IPv4 Distribution Options for the Last Eights
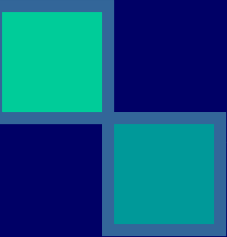
Choice of Risks and Assumptions

Previous Observations about Adoption

- What is a reasonable, available measure?
- Can the diffusion uncertainty be bound and quantified?
- Is there a feasible path which results is short IPv4/IPv6 co-existence?
- What are the implications in terms of possible actions?

Previous Findings

- What is a reasonable, available measure?
  - Routes and ASNs yield similar near-term results
  - The diffusion uncertainty was bound and quantified given this data.
- There is no feasible path which results is less than years of IPv4/IPv6 co-existence. Decades is not unreasonable.
- Observations from economics of security applied to IPv6; implications are that normal market measures may not result in diffusion.
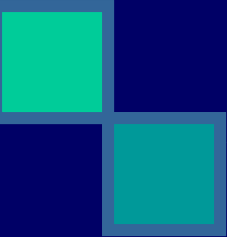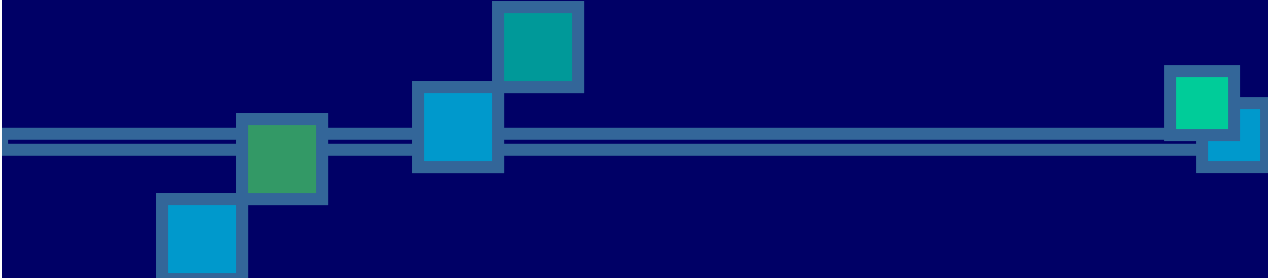
Options

- Do Nothing
- Government leads
    - This has been tried …
- RIR Lead: Market
- RIR Lead: Other

RIR Lead: Other

- Only allocate to organizations with a small address space previous allocated
- Only allocate a given amount of the v4 space per year
- Provide only a minimal routable allocations per organization per year

Policy Requirements (Potaroo)

- Address policies are intended to be applied uniformly

- Addresses are made available from the unallocated pool to meet demands for their use in networks

- The prevailing address policy regime characterizes addresses as a network attribute
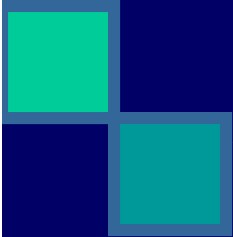
Not Policy Requirements

- Market requirements: Strong convexity requirement
  - 16 * Price (/24) < Price(/20) in all cases
  - This fails if IPv4 becomes a gateway technology or critical facility
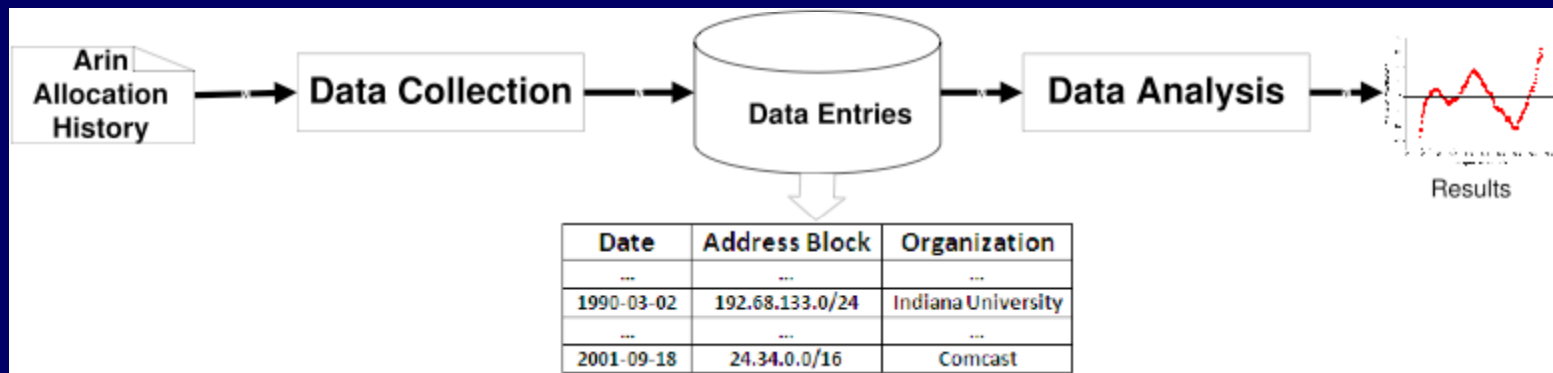- Avoidance of destructive market behaviors
  - speculation

Data and Assumptions

- Consistency over time
- IANA splits remaining blocks equally
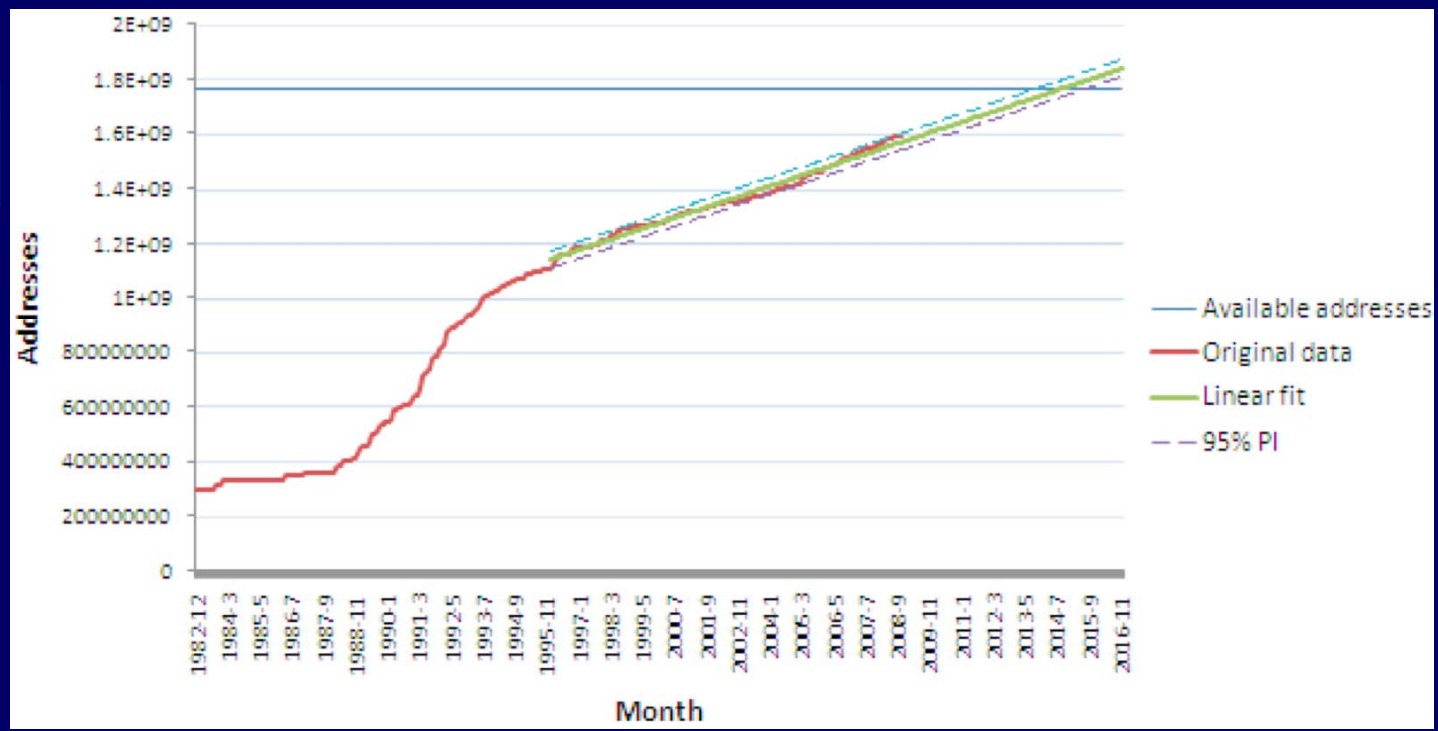- Whois is roughly correct

Data Foundation

- Regional Internet Registry (RIR) stats file
  - IPv4 address allocation history of ARIN.
- ARIN Whois and Cymru Whois
  - Associate AS to IPv4

Data Modeling Trends

Data Modeling Result

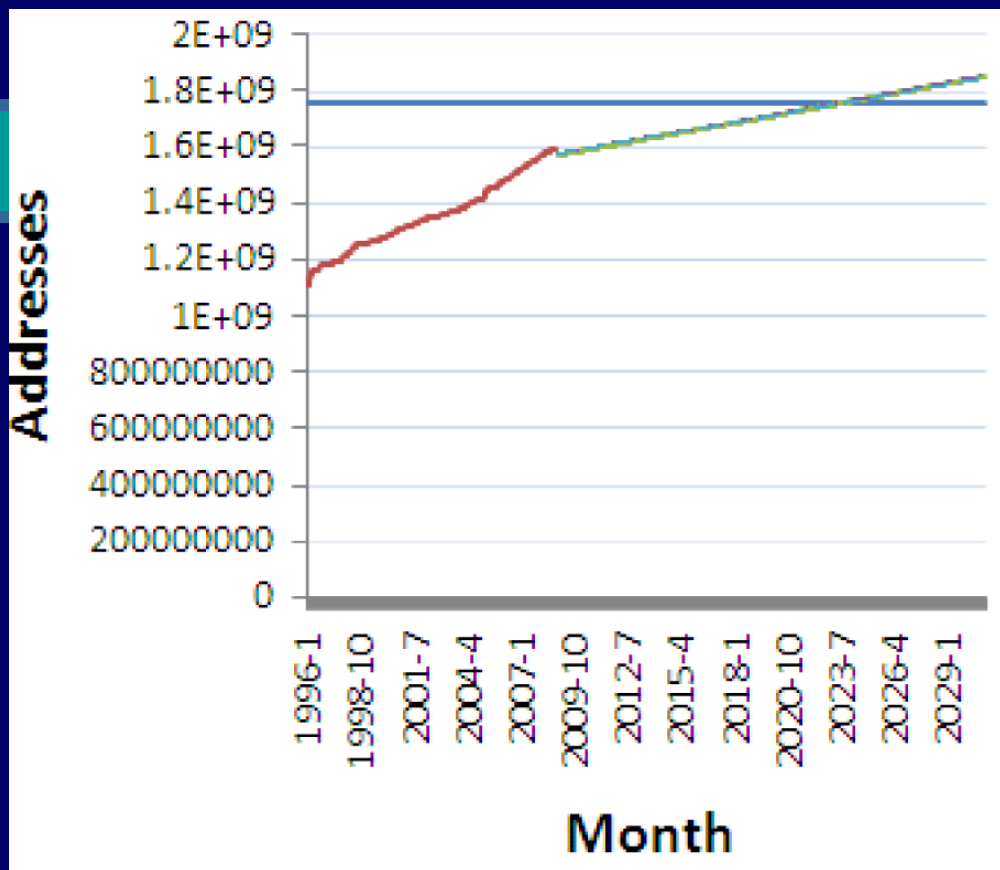| Allocation Range	Organizations in Range	Equivalent in /16s
/8 block ≤ Allocation	34	395 /16s
/12 block ≤ Allocation < /8 block	103	49 /16s
/16 block ≤ Allocation < /12 block	1268	712 /24s
/20 block ≤ Allocation < /16 block	3207	48 /24s
/24 block ≤ Allocation < /20 block	4302	5 /24s
Allocation < /24 block	8202	1 /24s

Policy 1: Organization Threshold

- Organizations above a certain threshold receive no additional addresses
- Justification
  - Larger organizations have tended to request large additional block
  - Larger organizations have more aggregate networking expertise to move to v6
  - Experience in translation at large scale could hasten v6 adoption, mitigating uncertainty for all parties
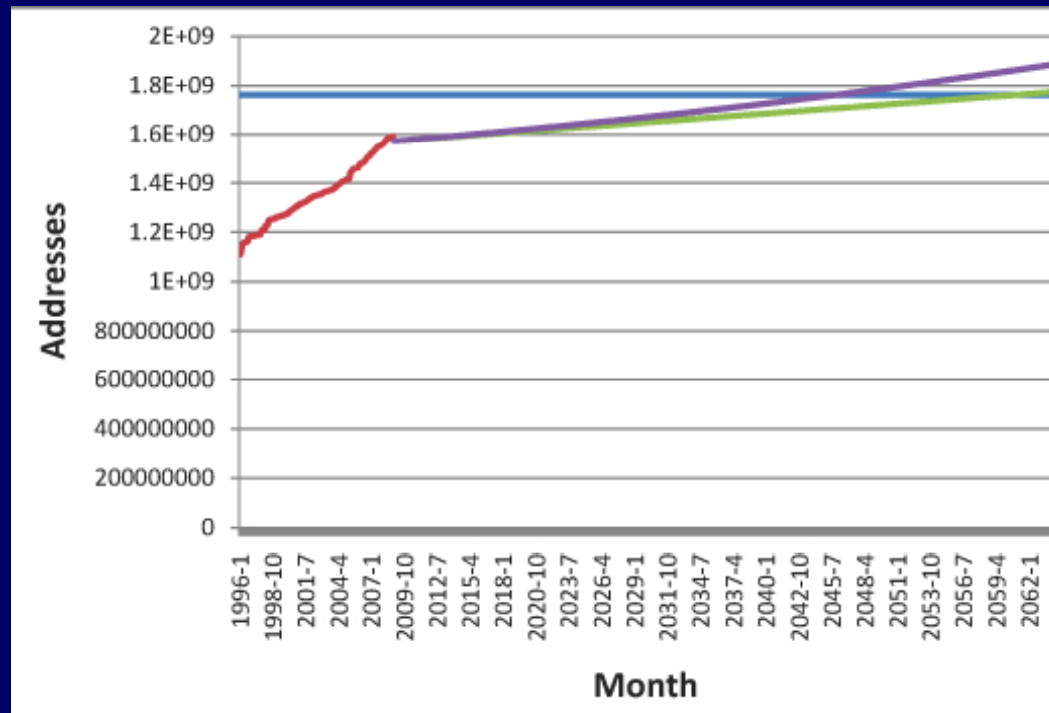 - Capacity, motivation, and impact

Modeling

- Subtract residual addresses from historical data.
- Use this data to form a projection, calculating linear and polynomial fits.
- Add the residual addresses back into projection for a starting or initial point for the projection.
- Use the curve generated to project exhaustion.
  - Imagine this policy had always been in place
  - Use this imagine the implications of the policy for the future
  - Begin 1997

Implications

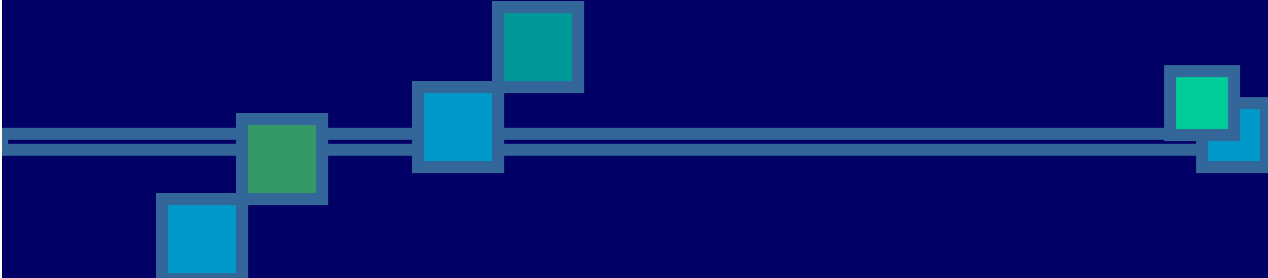- Using /12 as a threshold, a crossover in 2024 (or 2019)

Implications

- Using /20 as a threshold, exhaustion approaches 2045

Summary of Policy 1 Simulations

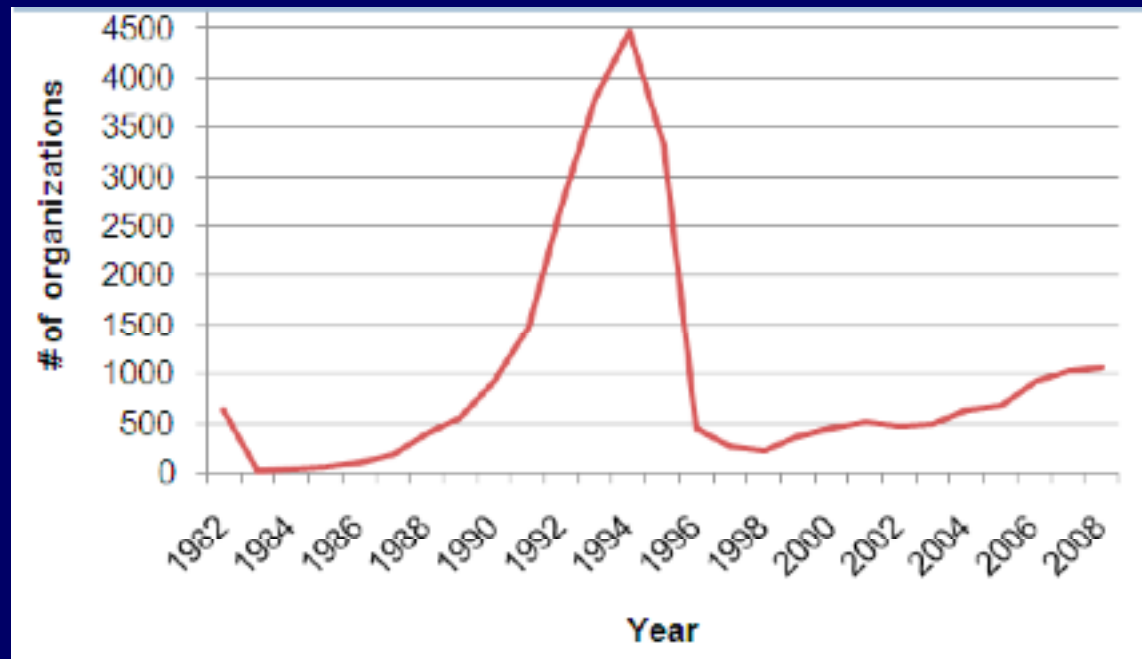| Model	Threshold/12			Threshold/16			Threshold/20		
		-\%95 PI	+\%95 PI	Projected	-\%95 PI	+\%95 PI		-\%95 PI	+\%95 PI
Linear	1/2024	11/2023	4/2024	12/ 2041	7/2040	8/2043	12/2060	8/2056	4/2066
Polyno mial	3/2019	3/2019	3/2019	6/2029	5/2029	7/2029	12/2045	11/2045	2/2046

- Assuming yesterday predicts tomorrow….

Policy 2: Per organization annual threshold

- Provide any organization that requests an allocation exactly one minimal routable block

- Justification
  - Fairness
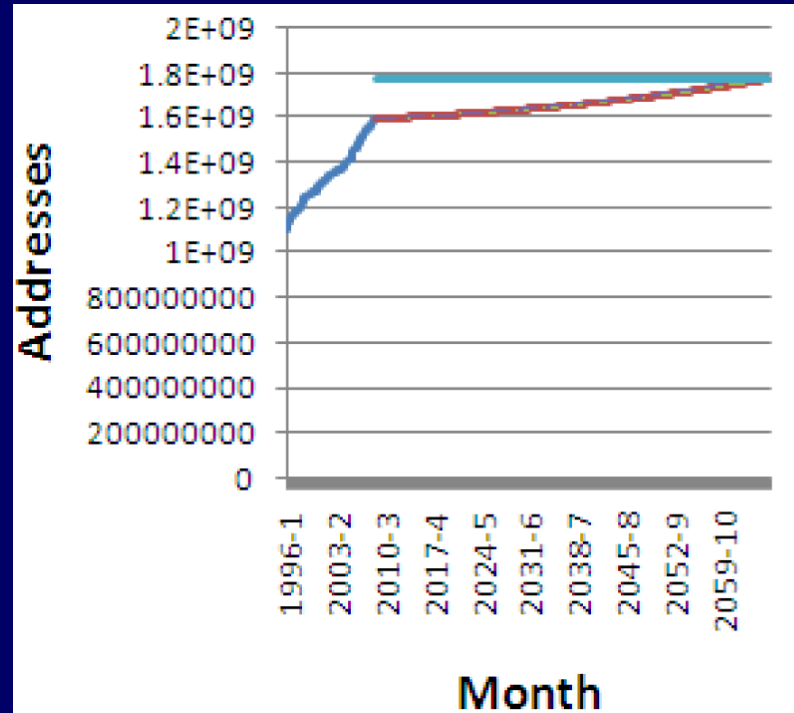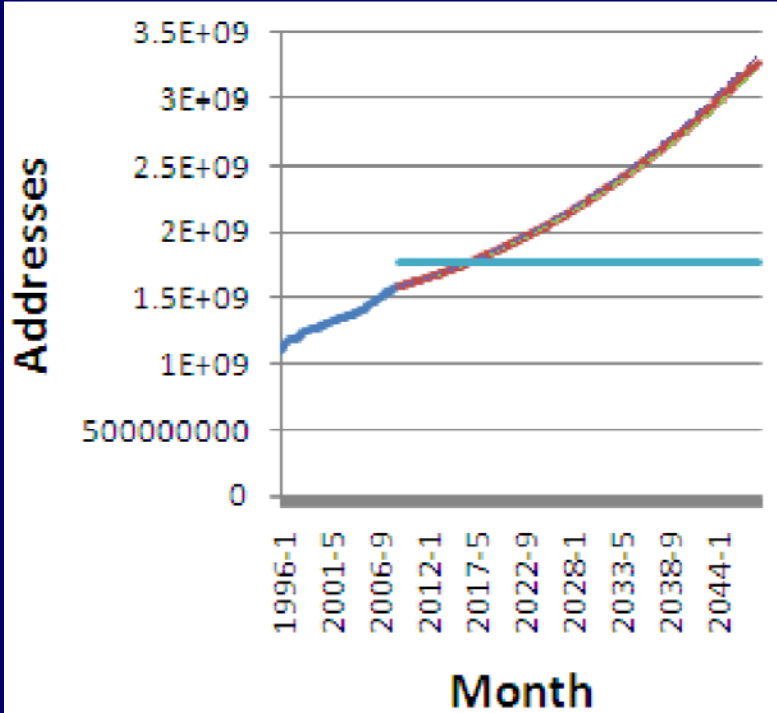 - Politics

Past Organizational Patterns

Resulting Per Organization Results

- Multiply number of organizations times allocations
- Select allocation size as minimally routable
    - /24?
- Determine exhaustion date by organizational count

Results for Policy 2

Results with a /18 and /20 as maximum allocations

Results for Policy 2

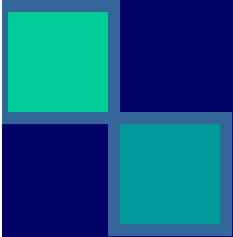| Allocation Size	/22	/20	/18
Estimated exhaustion	2060	2030	2017

Policy 3: Predetermine Exhaustion

- More of a thought experiment
- Pick a year
- Divide pool by time to that year
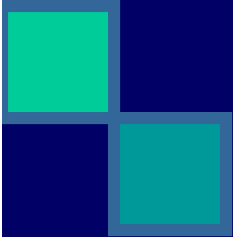- Allocate pool at a rate to make it to that year

How Low Could You Go?

- How small an allocation can you place in any given year before the allocations become impossible to route?

- How many allocations are you getting, per year, per average?

- Who would be refused?

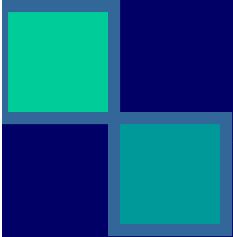- You can make this decision later than others.

As Low as You Like

- 3 /8 =~ 200k /24s
- 2000 24/s per year the result is 98 years
- 30 years the meet requests of 95\% of applicants could in theory, be met.
- 50 years the meet requests of 75\% of organizations could in theory, be met.
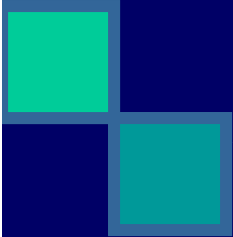
It is Up To You….. For Now

- RIR decisions could choose to manage exhaustion multiple ways
- This will determine the transition
- IPv4 will become in the next years
  - A critical facility?
  - A traded good?
  - A high level interconnection, backbone technology?

Top Holders of IPv4 Blocks

DoD Network Information Center
DDN-ASNBLK1 - DoD Network Information Center
ATT Internet Services
Comcast Cable Communications, Inc.
Cogent/PSI
AT&T WorldNet Services
Headquarters, USAISC
Cellco Partnership
Merit Network Inc.
AT&T Global Network Services
E.I. du Pont de Nemours and Co.
University of California at San Diego
HP-INTERNET-AS Hewlett-Packard Company
 SITA
Massachusetts Institute of Technology
Ford Motor Company