A First Look at IPv4 Transfer Markets

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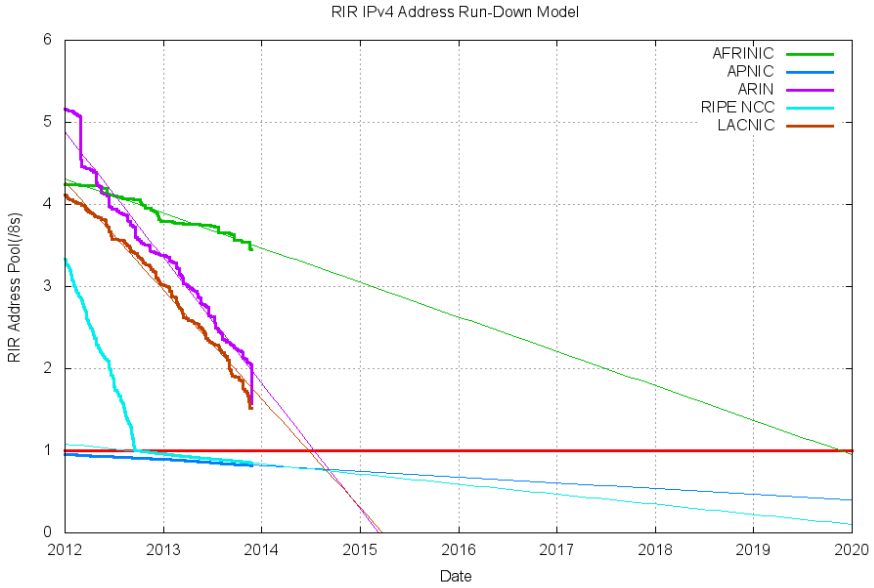
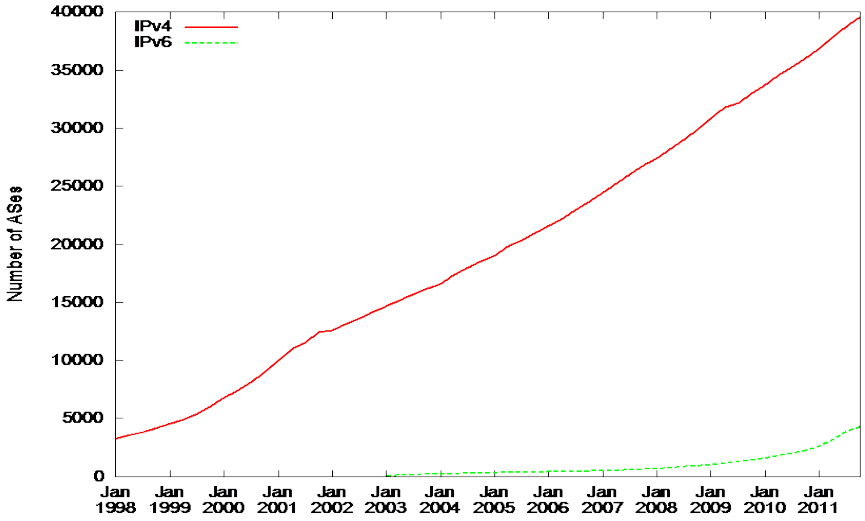
IPv4 Address Space

- Internet Registries are running out of IPv4 addresses



Source: Geoff Huston - **IPv4 Address Report** [http://www.potaroo.net/tools/ipv4/]



- Slow adoption of IPv6 protocol

IPv4 Transfers

- Organizations that need IPv4 addresses can purchase them from other organizations that have surplus
- Three RIRs have so far legitimized the transfer market

But there is debate about the existence of this market

- Does the market inhibit the transition to IPv6?
- Do transfers increase fragmentation of the routing table?
- Would grey-market transfers increase uncertainty about prefix ownership?

Objectives

- Analysis of Published Transfers
  - How are transfers evolving over time?
  - Do transfers facilitate a healthy redistribution of addresses?

  (Data used: List of transfers published by three RIRs)

- Detect Transfers “in the wild”
  - Can we detect transfers using publicly available routing data without any information from the RIR?

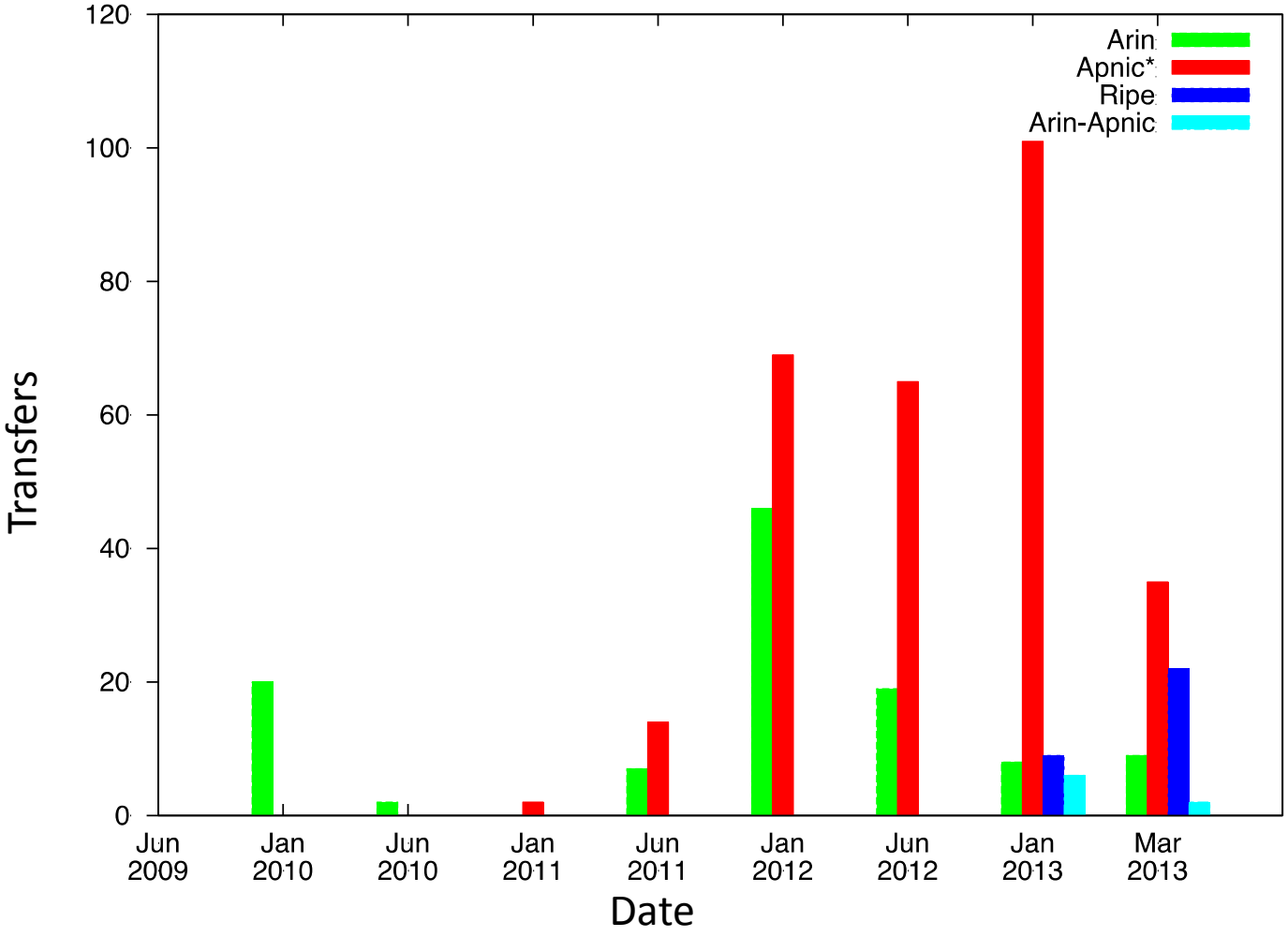
  (Data used: BGP routing tables from Routeviews and RIPE)

RIRs are now publishing lists of transferred address blocks

Internet Registry	Transfer Policy	First Published Transfers
RIPE	December 2008	October 2012
ARIN	June 2009	October 2009
APNIC	February 2010	January 2011
LACNIC	NA	NA
AFRINIC	NA	NA
ARIN <–> APNIC*	July 2012	October 2012

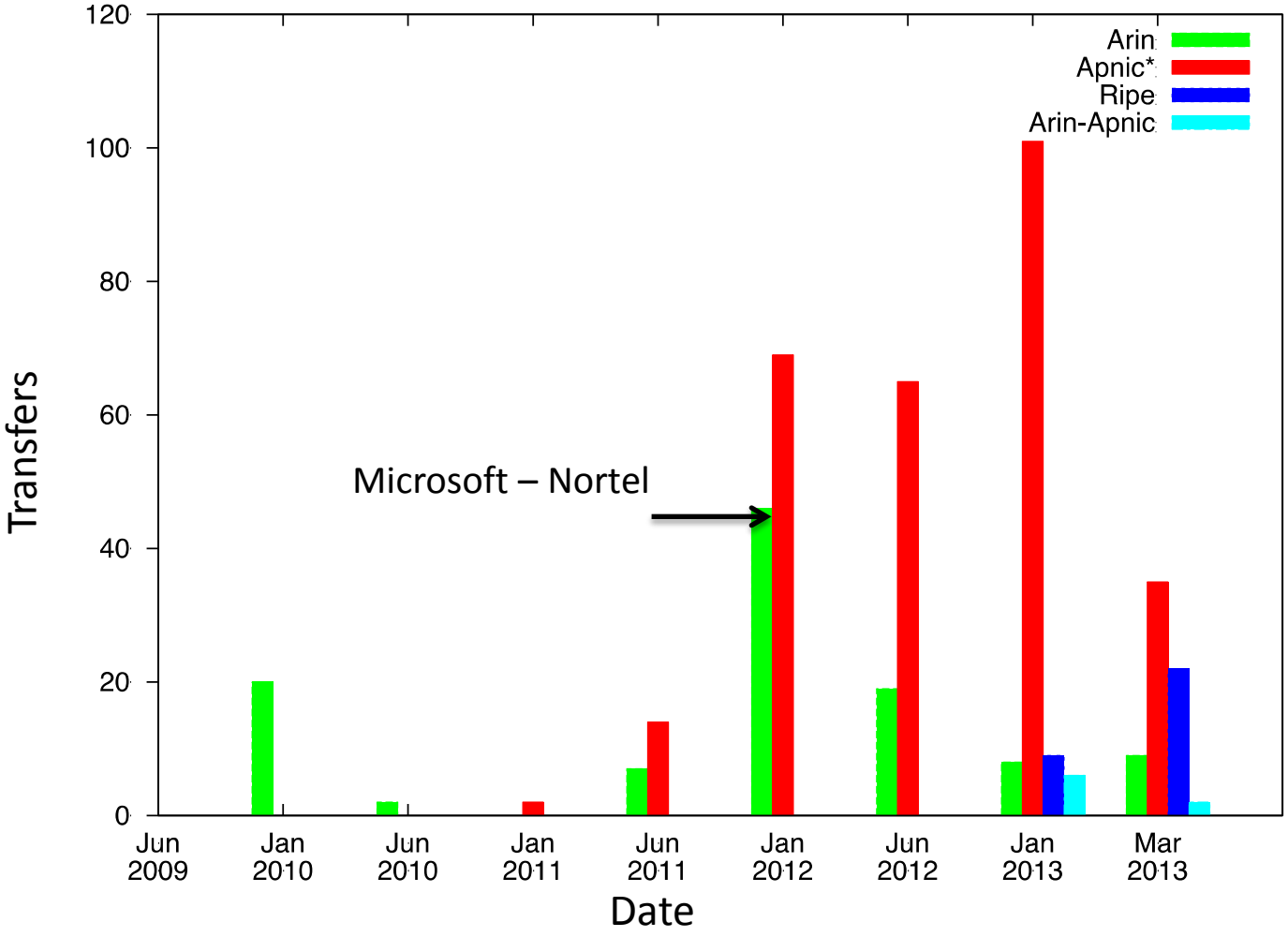
*Inter-RIR transfers are only authorized between ARIN and APNIC as of this time

Increasing Number of Published Transfers



* APNIC data includes non-market transfers (e.g. due to mergers & acquisitions)

Increasing Number of Published Transfers



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Which addresses are getting transferred?

- Legacy allocations account for 40% of all address space
  - These allocations were decoupled from need
- 75% of published transfers are from legacy allocations

RIR	% of all legacy allocation	% of transferred legacy allocation
ARIN	83.75%	90.14%
APNIC	6.5%	9.81%
RIPE	6.5%	0.05%
AFRNIC	2.17%	0
LACNIC	1.08%	0

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This appears to be a healthy redistribution of address space

Are organizations buying addresses to hoard them or to satisfy a real need?

Class	Before	After	Total
A	Unrouted	Unrouted	26
B	Routed	Unrouted	30
C	Unrouted	Routed	118
D	Routed	Routed	182

Visibility of the transferred blocks in the routing table

85% of the transferred blocks are routed after the transfer

RIR	Latency (Avg. months)	Remaining Addresses (/8s)
RIPE	1.1	0.85
APNIC	2.4	0.82
ARIN	6.7	1.56

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Class	Before	After	Total
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34%

51%

Visibility of the transferred blocks in the routing table

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RIR	Latency (Avg. months)	Remaining Addresses (/8s)
RIPE	1.1	0.85
APNIC	2.4	0.82
ARIN	6.7	1.56

Buyers need addresses more than sellers

- Utilization* of non-transferred address space for sellers/buyers:

RIR	Sellers	Buyers
ARIN	0.9%	5%
APNIC	2.5%	8%
RIPE	5.3%	19%

**ISI Census data (July 2012)*

- Utilization of blocks before being transferred

ARIN – 0.8%
APNIC – 3.9%
RIPE – 2.9%

Overall utilization of all non-transferred blocks was 9.4%

- Most of the sellers and buyers are registered in different countries

IPv4 Market and IPv6 adoption

- 52 % of buyers originated IPv6 prefixes, which is more than the overall fraction of ASes that originate IPv6 prefixes (20%)
- 48% of buyers went to the IPv4 market before deploying IPv6

May be too early to understand the impact of markets on IPv6 adoption. But we should not expect IPv6 deployment to eliminate the need for IPv4 addresses

- Estimated size of the IPv4 market ($11.25/address*)
  - Use the published list of transfers ;
  - Total value : ~ $130 million (11515904 IP addresses);

* - Microsoft – Nortel (2011)

Detecting transfers

- Transfers need to be approved by the RIRs
- But no mechanism currently exists to enforce organizations to report transfers to the RIRs

  What if transfers are already happening on the grey-market?

- We need a way to detect transfers “in the wild”
- Available data: BGP (Route views and RIPE)

Inferring transfers in BGP data

- Methodology:
  - Collect routing tables
  - Construct Prefix – AS mappings;
  - Candidate transfers : prefix for which there is a change in origin AS;

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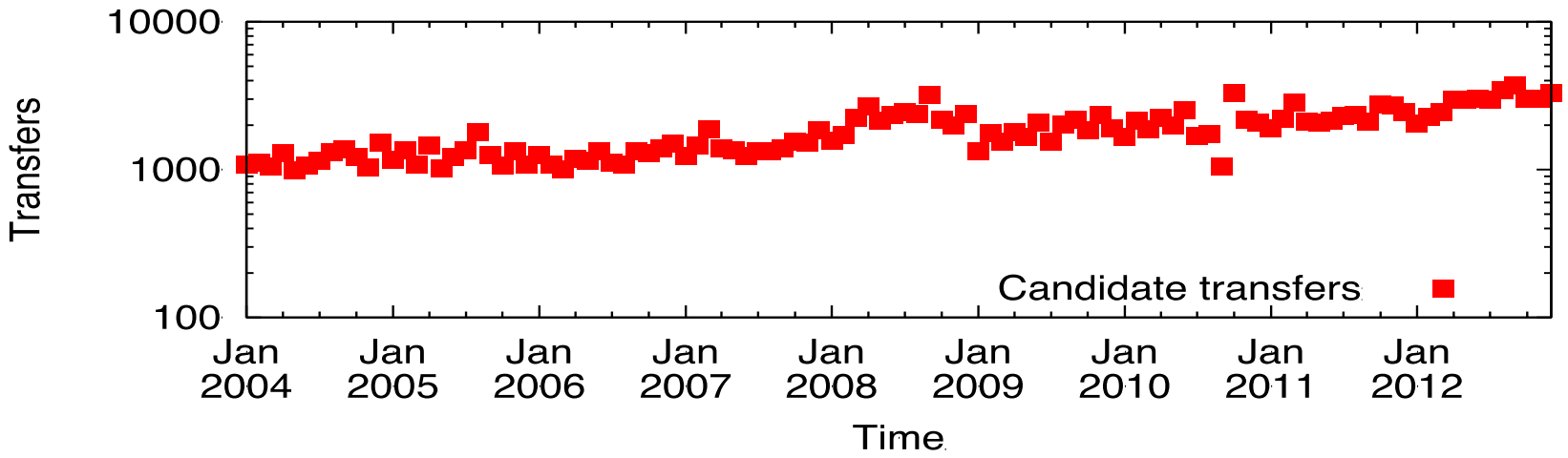
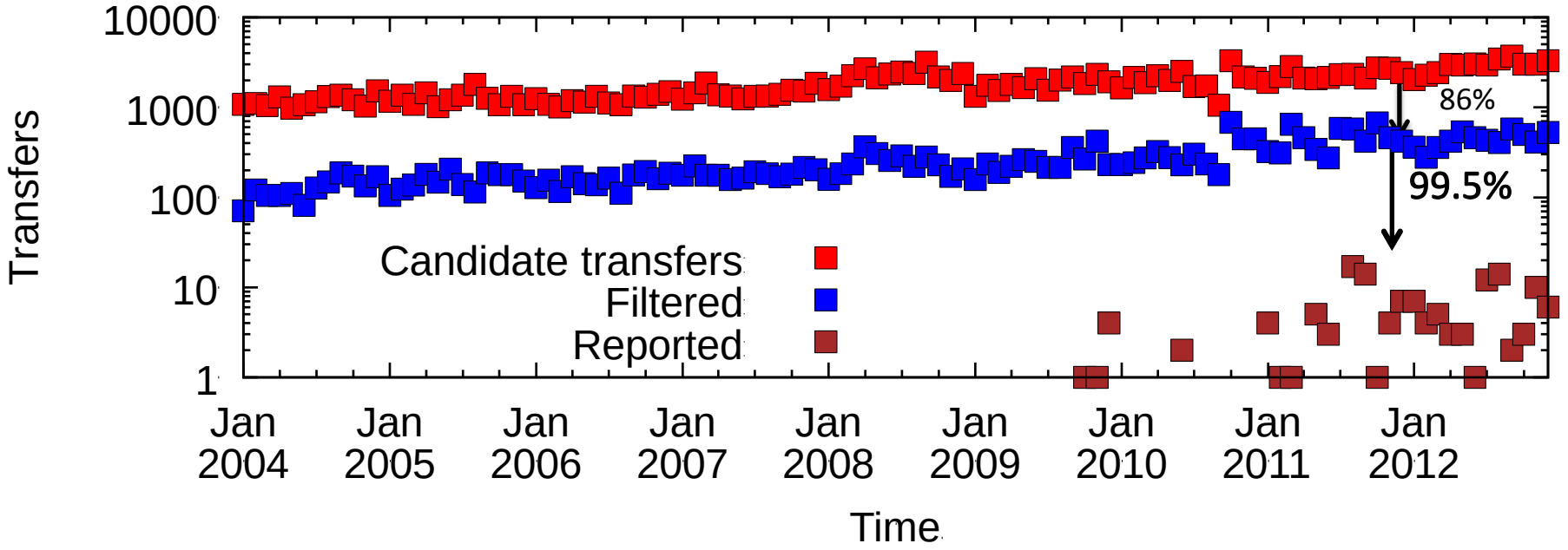


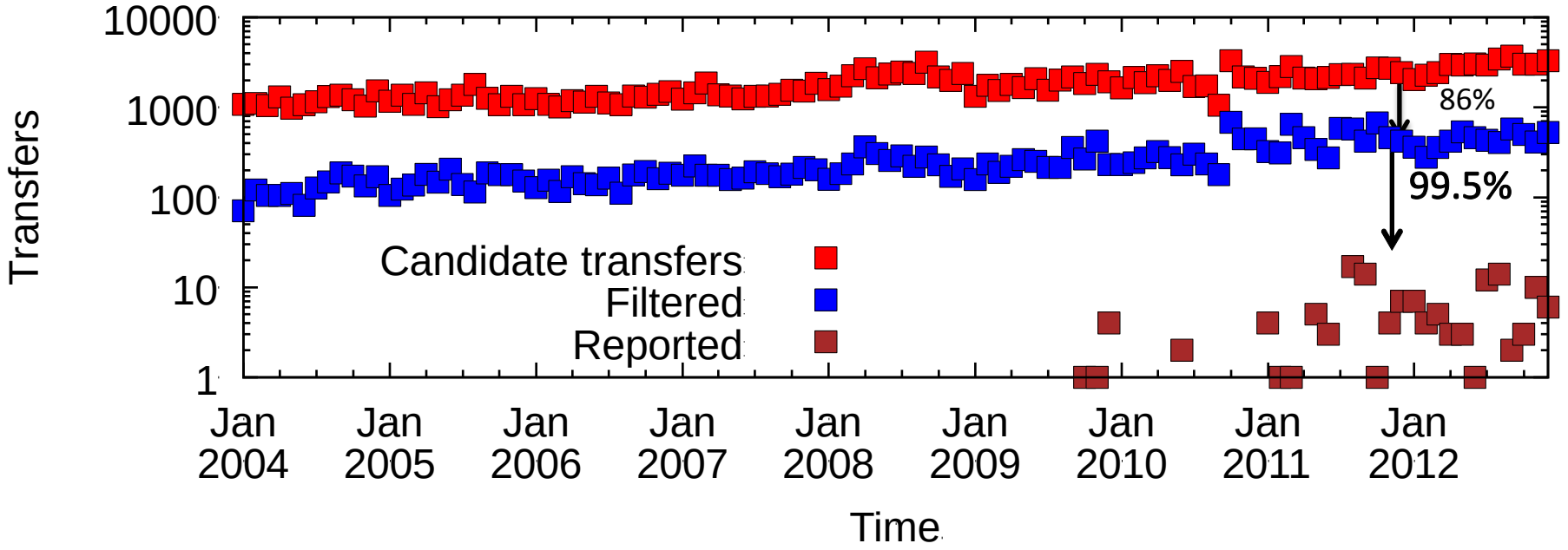
Goal: reduce the number of candidate transfers to a number feasible to examine manually

- Designed 10 filters to remove origin-AS changes due to reasons other than transfers

Results


Transfers
10000
1000
100
10
1
Candidate transfers
Filtered
Reported
86%
99.5%
Jan 2004
Jan 2005
Jan 2006
Jan 2007
Jan 2008
Jan 2009
Jan 2010
Jan 2011
Jan 2012
Time

Results



- Validation: use published transfers(routed before and after)

Total	Undetectable	False negative	Detected
144	68*	31*	45

- Most of the false negative – APNIC non-market transfers

Conclusions

- Published transfers are increasing over time
  - Most transfers come from legacy allocations
  - IPv4 transfer market seems to serve its intended purpose
- An attempt to detect transfers “in the wild”
  - Our filters reduced the number of candidate transfers by an order of magnitude
  - In spite of filtering, the noise in BGP data produces an order of magnitude more candidate transfers than the published ones
- We are currently exploring augmenting BGP data with other sources of data such as DNS and data-plane measurements