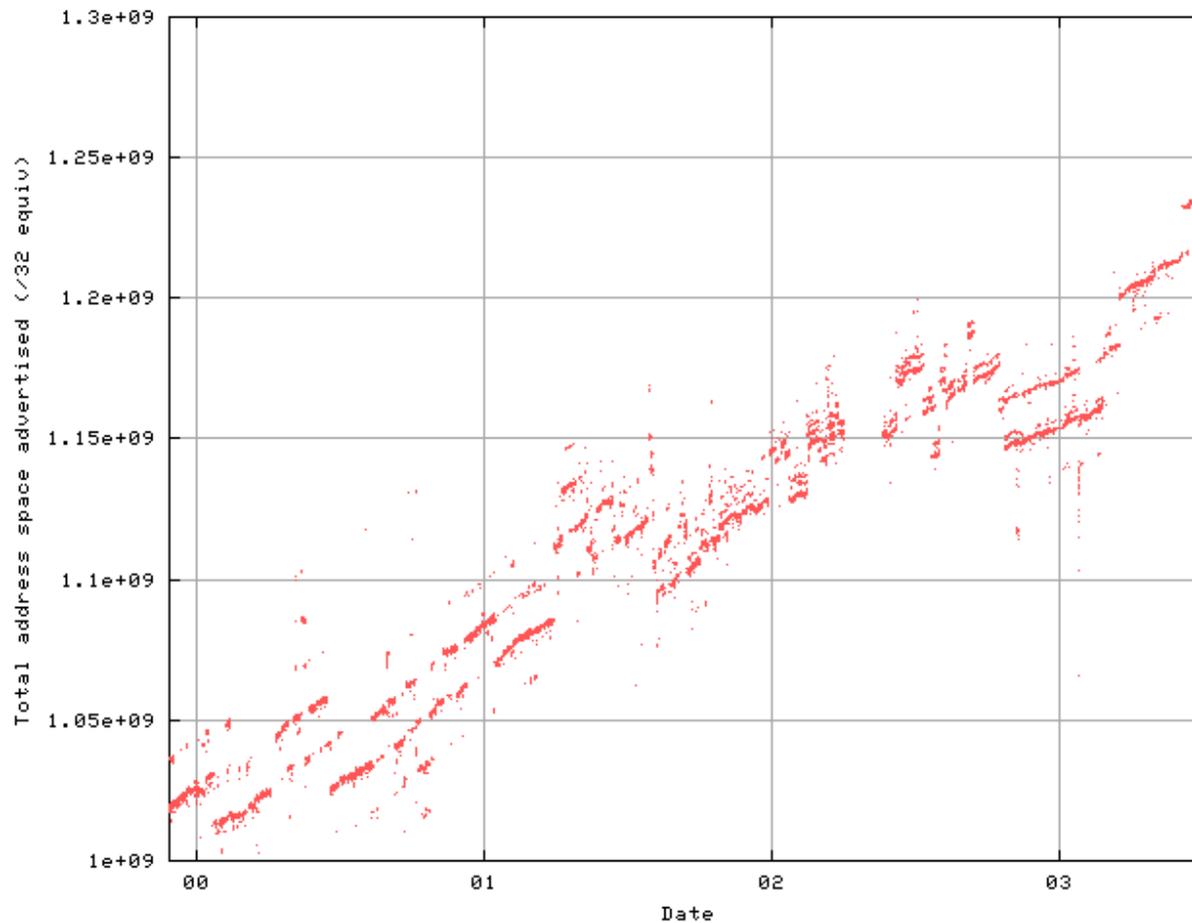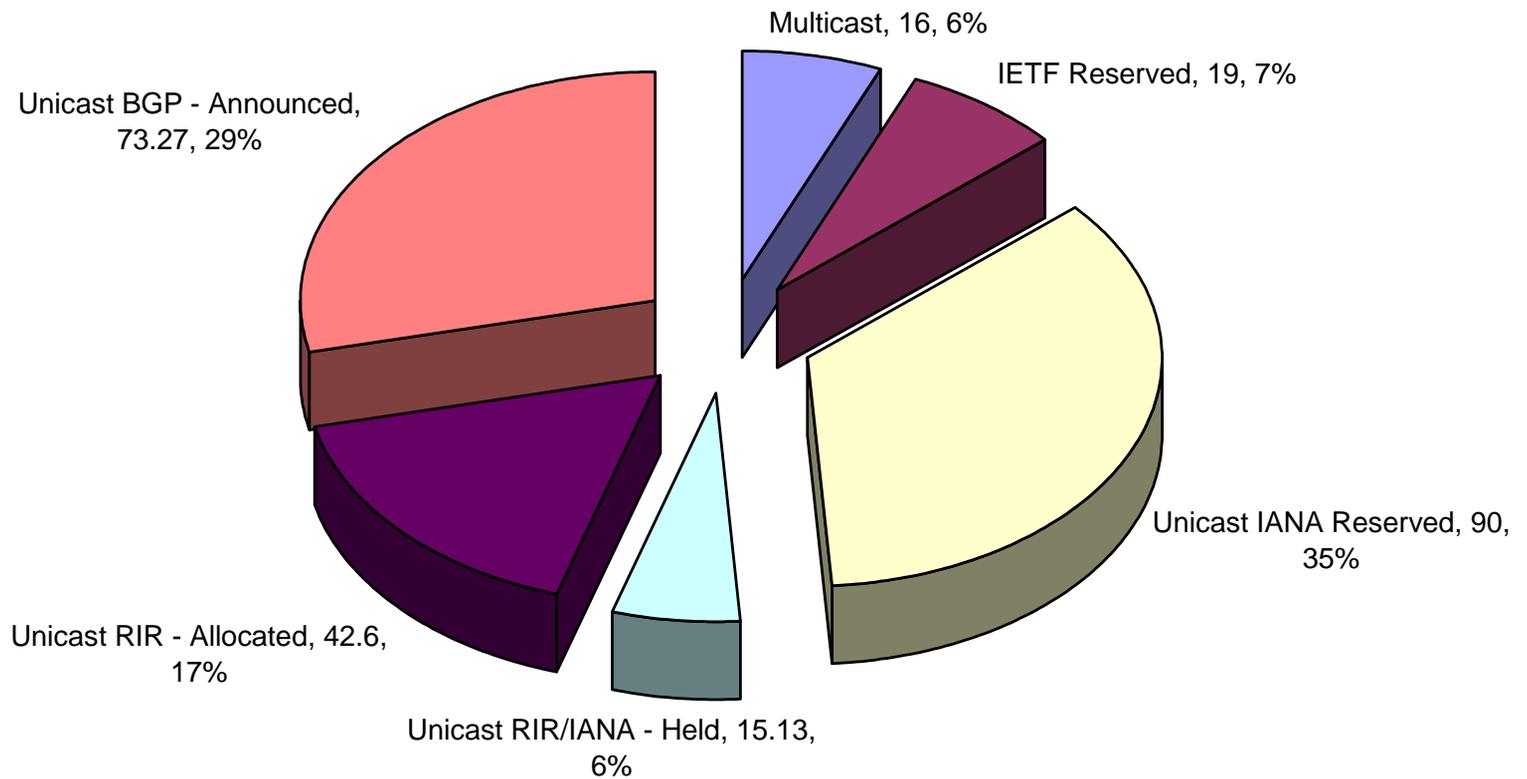
BGP Address Allocations /8

Address Allocation Status - by /8

Legend:
- Reserved
- IANA
- Unallocated
- Unadvertised
- Advertised
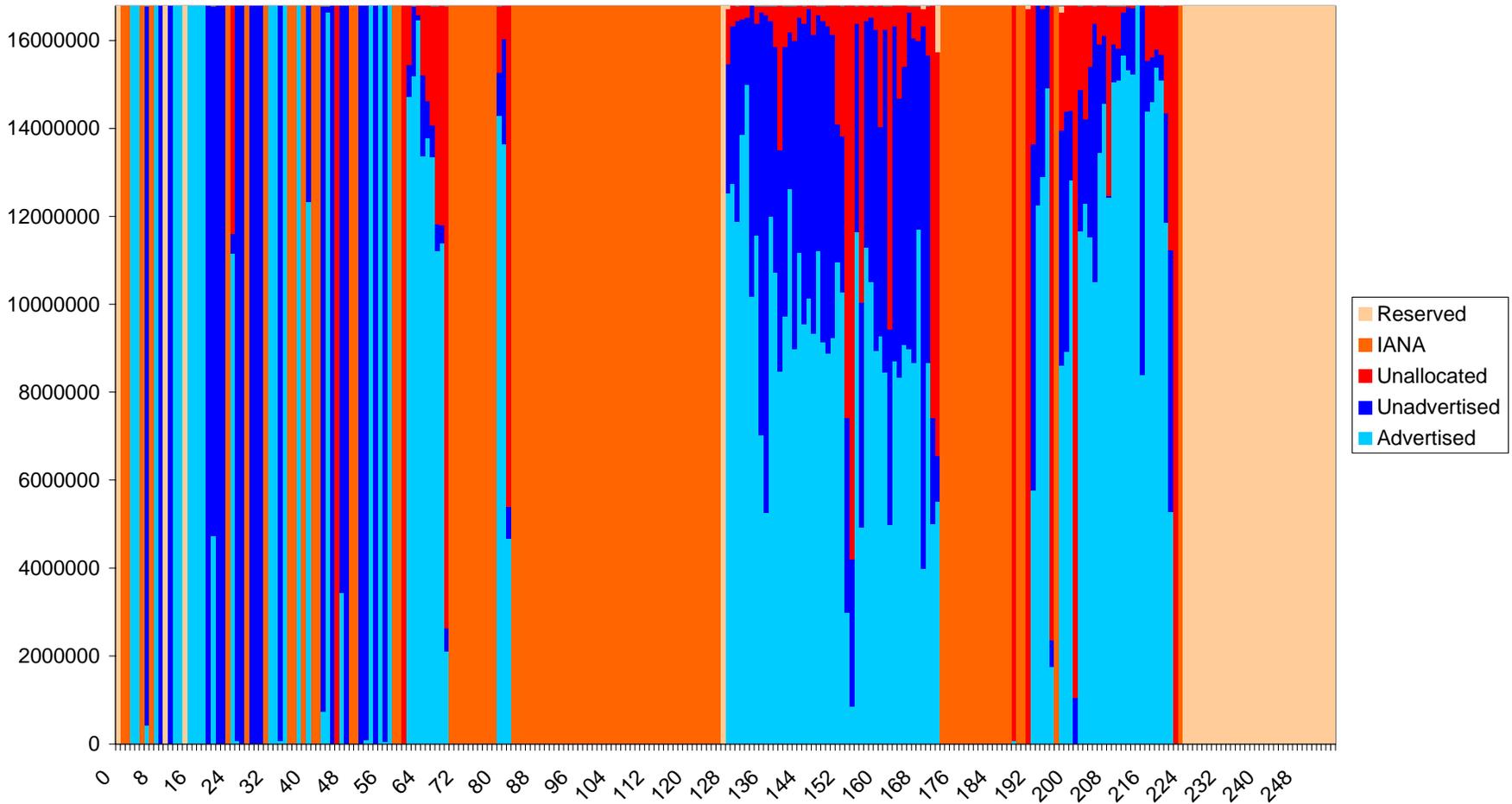
# BGP Address Span

BGP Table - Address Span
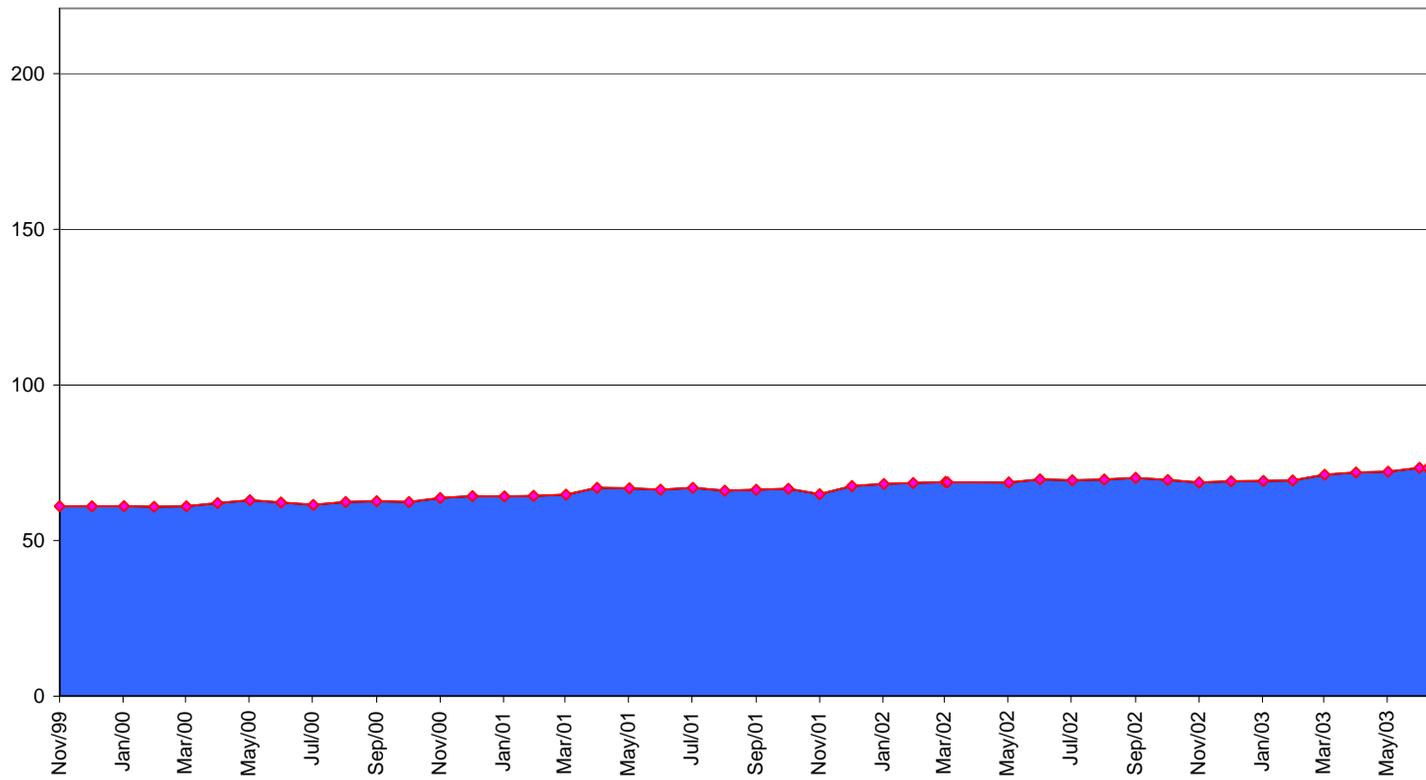
# BGP Projections

BGP Announced Address Space - Projection
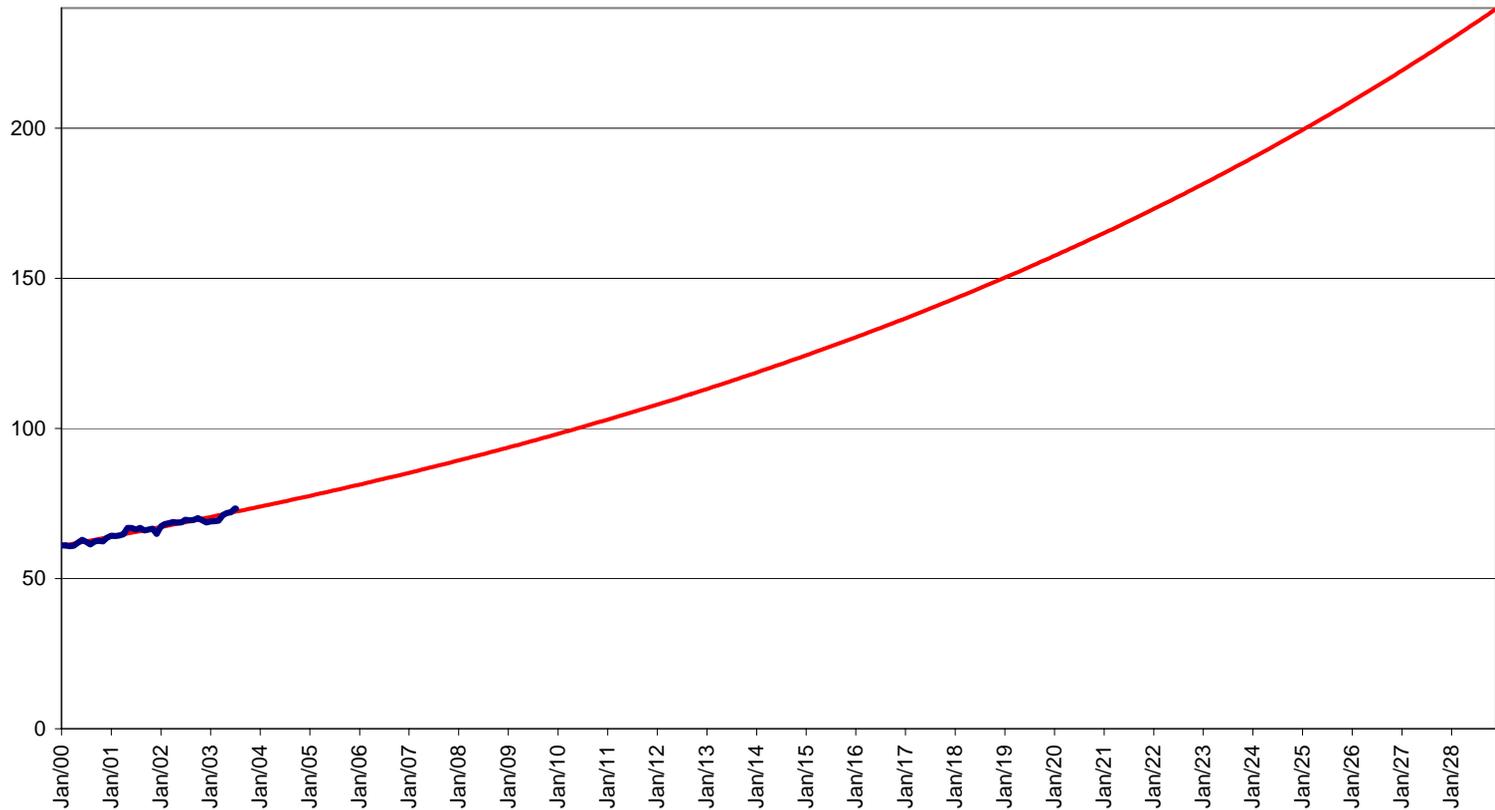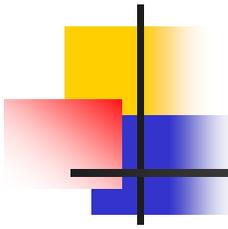
BGP Projections

- This projection of 2027 (221 /8s) and 2028 (240 /8s) uses a 3 year baseline

  - This is much shorter than the IANA and RIR projections

  - There are, again, considerable uncertainties associated with this projection

Combining the Data

IPv4 Address Space
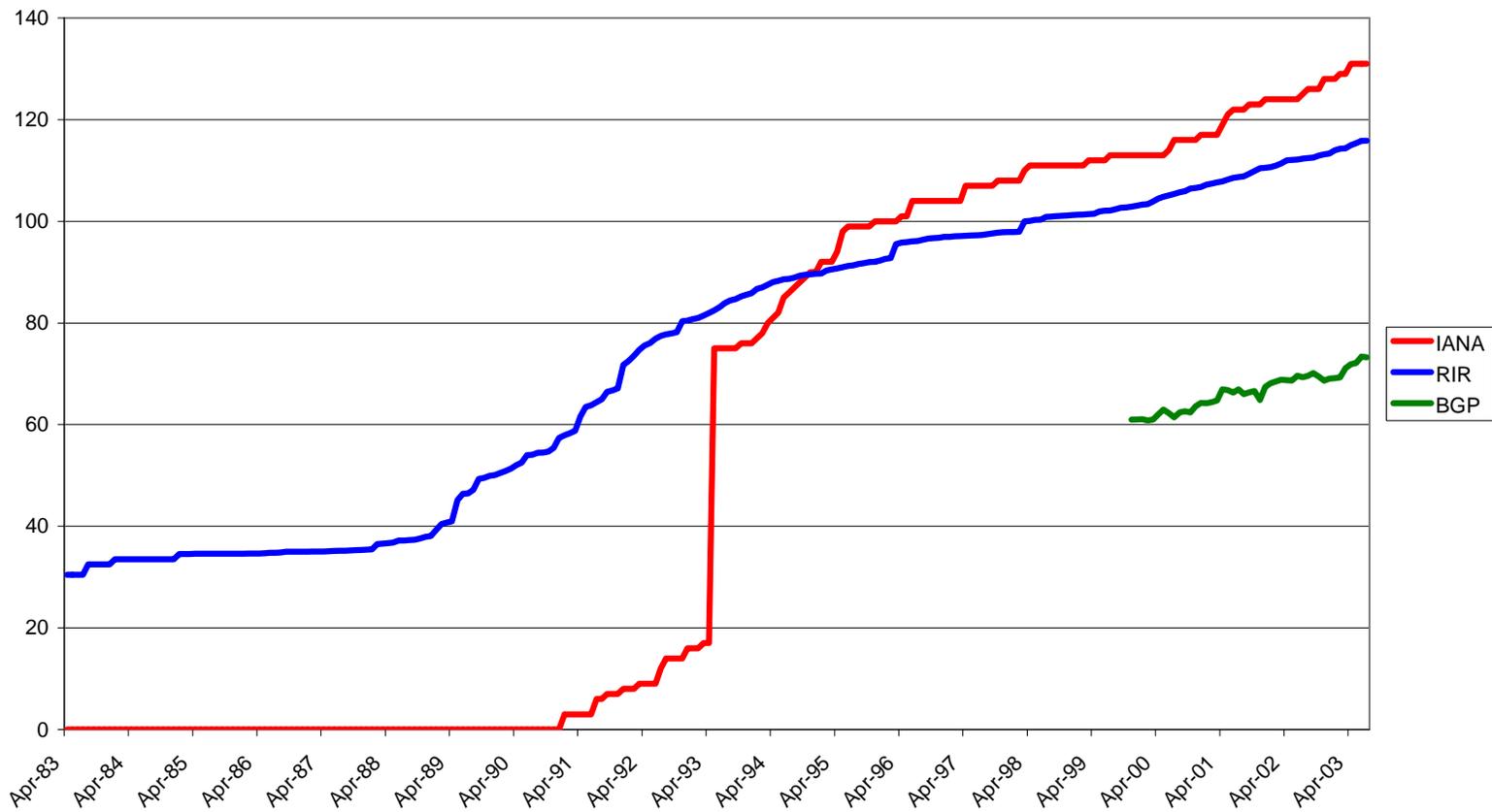
Recent Data

IPv4 Address Space
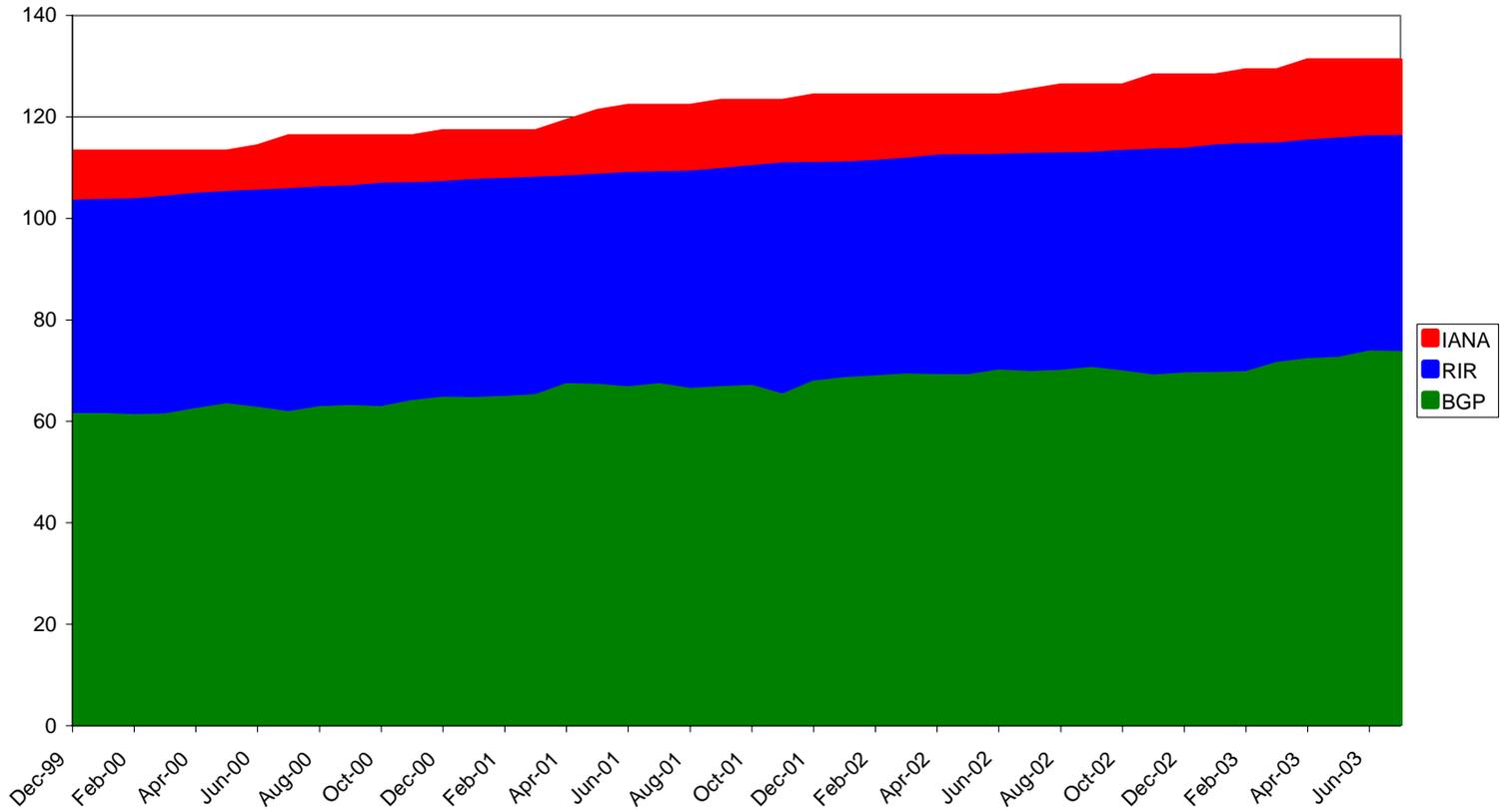
Holding Pools

Size of Holding Areas
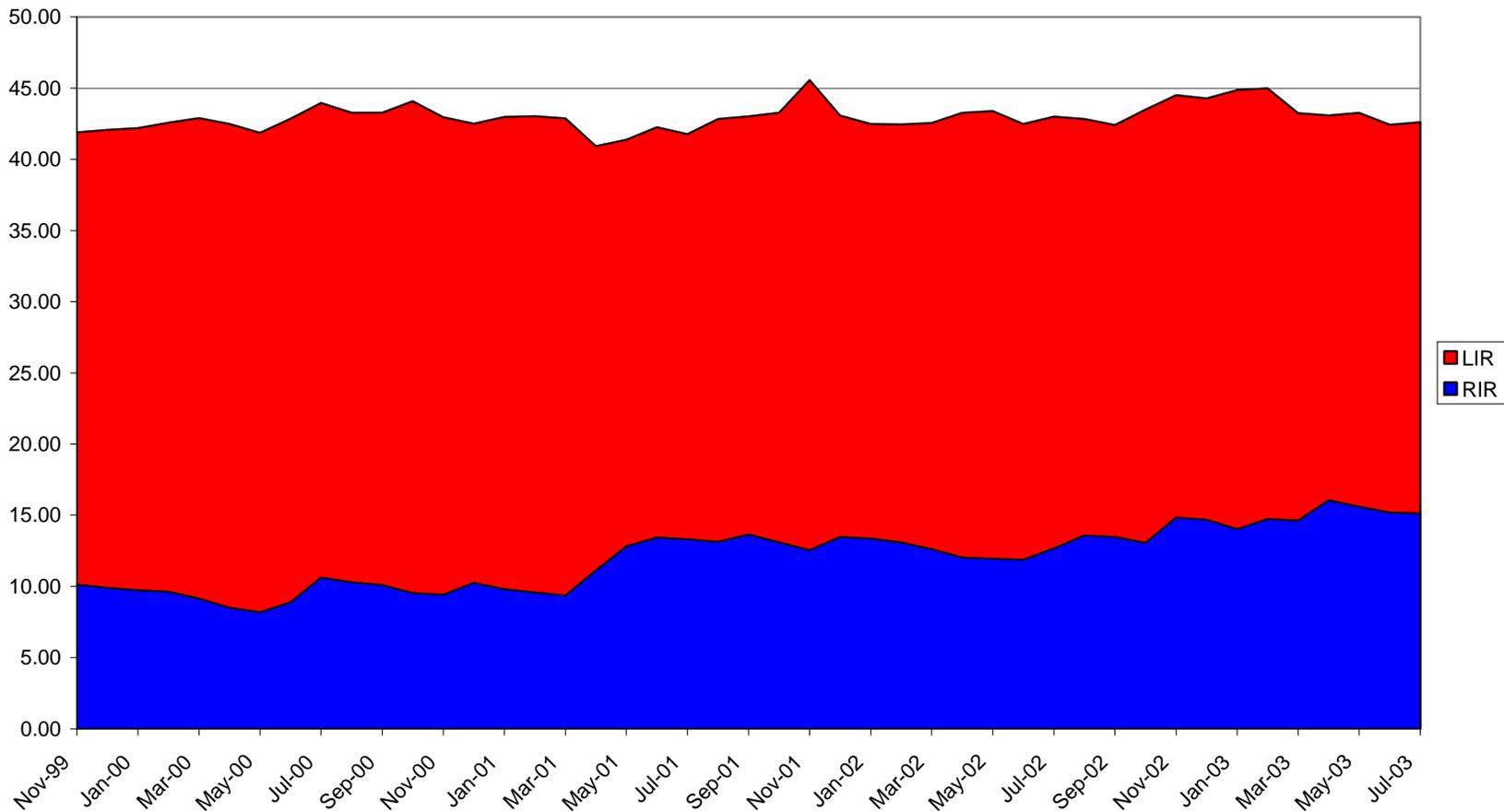
Age of Unannounced Blocks

Age Distribution of Unadvertised Address Space (/8)
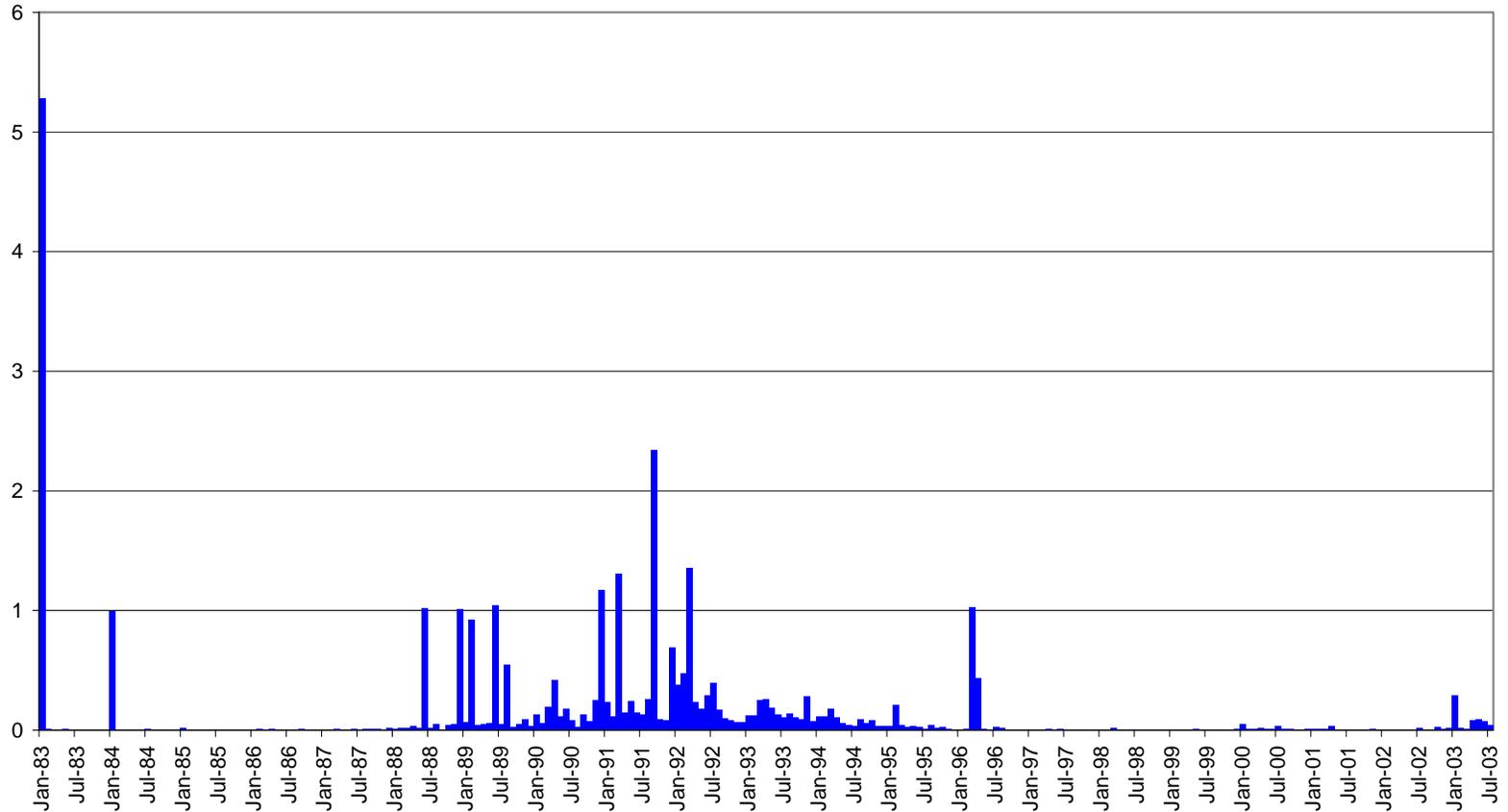
Age of Unannounced Blocks (cumulative)

UnAdvertised IPv4 space (/8) cumulative
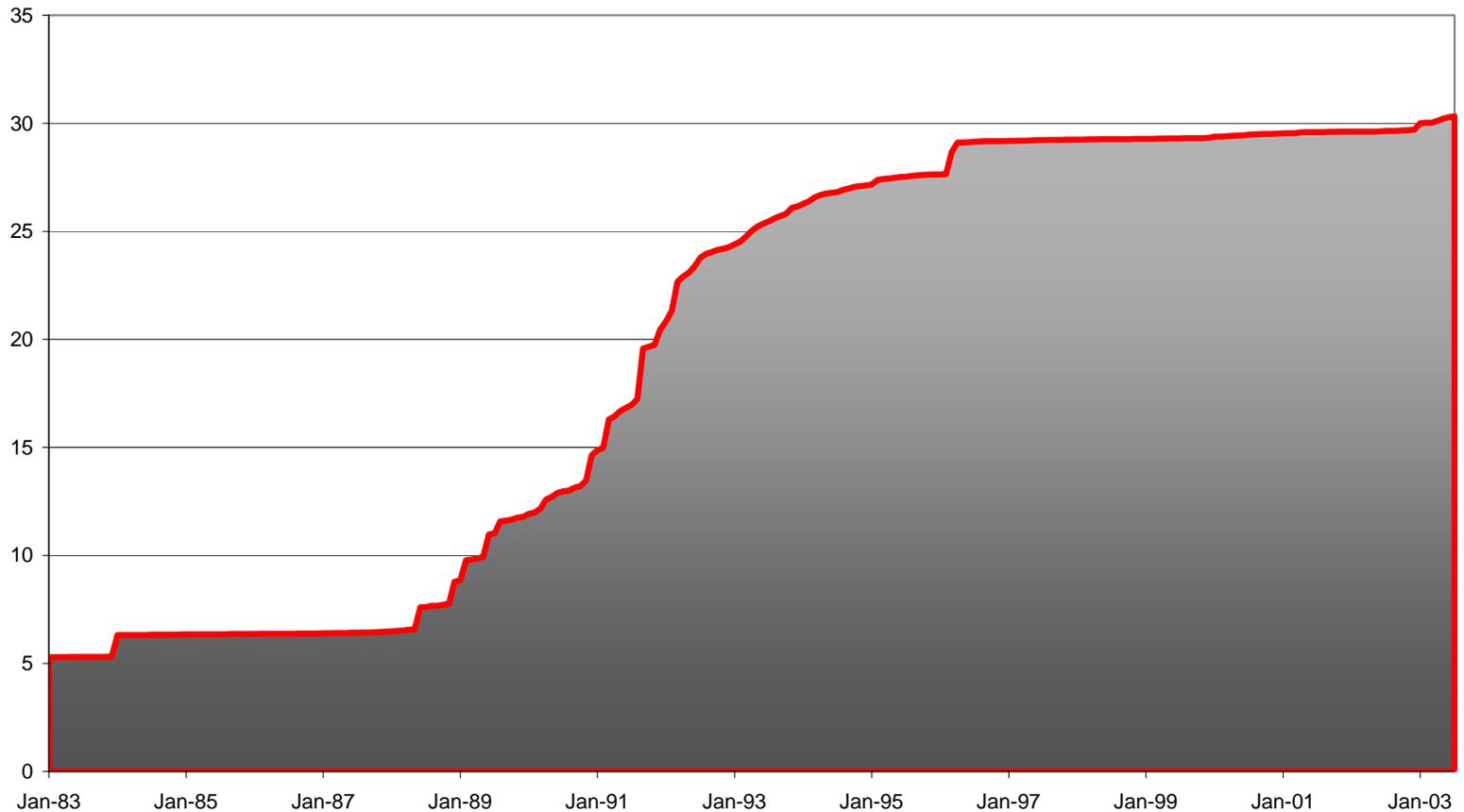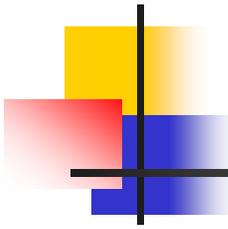
Modelling the Process

- Assume that the RIR efficiency in allocation slowly declines, then the amount of RIR-held space increases over time

- Assume that the LIR efficiency declines at a slightly higher rate due to the factor of H-density considerations being applied to increasingly larger LIR address pools

- Assume an exponential best fit model to the announced address space projections and base RIR and IANA pools from the announced address space projections, using the above 2 assumptions

Modelling the Process

IPv4 Model

IANA Pool Exhaustion

RIR Pool Exhaustion

Legend:
- IANA
- RIR
- IANA-P
- RIR-P
- BGP-P
- Hold-RIR
- Hold-LIR
- BGP

Projections
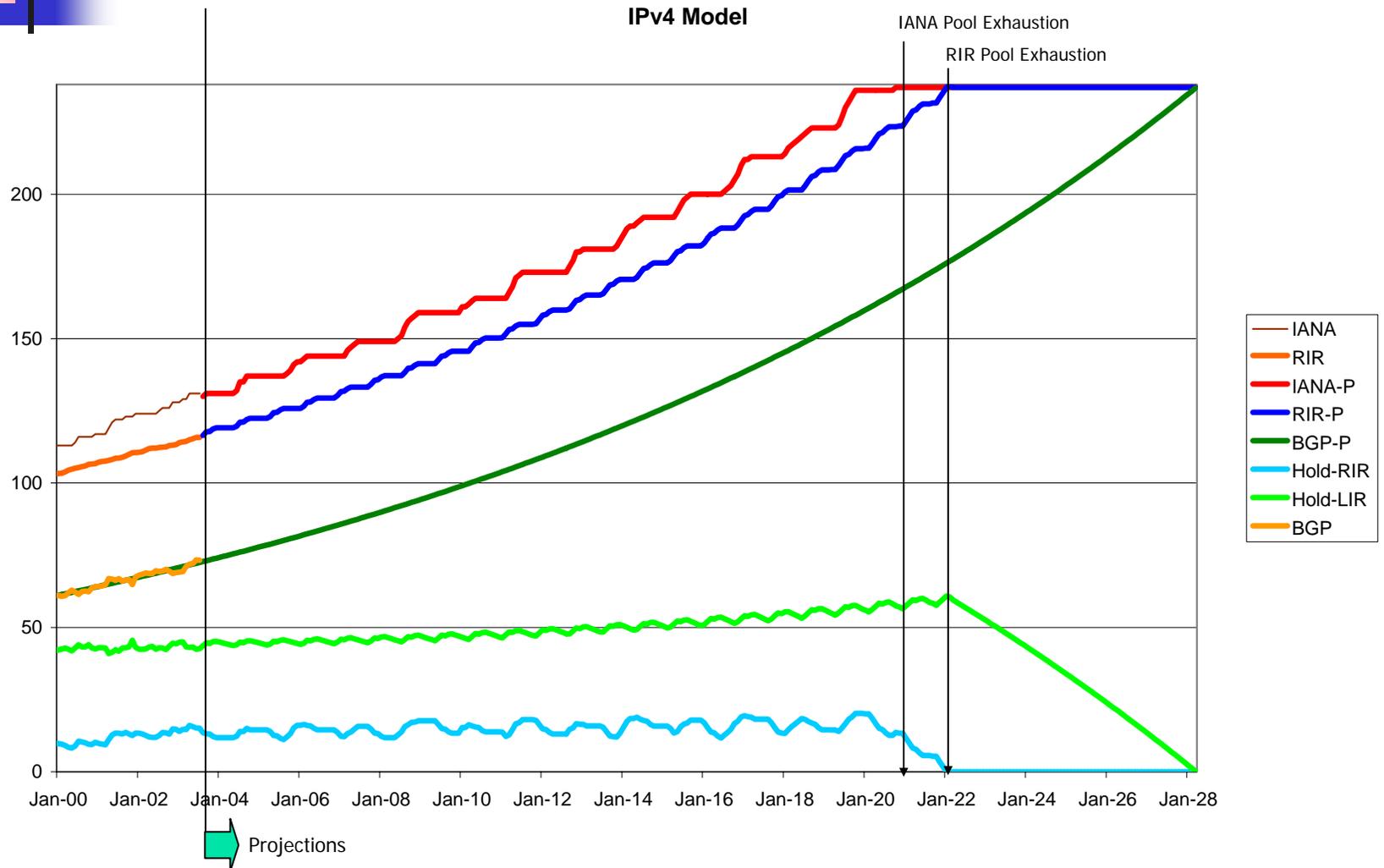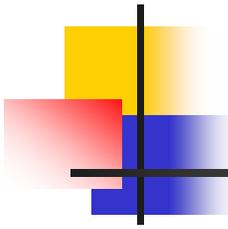
Questions:

- Is the model of the LIR and RIR holding pools accurate?
- What proportion of IANA-allocated blocks are routed?
- What is the distribution of held space across the V4 space?
- What forms of disruptive events would alter this model?
- What would be the extent of the disruption (order of size of the disruptive address demand)?
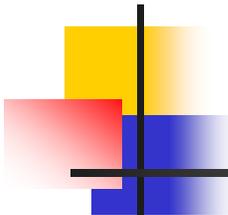
Observation

- Extrapolation of current allocation practices and current demand models using an exponential growth model derived from a best of 2000 – 2003 data would see RIR IPv4 space allocations being made for the next 2 decades (until 2022)
  - There are many factors that could alter this demand model!