

# A Primer on IPv4 Scarcity

Best of CCR  
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London

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# IPv4 Scarcity



As of today only ~2% of the IPv4 address space “free”

*routing data*

*allocation files*

*transfer logs*

*RFCs*

*routing registries*

*broker statistics*

Many institutions involved, 35 years of evolution

Patchwork of different sources of information

*policy documents*

*WHOIS*

*policy mailing lists*

**What is IPv4 scarcity? What factors affect it? What challenges does it pose? How are we dealing with it?**

# Agenda

- The History of IPv4 Address Space
  - ➔ Management
  - ➔ Allocation
  - ➔ Routing
- IPv4 Addresses: A Virtual Resource
- The Emerging Address Market

# A History of IPv4 Address Block Management

1981

Early Registration

- Informal Distribution
- Scarcity minor issue
- Non-commercial Internet

~1992

Needs-Based Provision

- Distribution process
- Justification of need
- ISPs don't pay for IPs

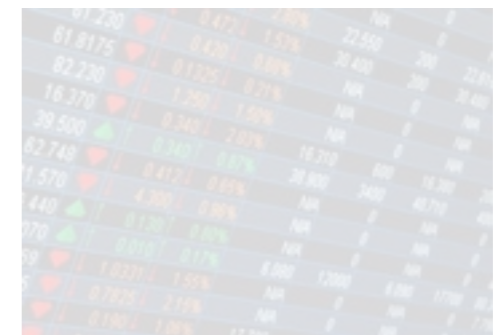
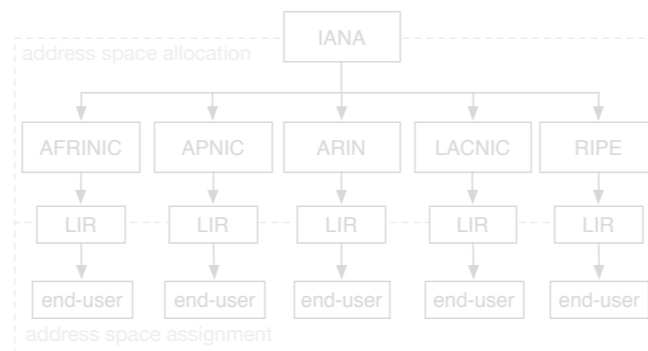
~2011

Depletion & Exhaustion

- Address Markets
- Money comes into play!



Jon Postel  
† 1998



# Early Registration Phase: Policies

## RFC790

J. Postel

ISI

September 1981

current information can be obtained from Jon Postel. 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.

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phone: (213) 822-1511

ARPANET mail: POSTEL@ISIF

- Rather Informal address distribution
- First RFC: More than 700M IPv4 addresses registered
- Classful Addressing, heavy internal fragmentation

# A History of IPv4 Address Block Management

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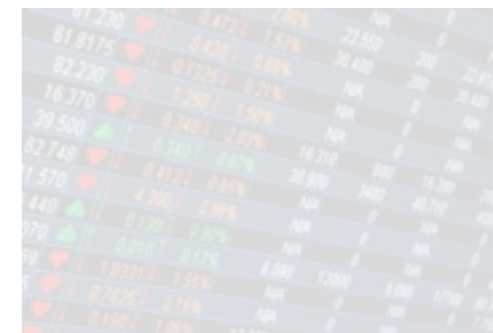
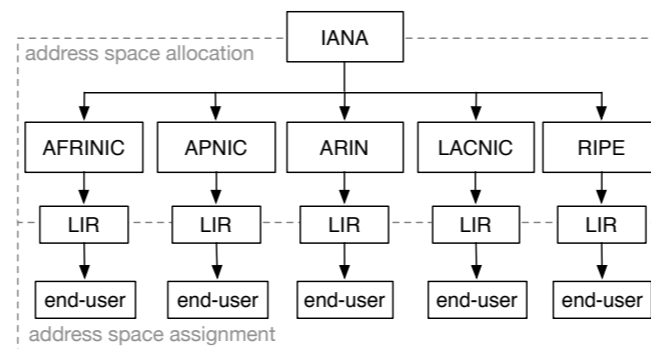
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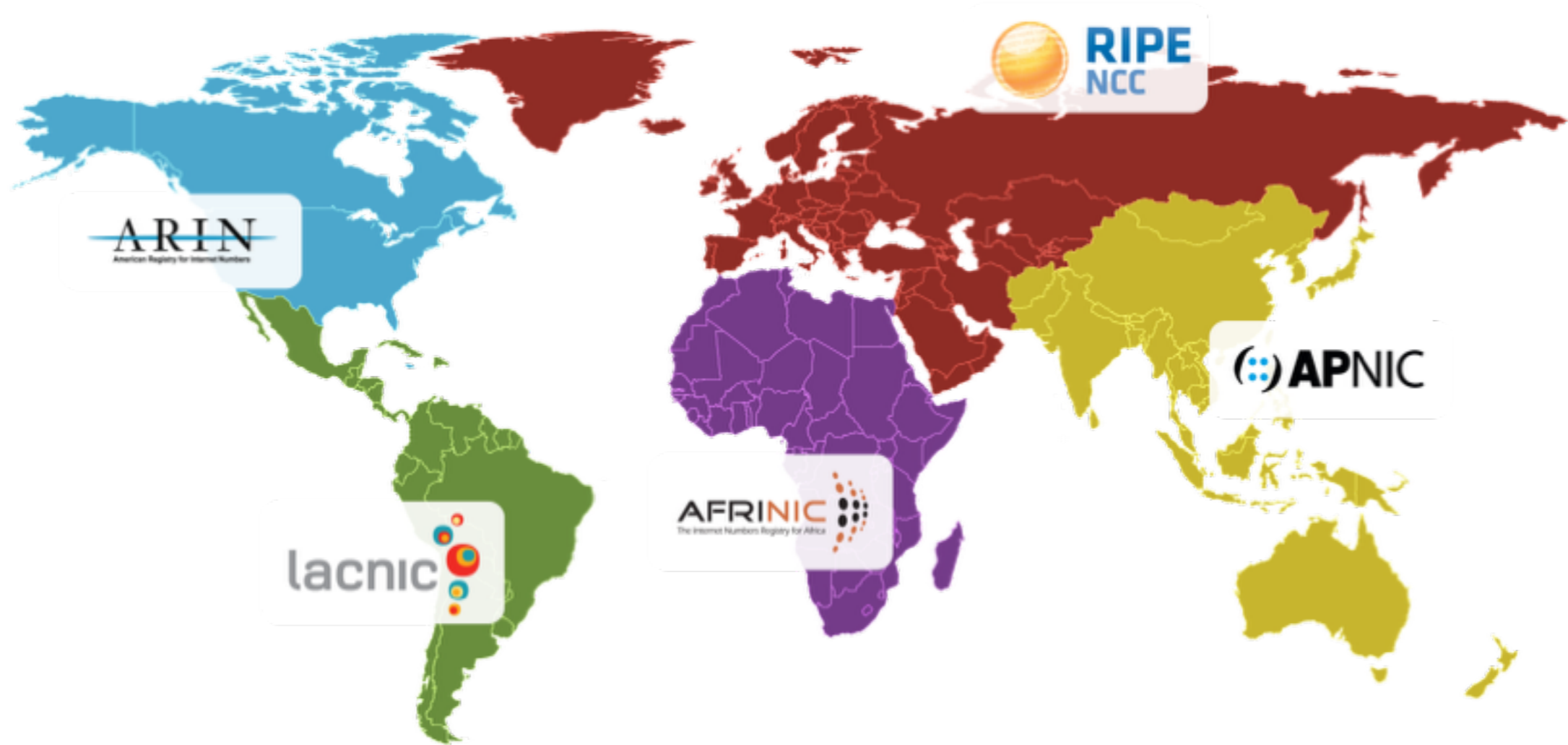
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# Needs-based Provision Phase

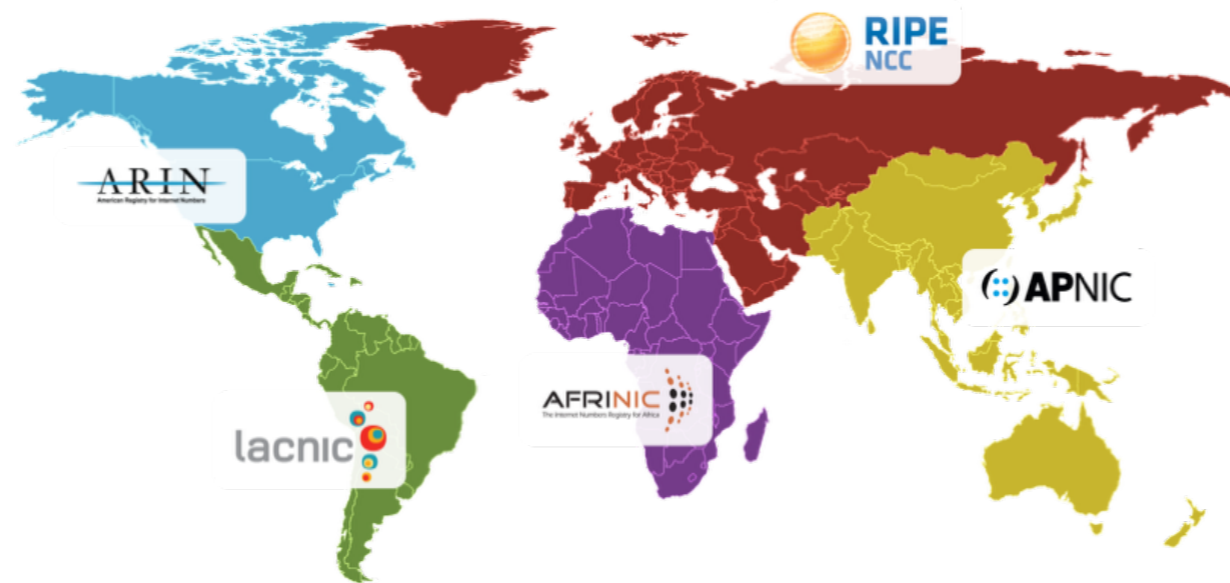
## The Registry Framework





# Needs-based Provision Phase

## The Registry Framework



- One primary goal: address space conservation
- ISPs must justify “**need**”
  - Efficient utilization of previously allocated blocks
  - Intended use of blocks

# A History of IPv4 Address Block Management

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Early Registration

Needs-Based Provision

Depletion & Exhaustion

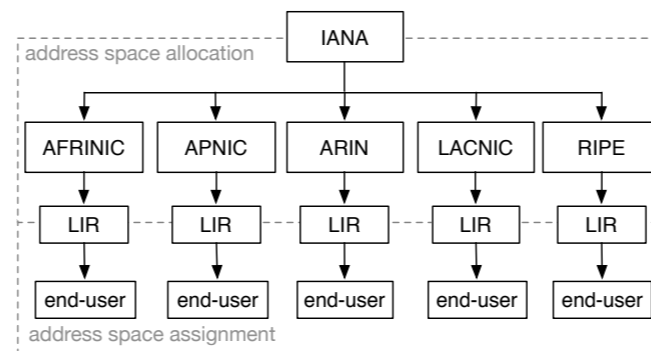
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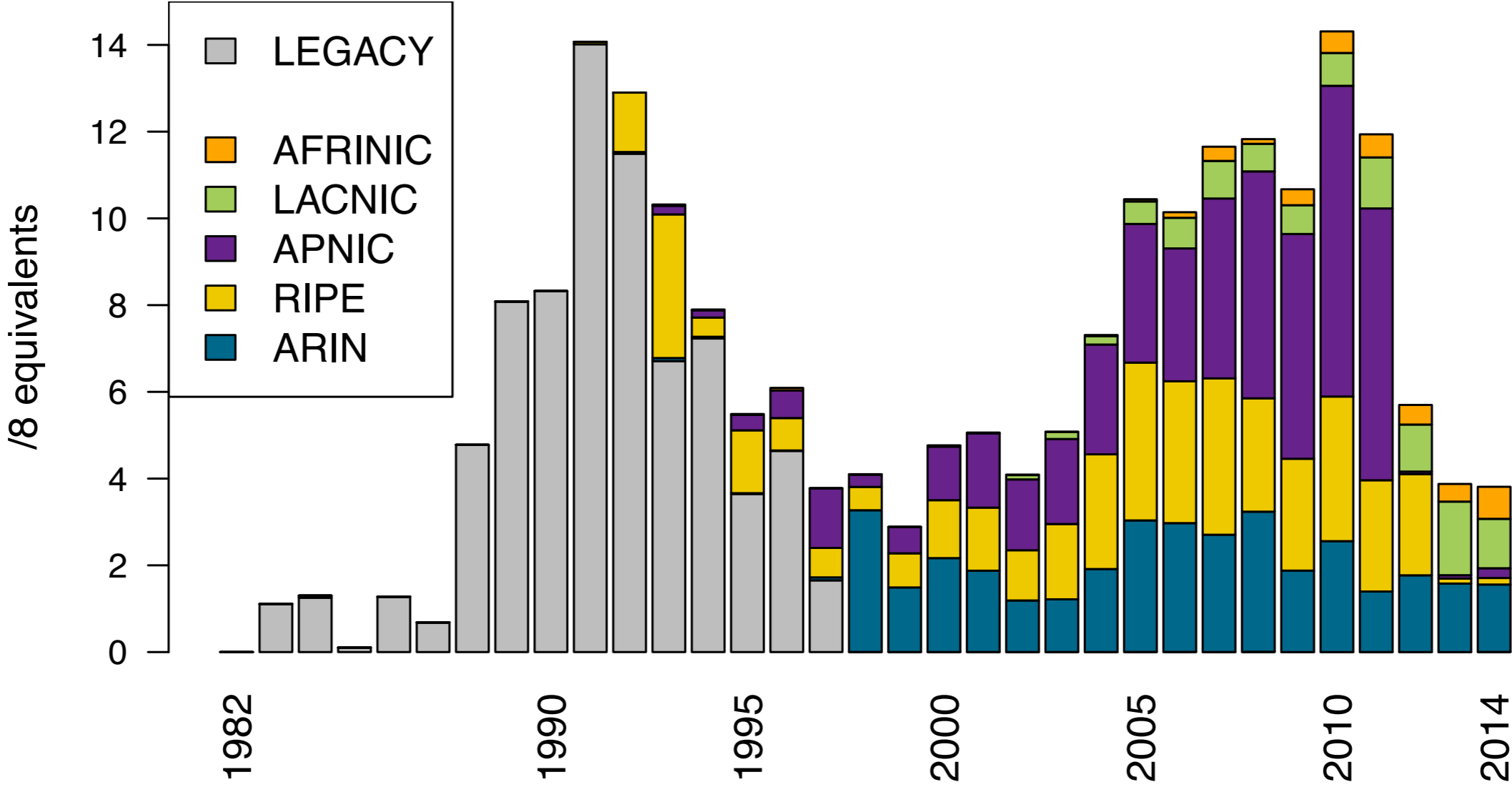
# Depletion and Exhaustion Phase

- The IANA distributed its last 5 /8 blocks to the RIR (2011)
- Strict allocation policies for last remaining blocks
  - ➔ New market entrants can still receive a last small block
- Emergence of Address Transfer Markets
- Introduction of Transfer Policies

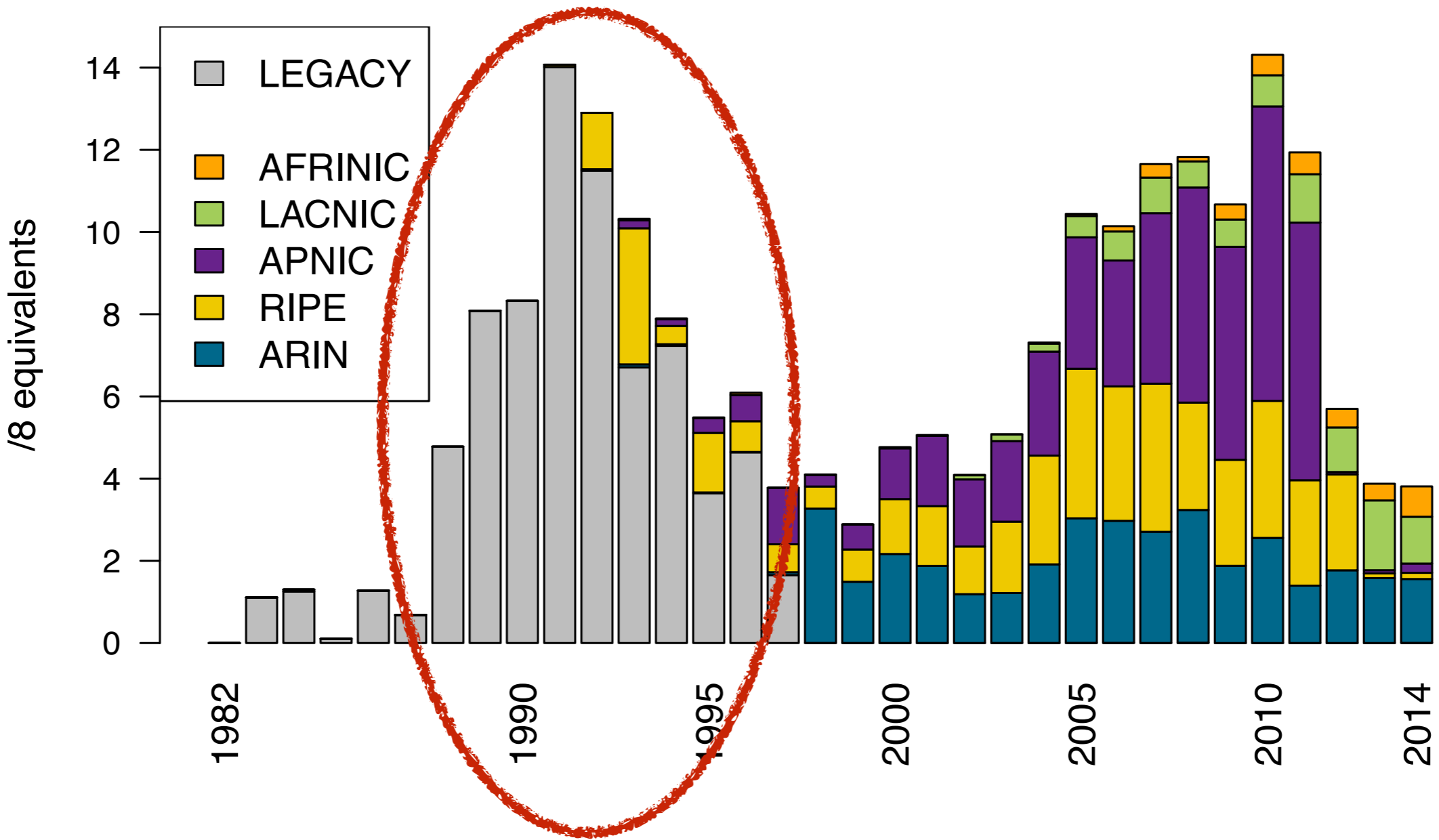
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- The History of IPv4 Address Space
  - ➔ Management
  - ➔ **Allocation**
  - ➔ Routing
- IPv4 Addresses: A Virtual Resource
- The Emerging Address Market

# A History of Allocations

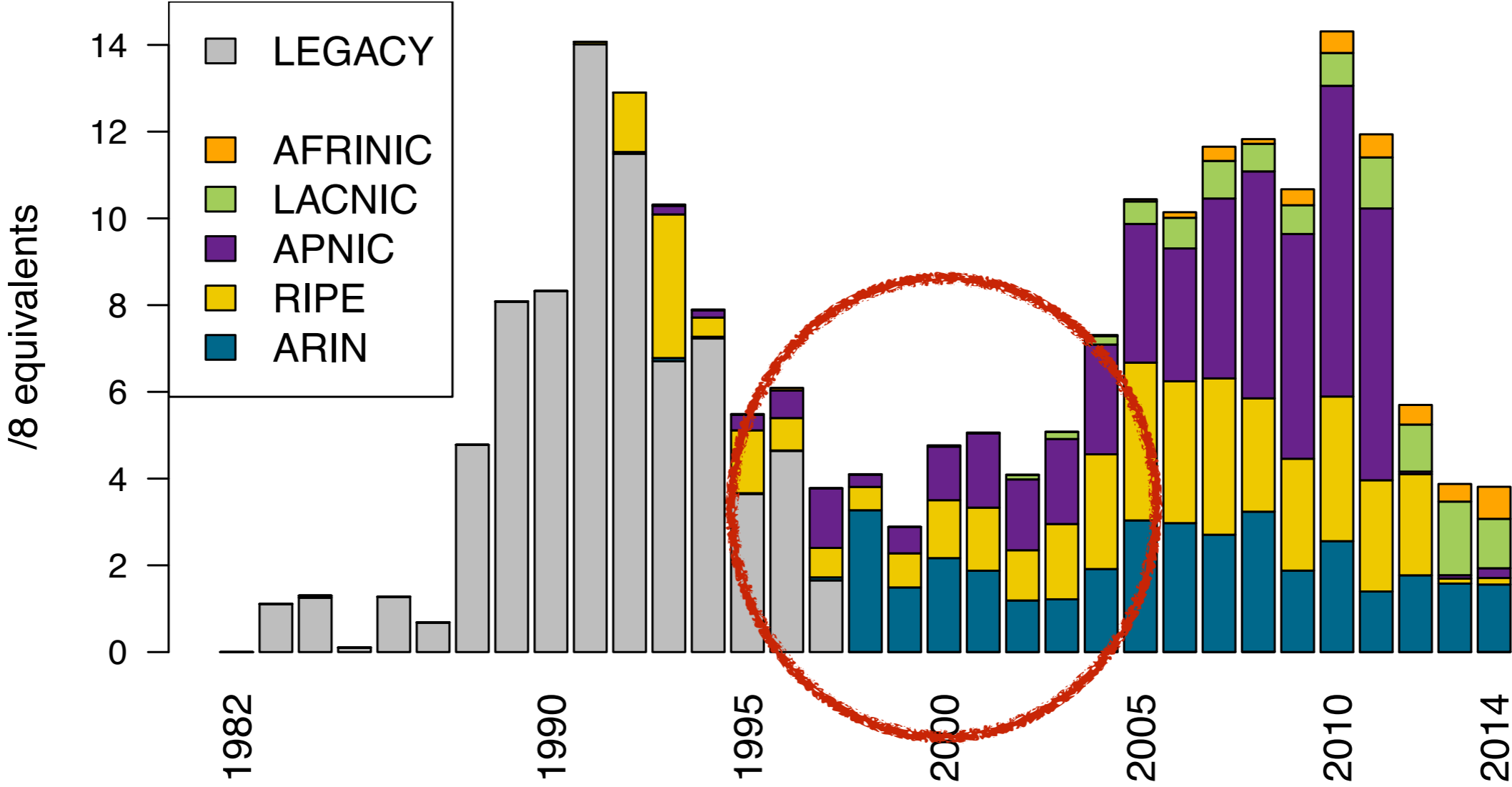


# A History of Allocations



around 40% of the routable address space are LEGACY

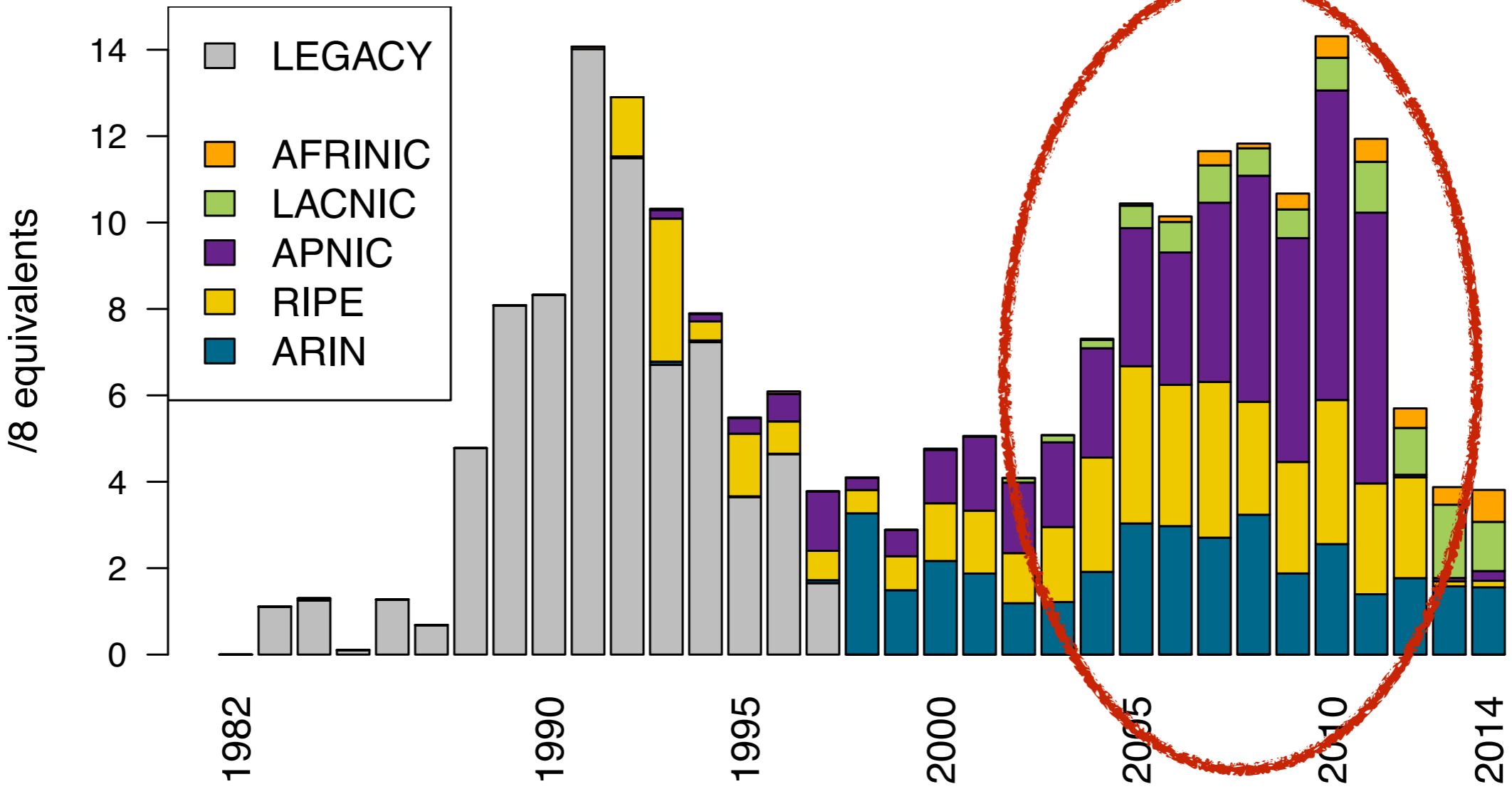
# A History of Allocations



address space conservation shows effect

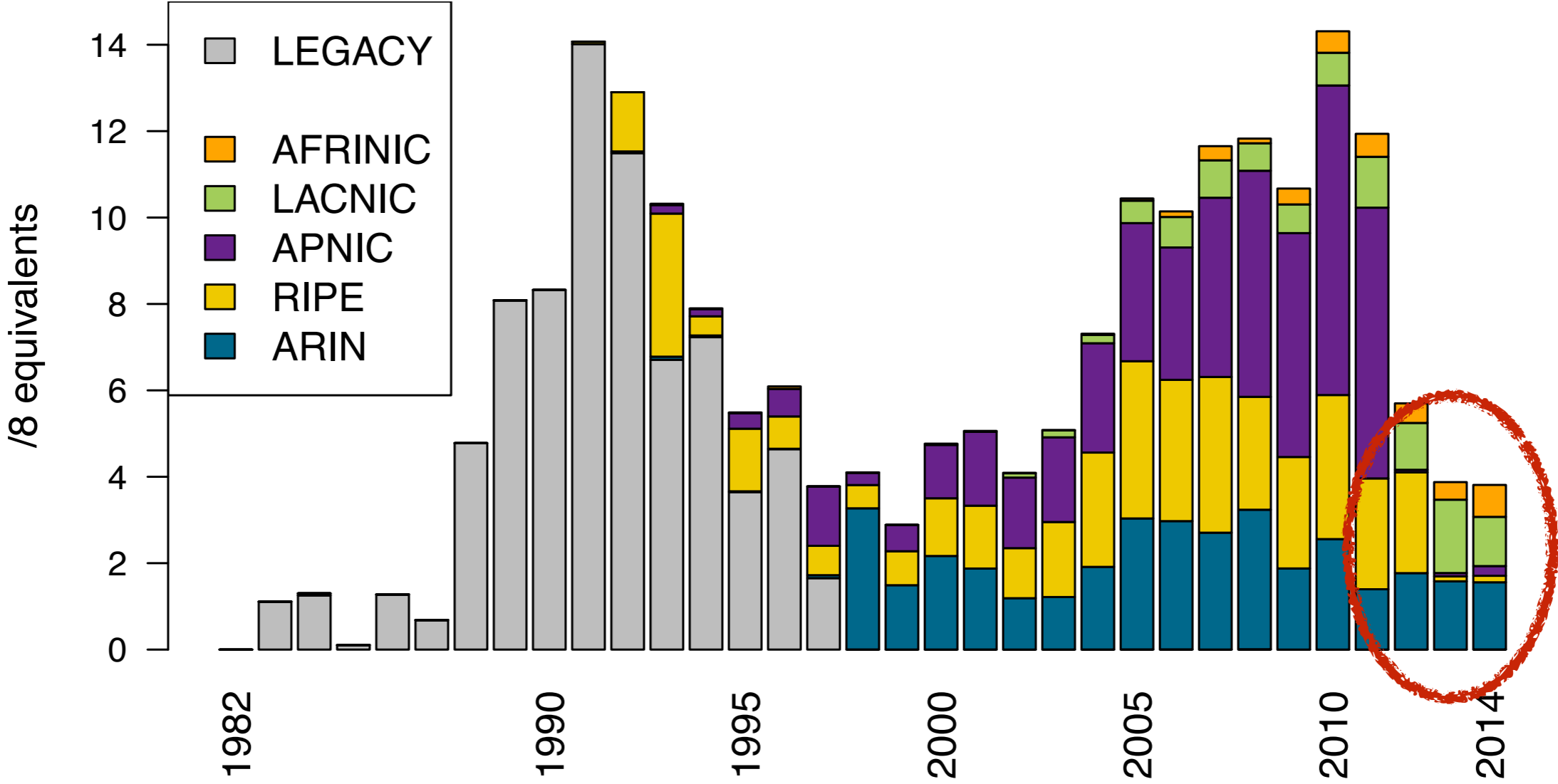


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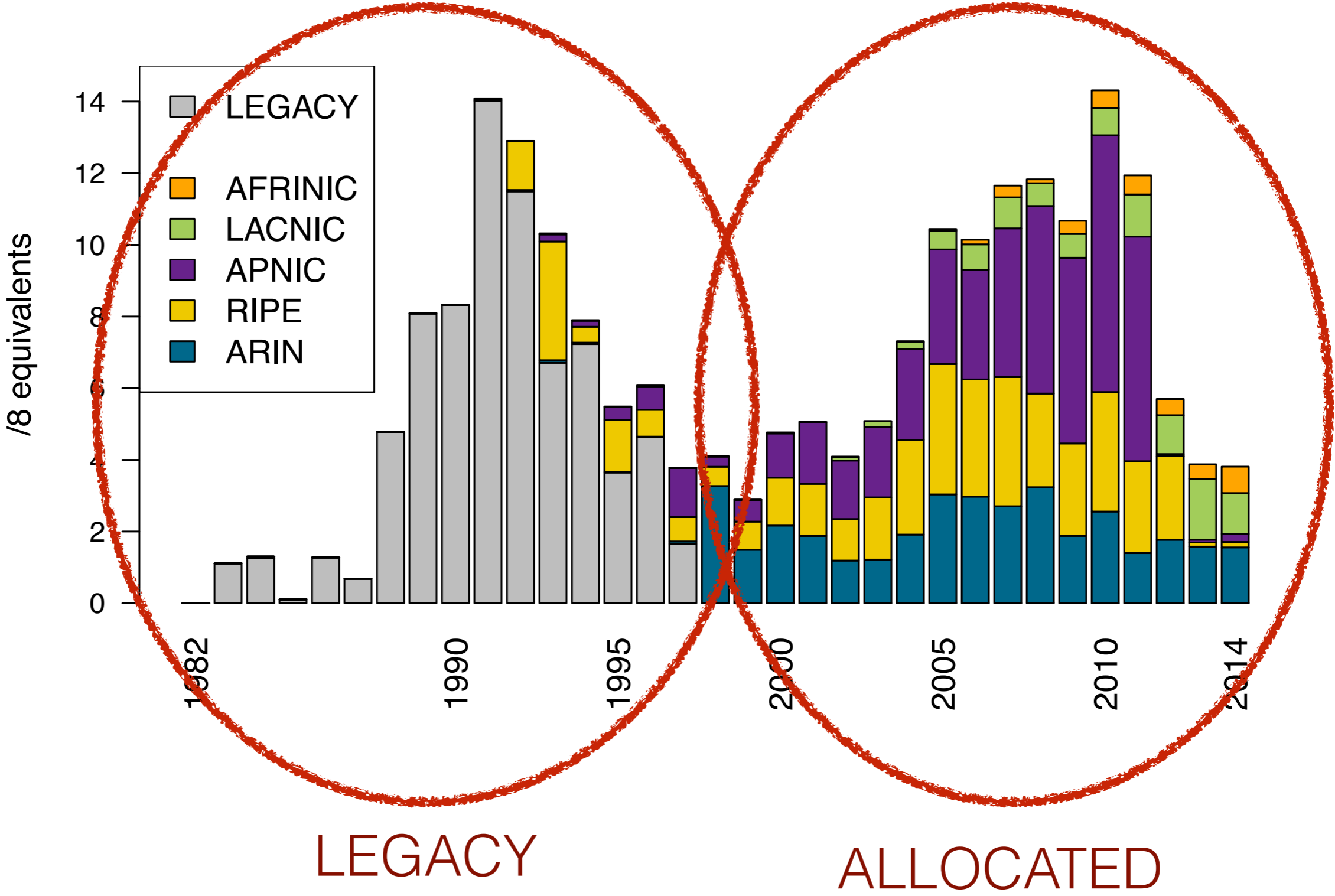
rapid consumption (primarily in Asia)

# A History of Allocations



depletion (APNIC and RIPE exhausted)

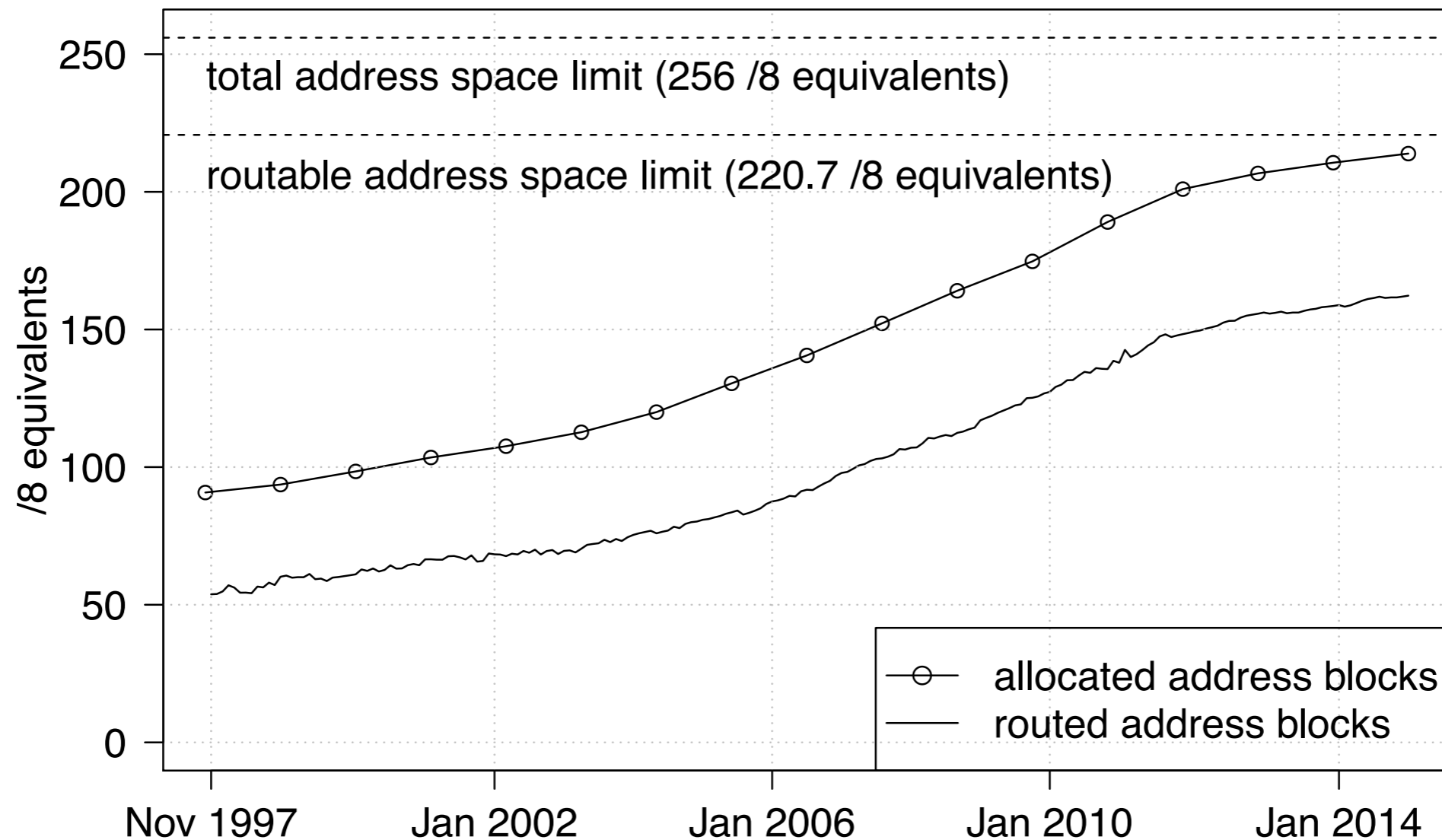
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# Agenda

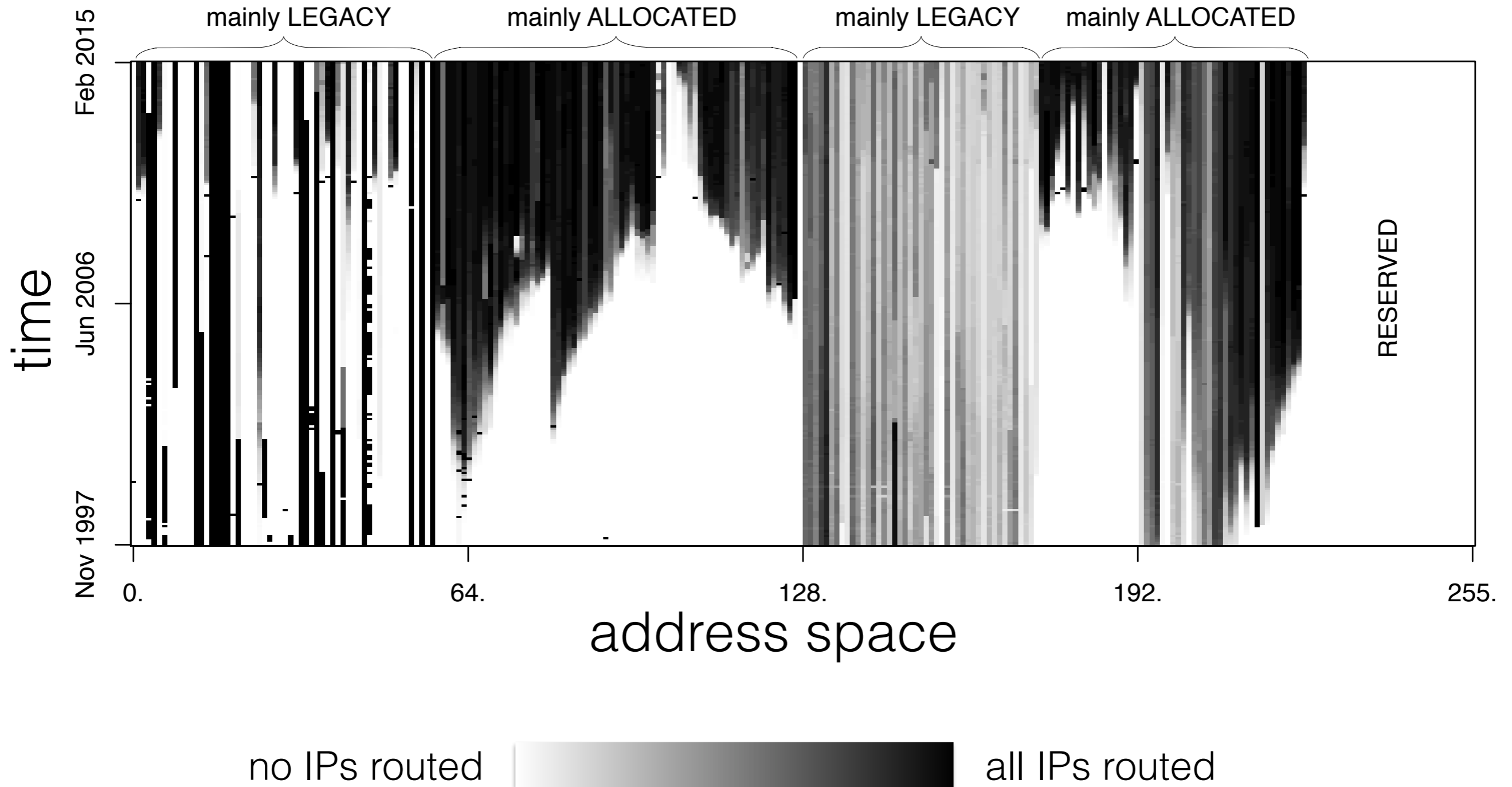
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# The Routing Gap

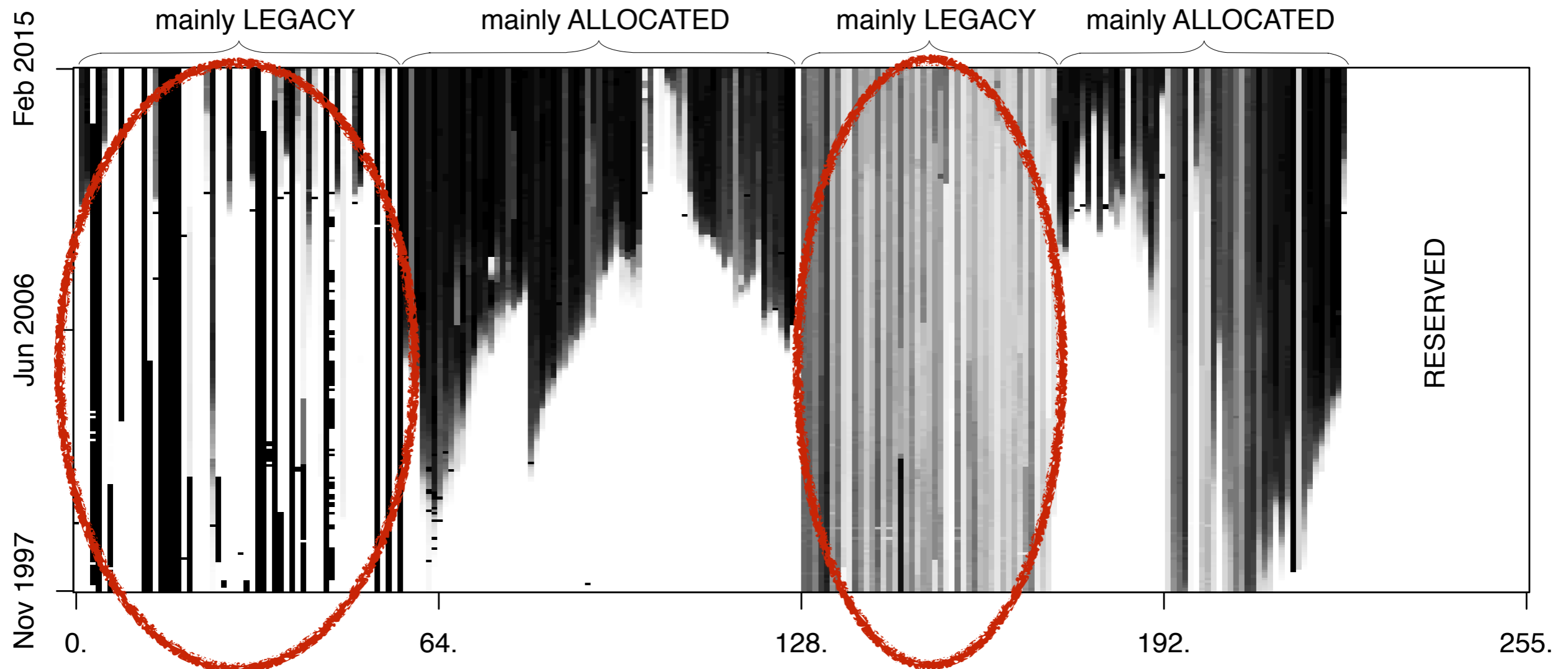


**Large amounts of address space unrouted**

# A Spatiotemporal View of the Address Space



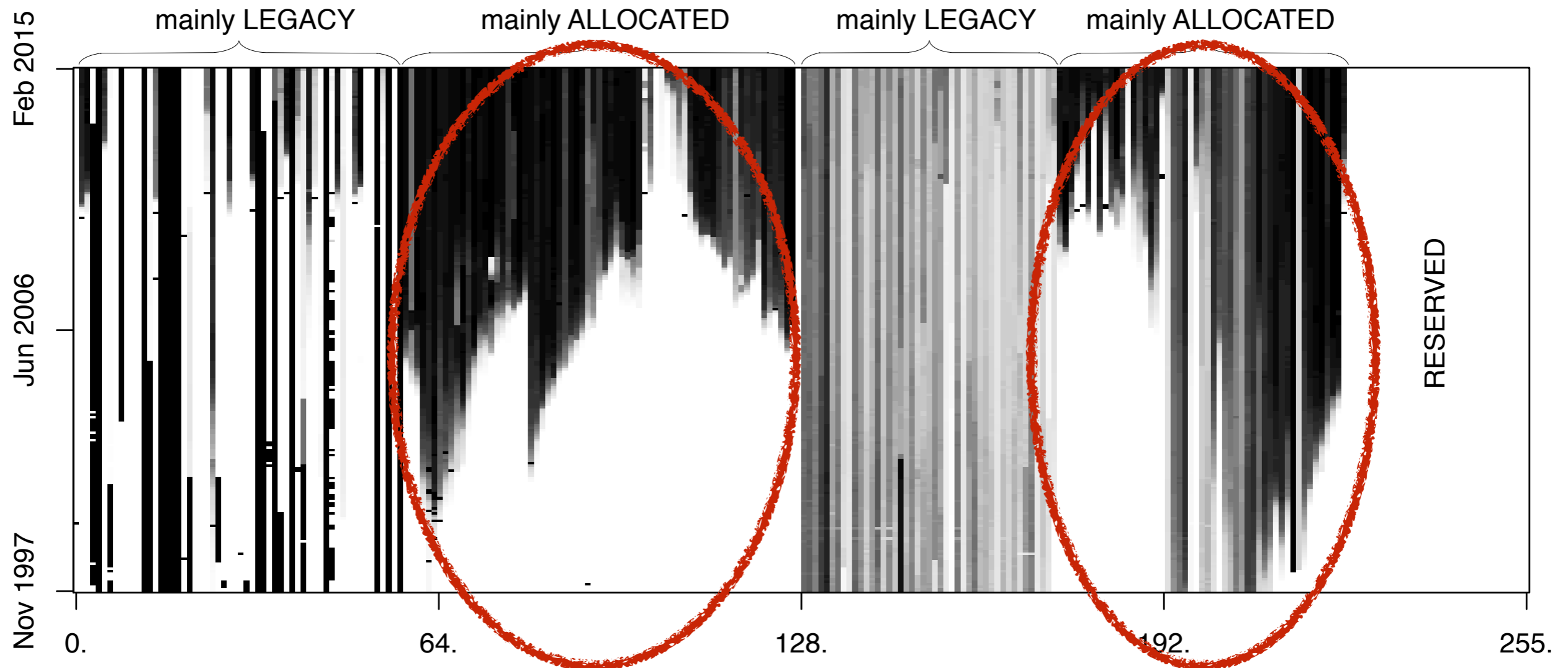
# A Spatiotemporal View of the Address Space



LEGACY ranges: poor utilization; little change over the years



# A Spatiotemporal View of the Address Space



ALLOCATED ranges: higher utilization, policies show effect

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# IPv4 Addresses: A Virtual Resource

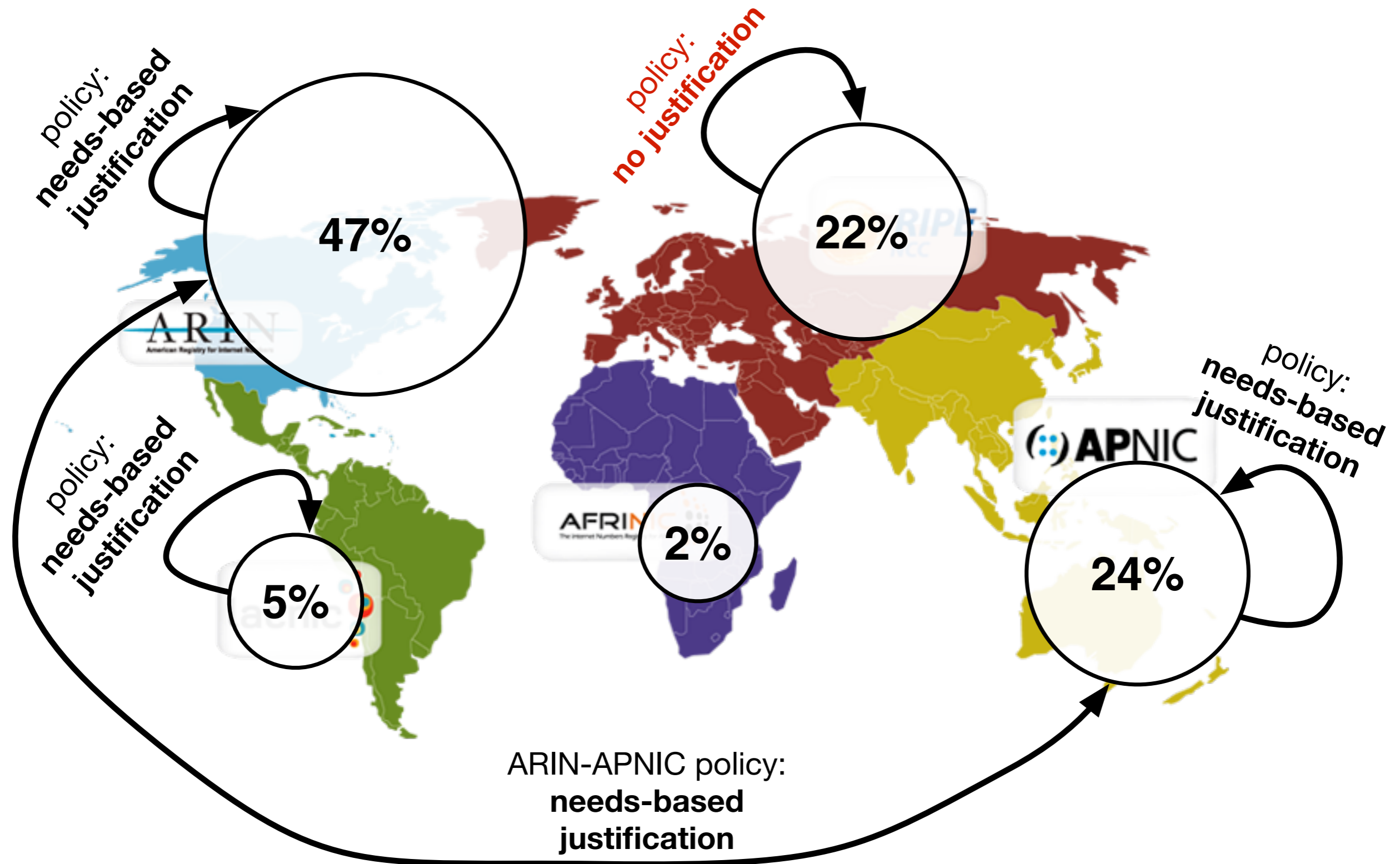
- For 30 years, IPs were handed out “for free”\*\*
  - ➔ Availability of IPs was not an entrance barrier for ISPs
- Now, the RIRs have very few blocks left
  - ➔ IPv4 addresses are goods exchanged on markets



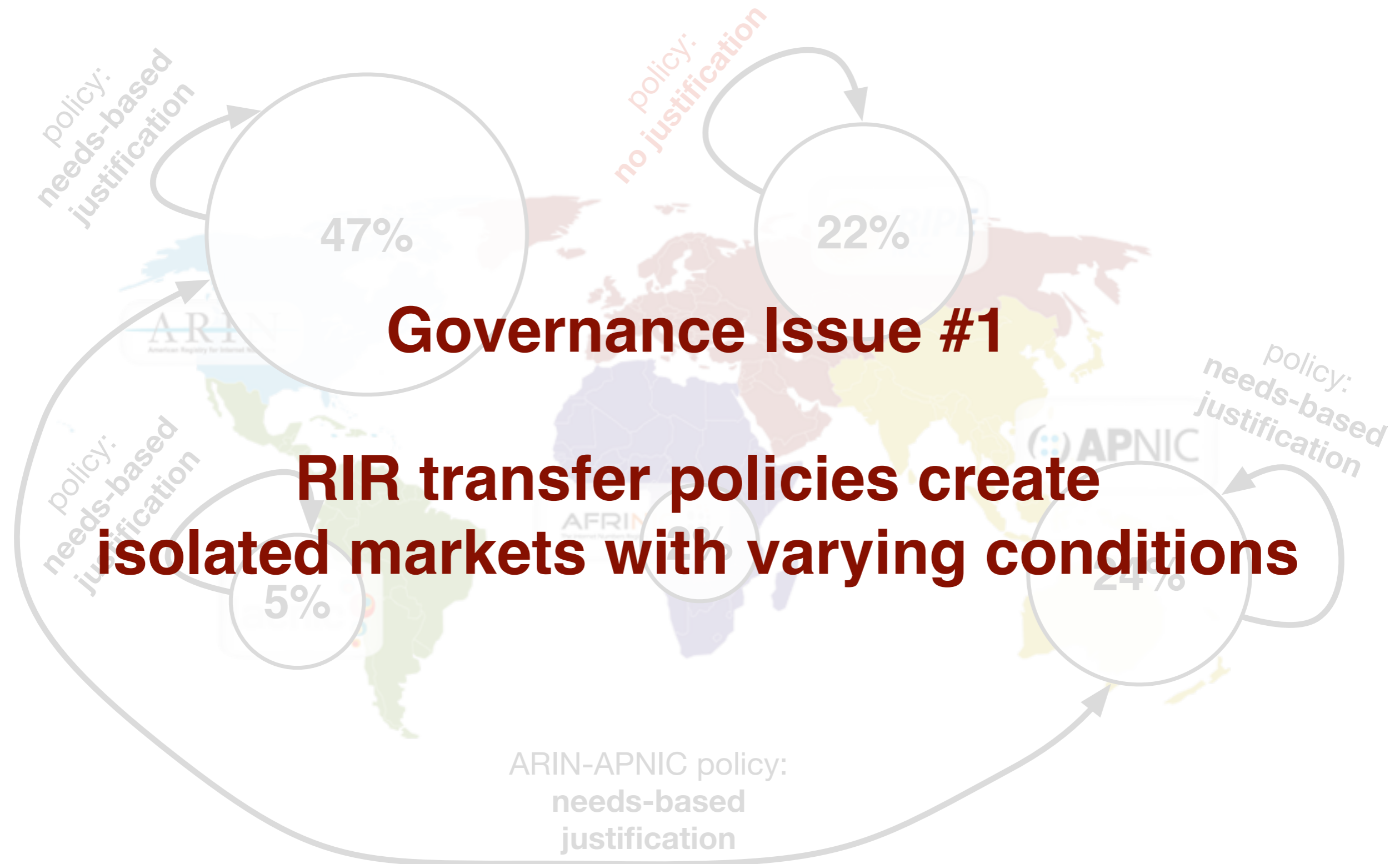
## Internet Governance Issues

\*\*albeit administrative fees, RIR membership etc.

# IP Addresses and RIR Transfer Policies



# IP Addresses and RIR Transfer Policies



# Transfer Policies for Everybody?

- ~40% of the address space is of type LEGACY
- Registrations from the 80's and 90's
- Administration was later shifted over to the RIRs
  
- Grandfathering principle?
- **Are LEGACY blocks subject to RIR policies?**

# Transfer Policies for Everybody?

- ~40% of the address space is of type legacy
- Registrations from the 80's and 90's
- **Governance Issue #2**
- Administration was later shifted over to the RIRs
- **LEGACY address blocks harbour the largest supply of unused addresses.**
- **Relationship RIRs <-> LEGACY holders?**
- Are LEGACY holders subject to RIR policies?  
**Their legal status is still unclear.**



# Resource Certification

- IP Addresses are virtual resources
- BGP has no means of validating route announcements
  
- Solutions: Routing Registries, RPKI
- Large portions of the address space not covered
- Prominent cases of address hijacking

# Resource Certification

- BGP was not designed for IPv4 scarcity

## **Governance Issue #3**

- No means of validating route announcements

**Address Management (RIRs) is de-coupled from the actual usage.**

- Solutions: Routing Registries, RPKI

## **Policy Enforcement?**

- Large portions of the address space not covered

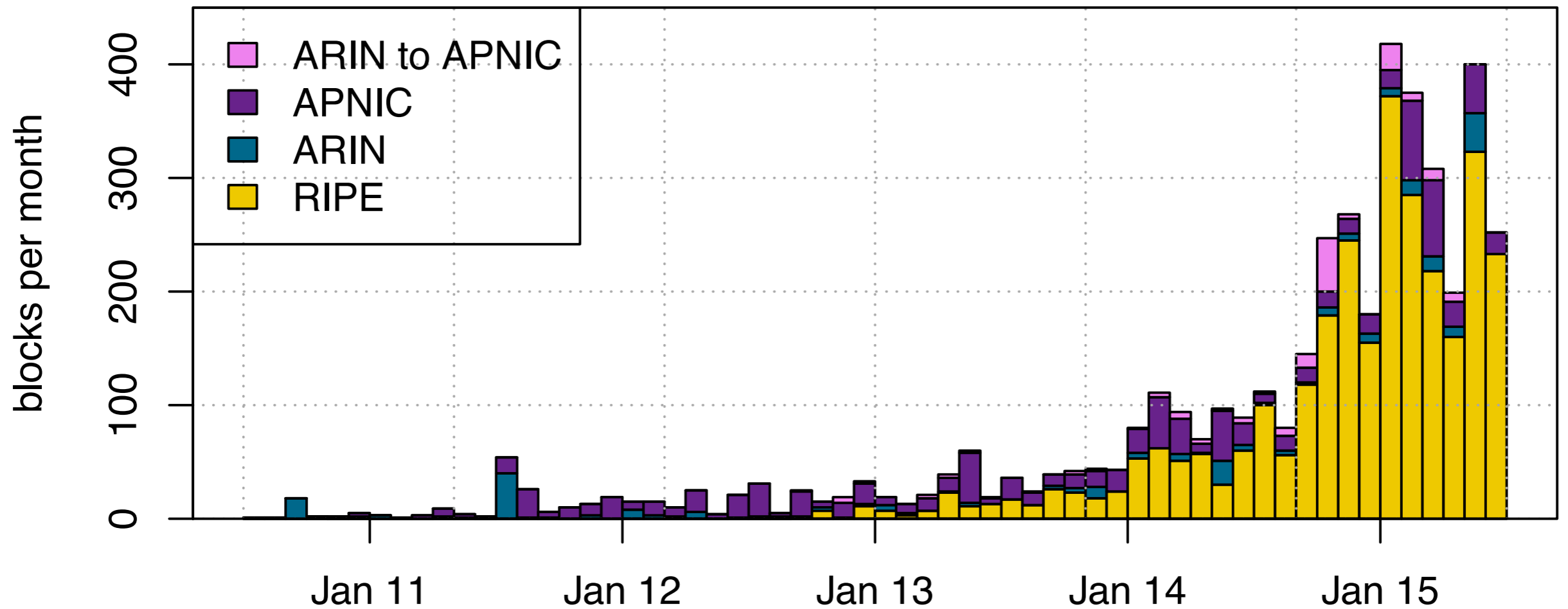
- Prominent cases of address hijacking (YouTube)

## **Black Market?**

# Agenda

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# The Emerging Address Market



data source: RIRs

**total transferred: 3.6 /8s (1.7% of routable space)**

# Prices?

- Not publicised! Only partial data from brokers

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	ARIN	APNIC	RIPE
/16	<b>\$360K</b> \$5.5/IP	<b>\$425K</b> \$6.5/IP	<b>\$537K</b> \$8.2/IP

data: [www.ipv4marketgroup.com](http://www.ipv4marketgroup.com)

**Policies directly affect prices**

# Conclusion

- IPv4 addresses are now a virtual resource
- Scarcity problem is not only protocol-related
- New challenges for the community
  - How to adapt policies to this situation?
  - How to provide resource certification?
  - ➔ How to ensure further growth of the Internet?

# Conclusion

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  - How to provide resource certification?
  - ➔ How to ensure further growth of the Internet?

**IPv4 Scarcity might impact the growth of the Internet**

**Internet Governance impacts IPv4 Scarcity**