Are We Growing Fast Enough?

A snapshot of the global IPv6 routing table

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NANOG 51, Miami
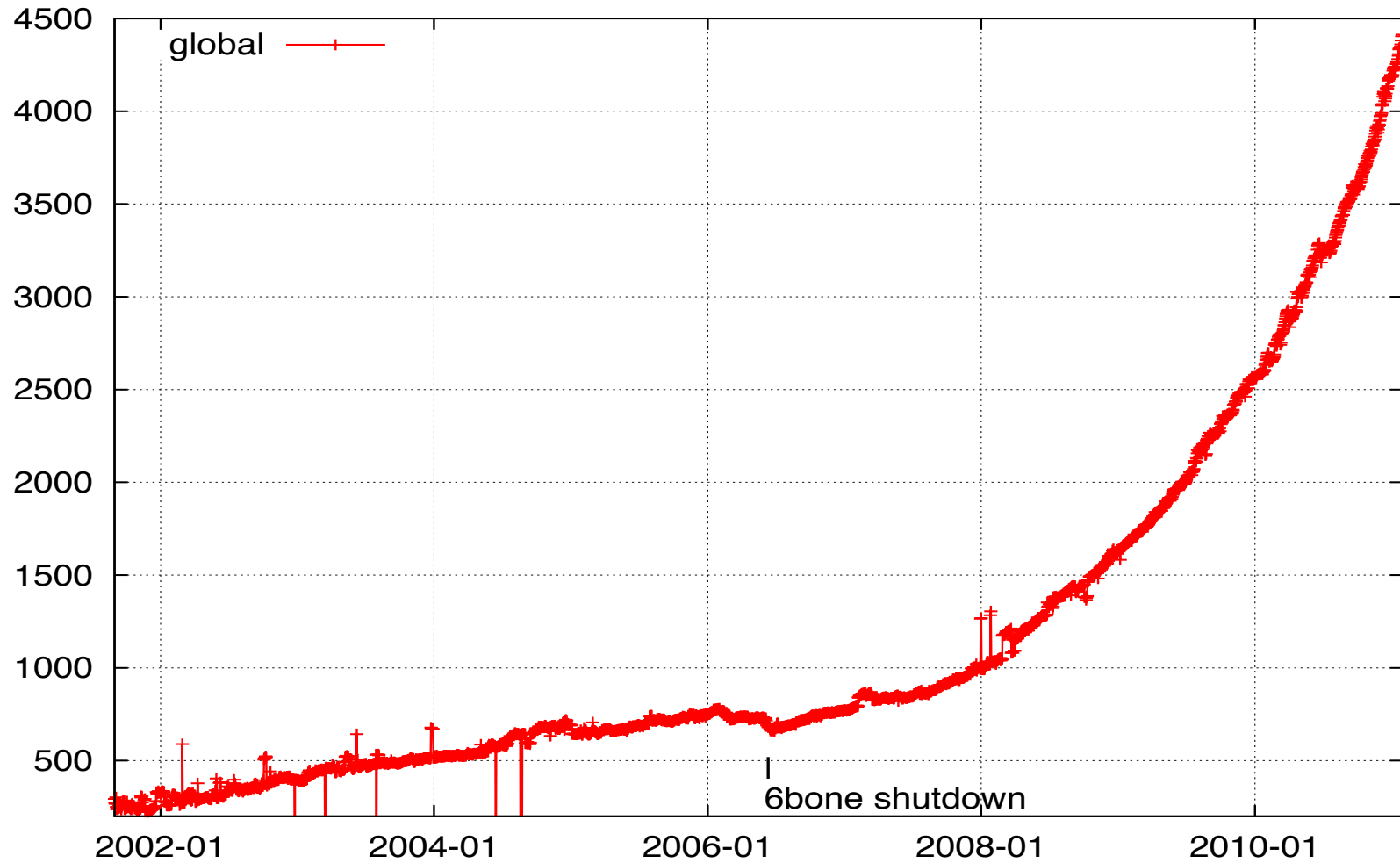
presented by CJ Aronson

Overview

- pictures & trends

- numbers. . .

- things that should not be there. . .

- route6 current practices
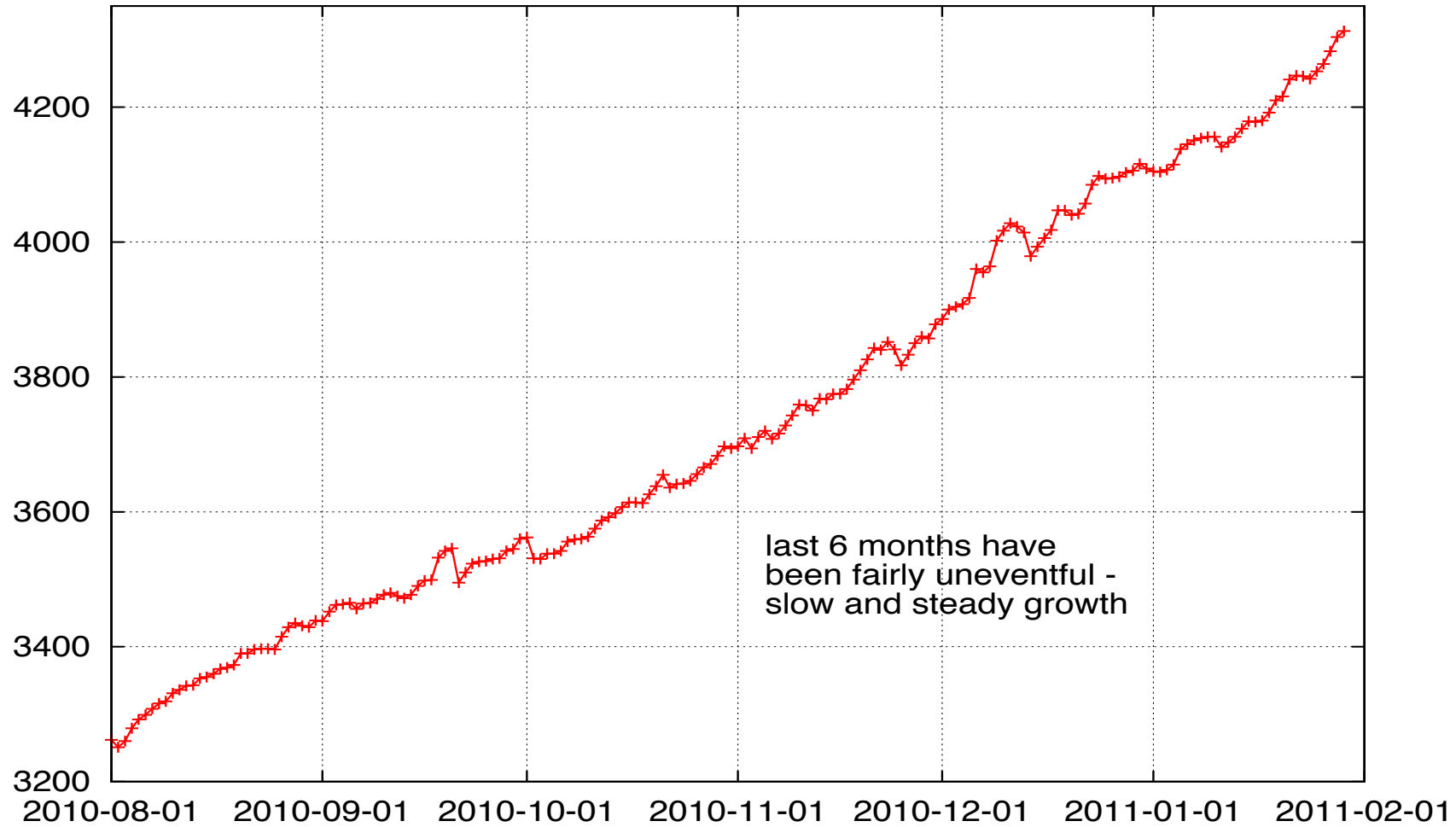
- references

Slides online at:

http://www.space.net/˜gert/RIPE/NANOG51-v6-table.pdf

Prefixes in BGP Table

Graphics: Total Prefixes - 9.5 years

Graphics: zoom into last 6 months

last 6 months have
been fairly uneventful -
slow and steady growth

Graphics: trends? (38 months)

least-squares quadratic fit model
matches data surprisingly well

so we're back to a 'typical'
internet growth curve
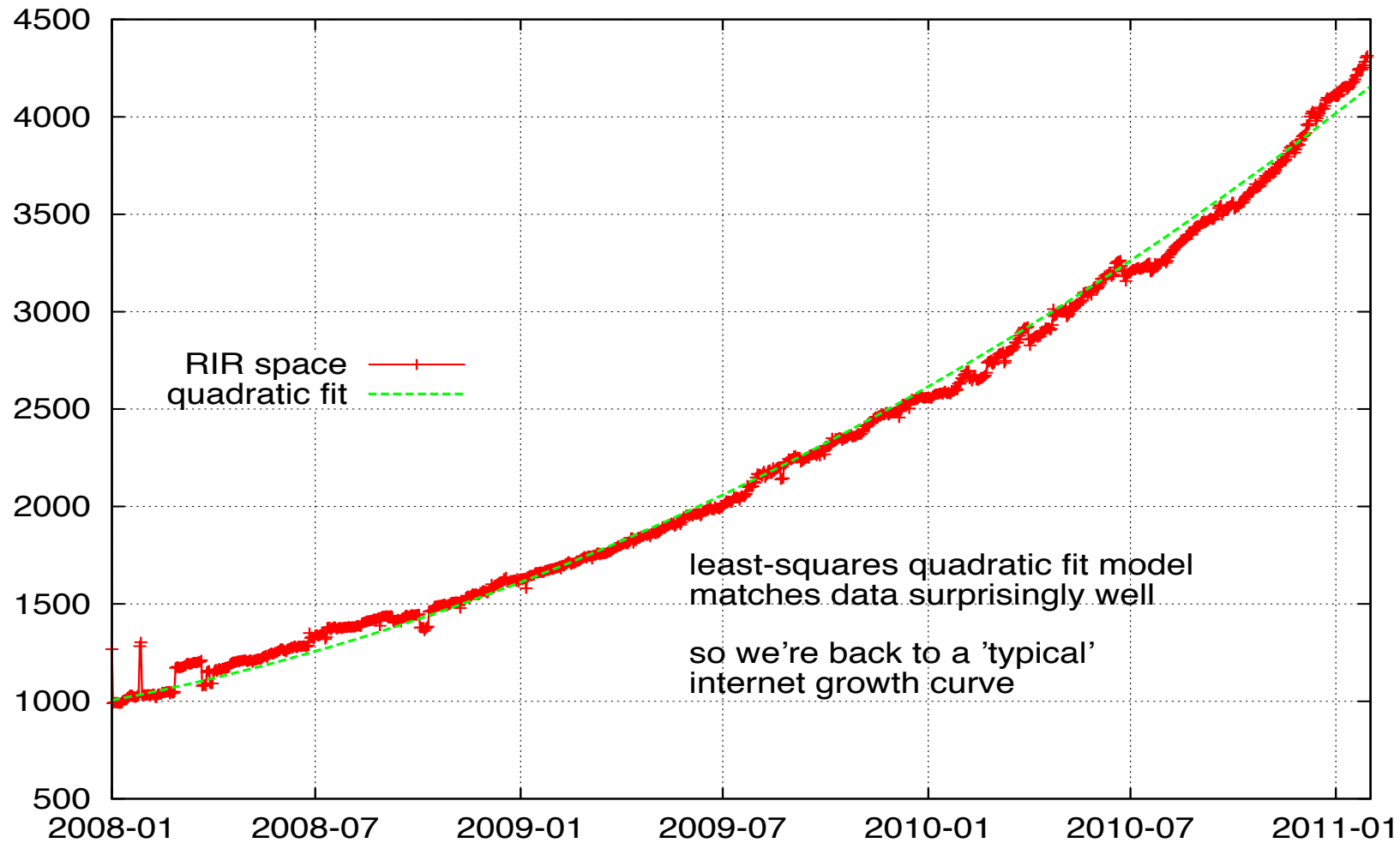
Graphics: prefixes by RIR region
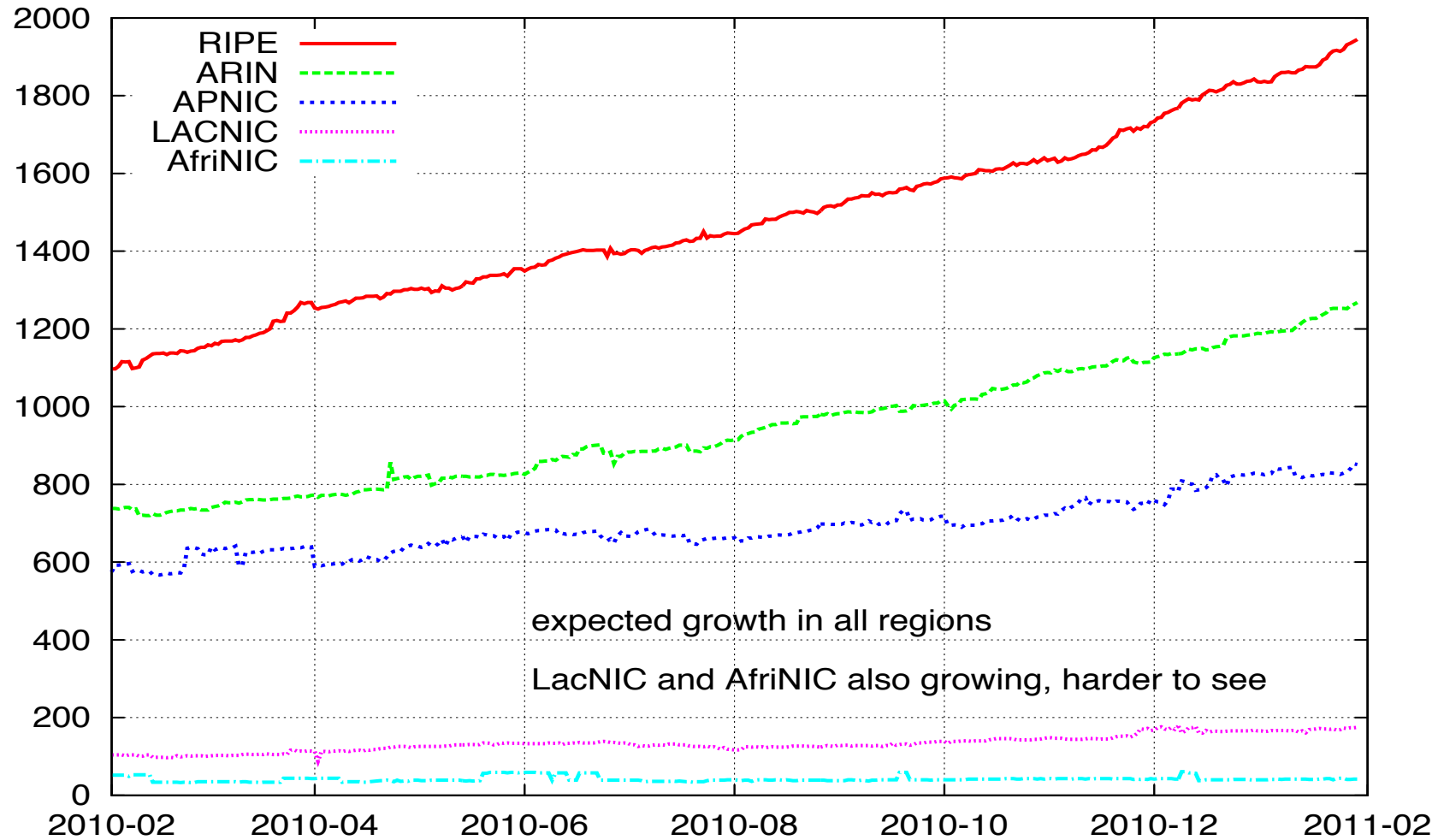
Graphics: prefixes by country (RIPE)
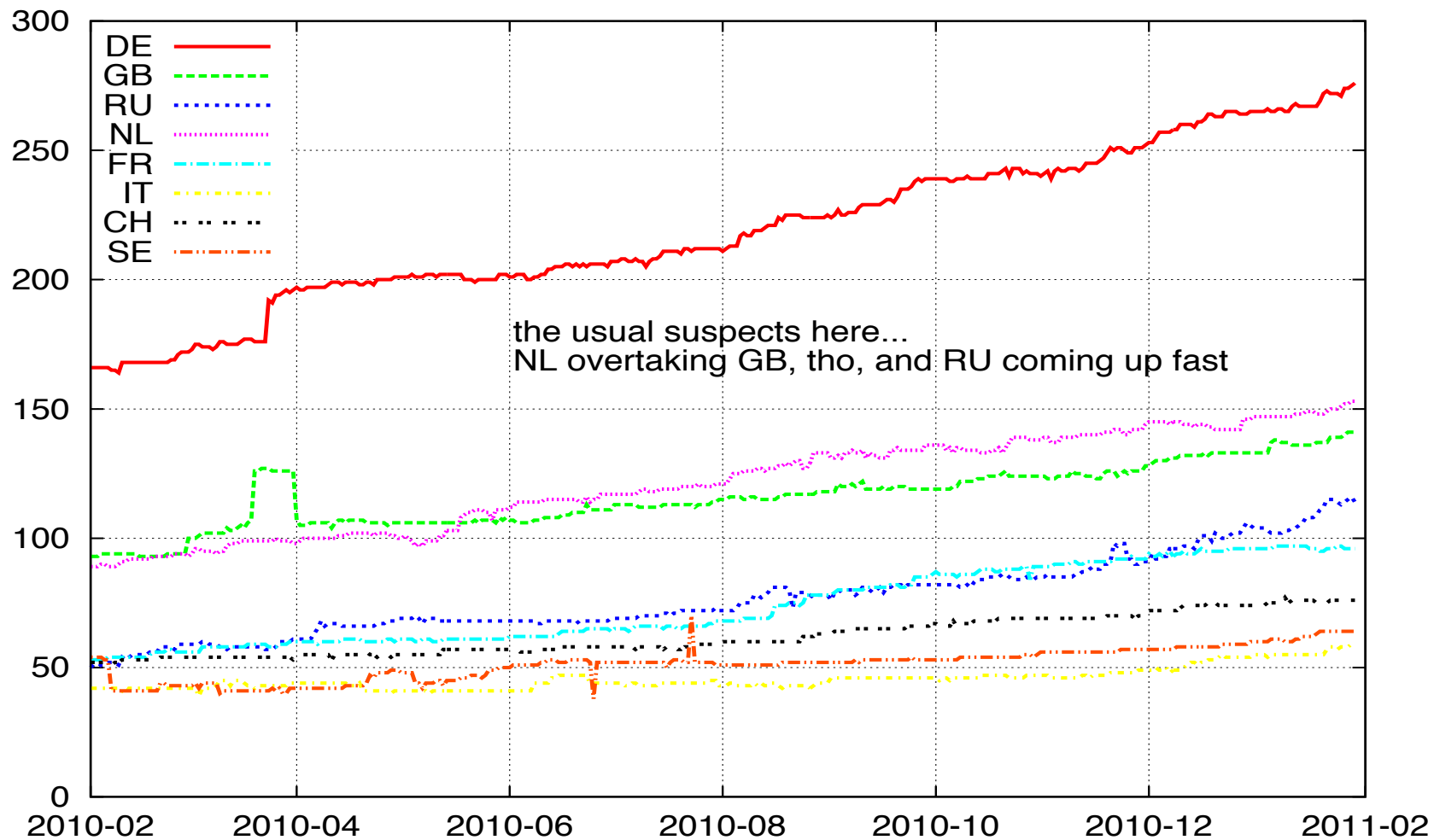
the usual suspects here...
NL overtaking GB, tho, and RU coming up fast

note: graph shows top 8 countries by number of RIR allocations

Graphics: prefixes by country (APNIC)

note: graph shows top 8 countries by number of RIR allocations

Graphics: prefixes by country (ARIN)

political structure in ARIN land makes
by-country statistics somewhat less-than-exciting...

interesting country codes showing up
in ARIN stats files, though

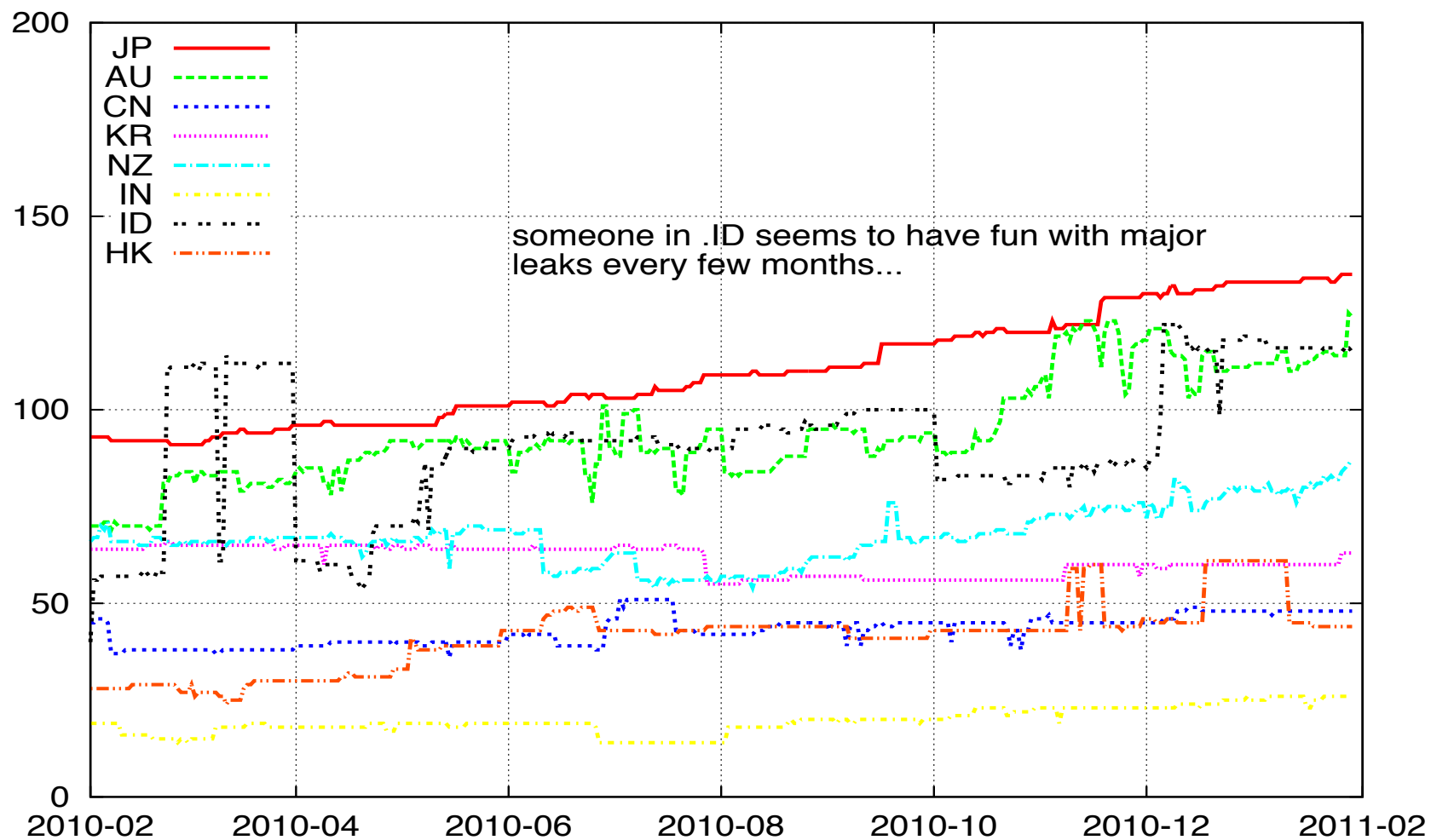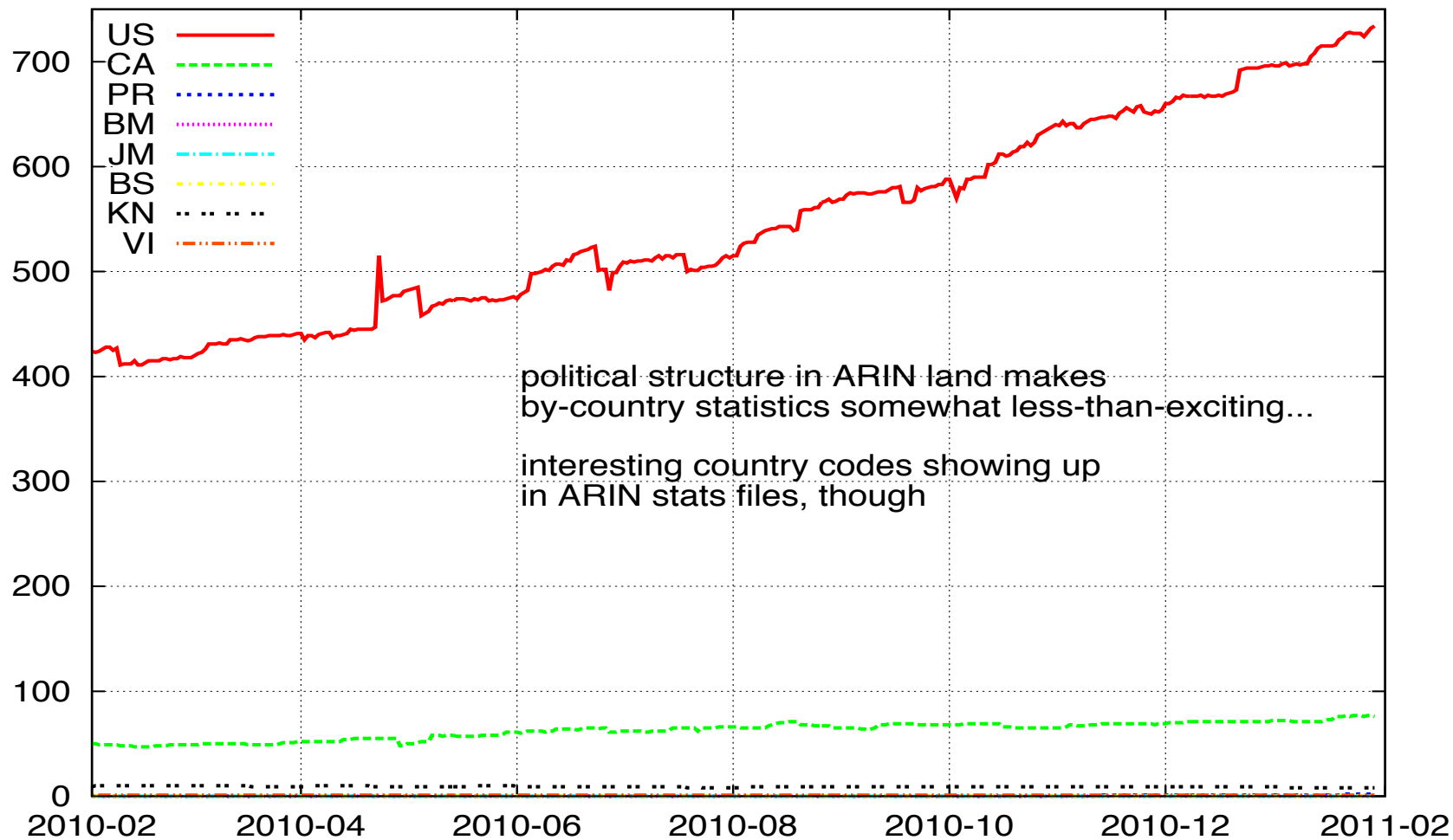note: graph shows top 8 countries by number of RIR allocations

Graphics: prefixes by country (LACNIC)

note: graph shows top 8 countries by number of RIR allocations

Graphics: prefixes by country (AfriNIC)

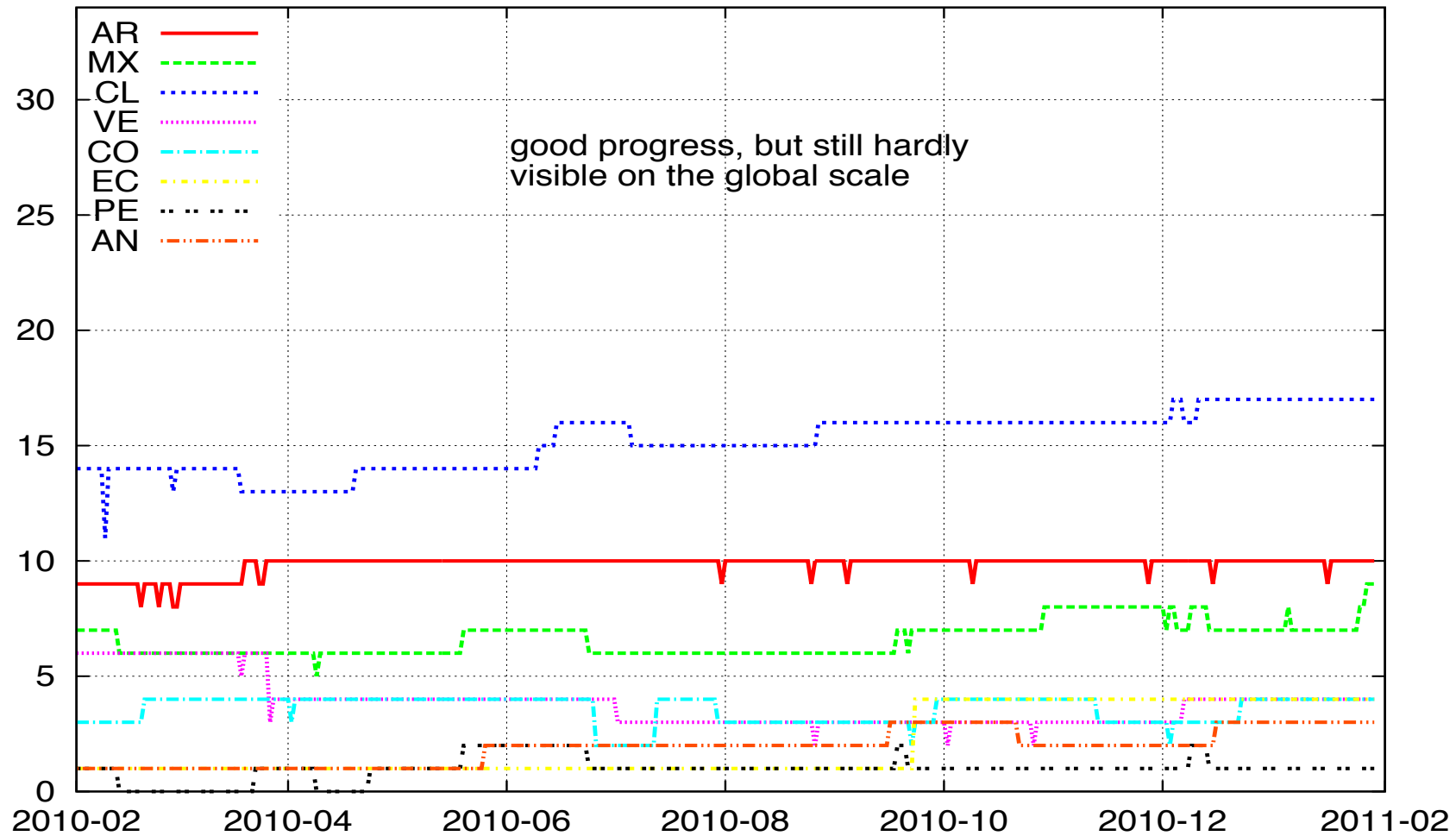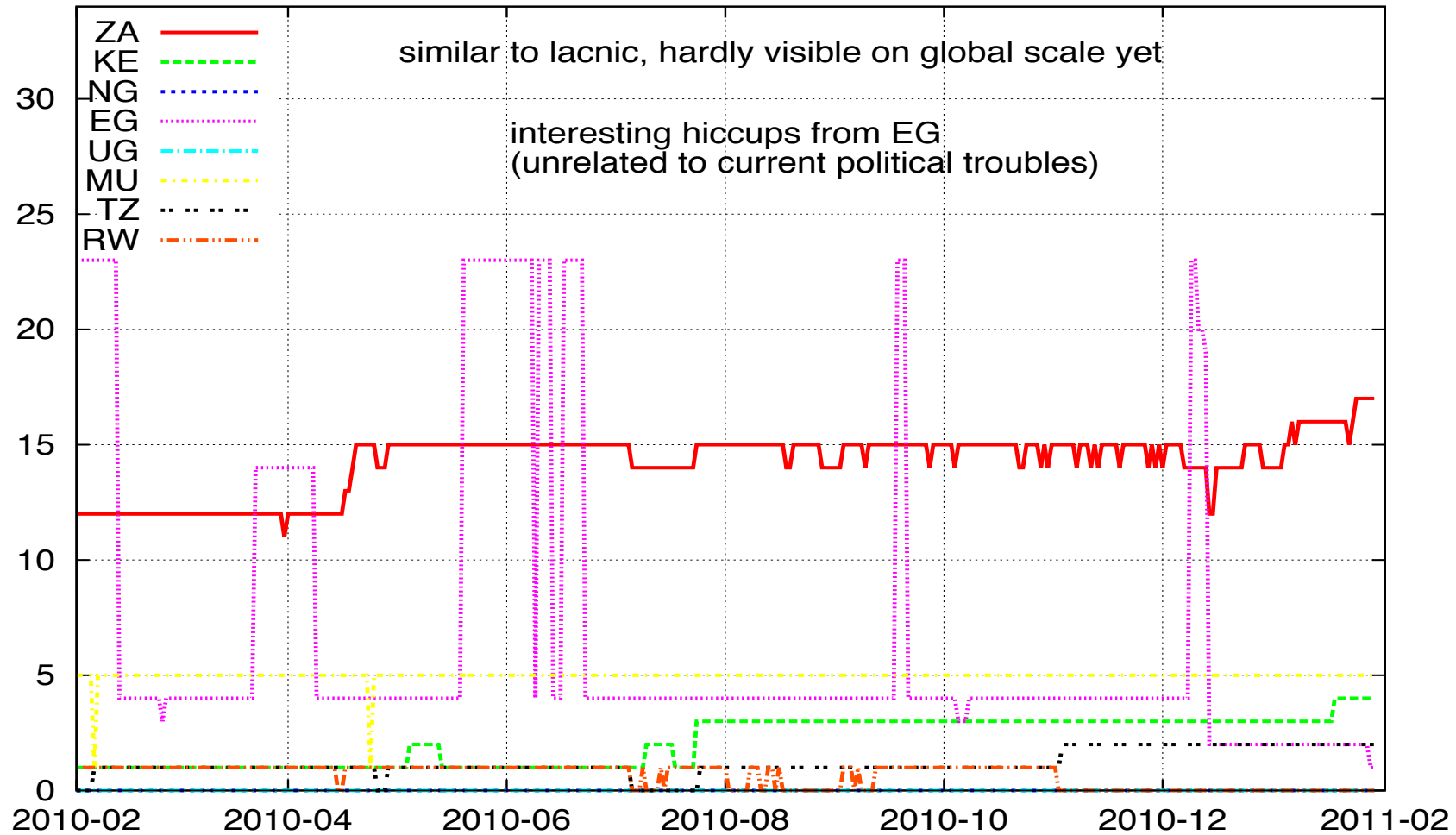similar to lacnic, hardly visible on global scale yet

interesting hiccups from EG
(unrelated to current political troubles)

ZA
KE
NG
EG
UG
MU
TZ
RW

note: graph shows top 8 countries by number of RIR allocations

AS Numbers

Numbers - AS numbers

- as of 2011-01-23: 2981 unique AS#s visible (2009-10-04: 1674)
  - 2214 origin-only ASes (no transit paths seen) (1207)
  - 706 ASes originate & give transit (419)
  - 61 transit-only ASes (e.g. 276, 567, 1998, 6667, . . .) (48)
- different number of prefixes announced
  - 2457 ASes originate 1 prefix (1403)
  - 265 ASes originate 2 prefixes
  - 77 ASes originate 3 prefixes
  - 42 ASes originate 4 prefixes
  - 79 ASes with "more than that", max. is 39 & 40 prefixes
- note: all paths observed from AS5539
- note: numbers skewed by ~36 4-byte-ASes (old collector sw)

Graphics: AS Numbers (v6 BGP)
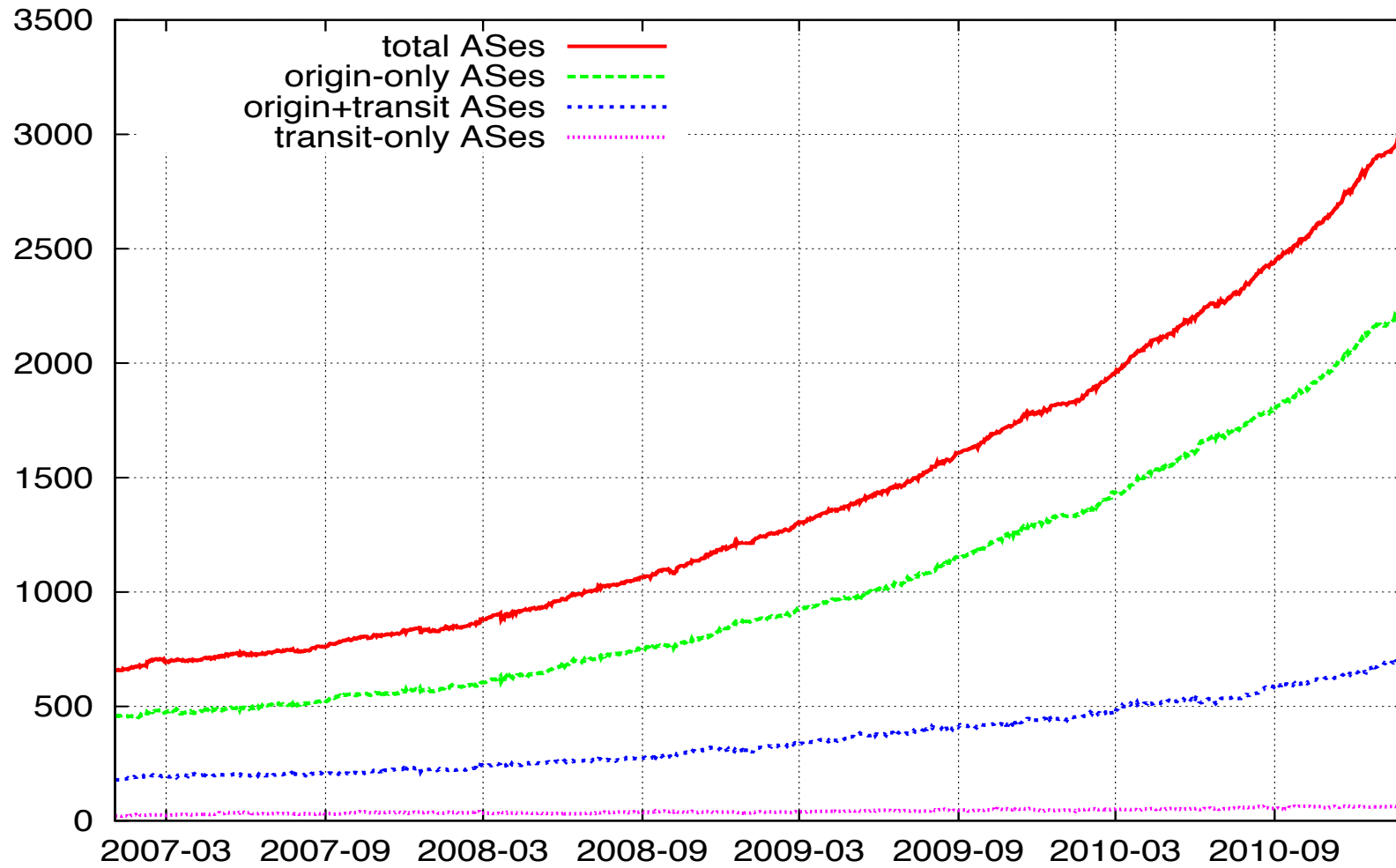
Graphics: AS Numbers (v4 BGP)

total ASes (IPv4 BGP)

IPv4 still growing fast

yearly increase in IPv4 ASes (+3100)
is still higher than total(!)
number of IPv6 ASes (2940) :-(

Graphics: AS Number Ratio (v6 BGP/v4 BGP)

ratio (ASes in IPv6 BGP/ASes in IPv4 BGP)

at first glance, this looks like a nice growth...
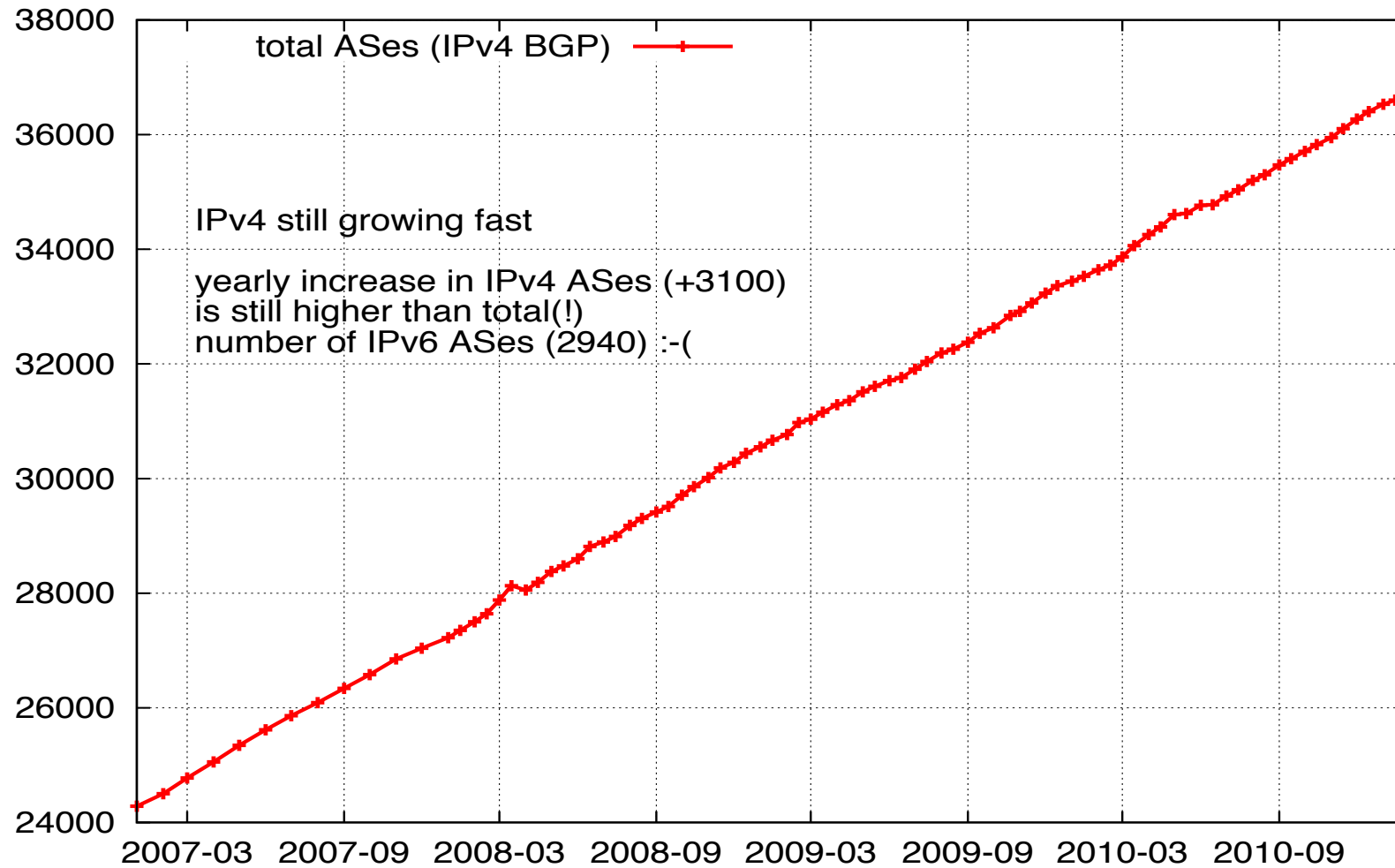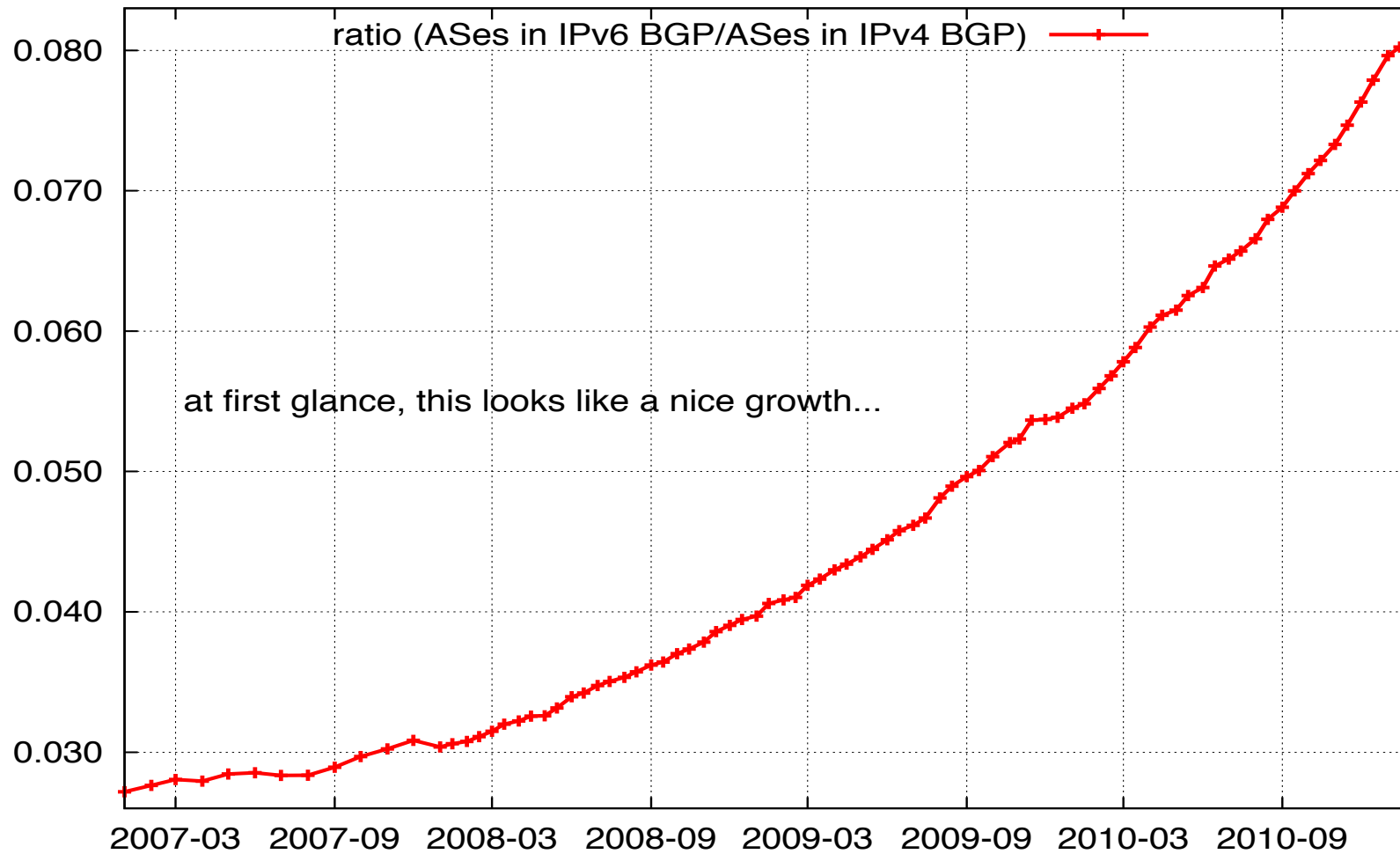
Graphics: AS Number Ratio (v6 BGP/v4 BGP)
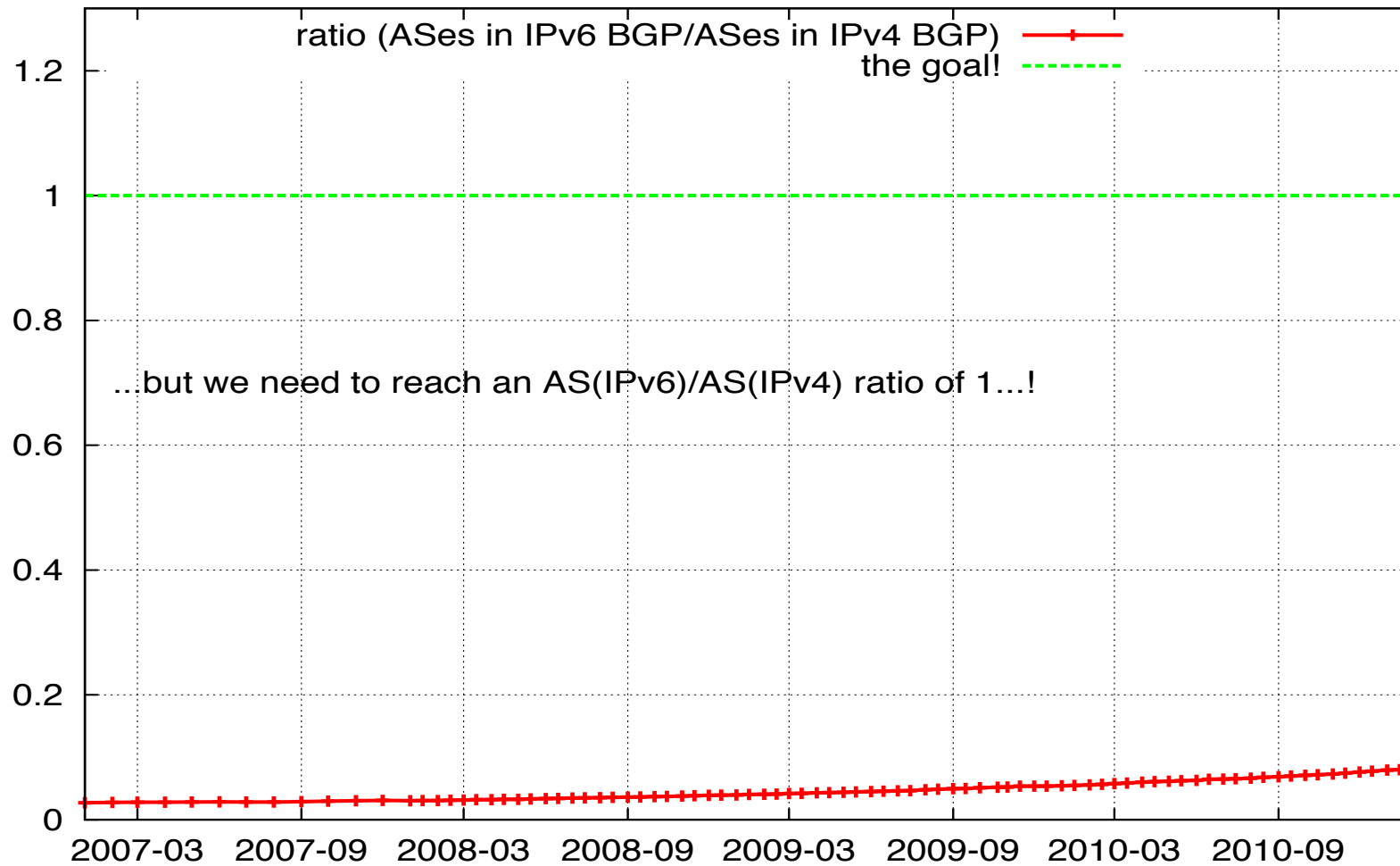
Numbers: ASes and AS ratio

- so we see nice growth in ASes participating in IPv6 BGP

- . . . but IPv4 BGP growth is still very fast

- ratio of "ASes with IPv6" to "ASes with IPv4" *is* growing

- ratio is not growing fast enough!

- at the current growth rate, it will take 6+ years for all ASes to have IPv6

- **brace yourself for the impact!**

(. . . insert small picture of train wreck here)

Graphics: Prefixes per AS (v4+v6)

IPv4 prefixes per AS
IPv6 prefixes per AS

in IPv4, average (mean) IPv4 prefixes per AS = 10.5
in IPv6, average (mean) IPv6 prefixes per AS = 1.4

--> theoretically, IPv6 could reduce routing table size by factor 7
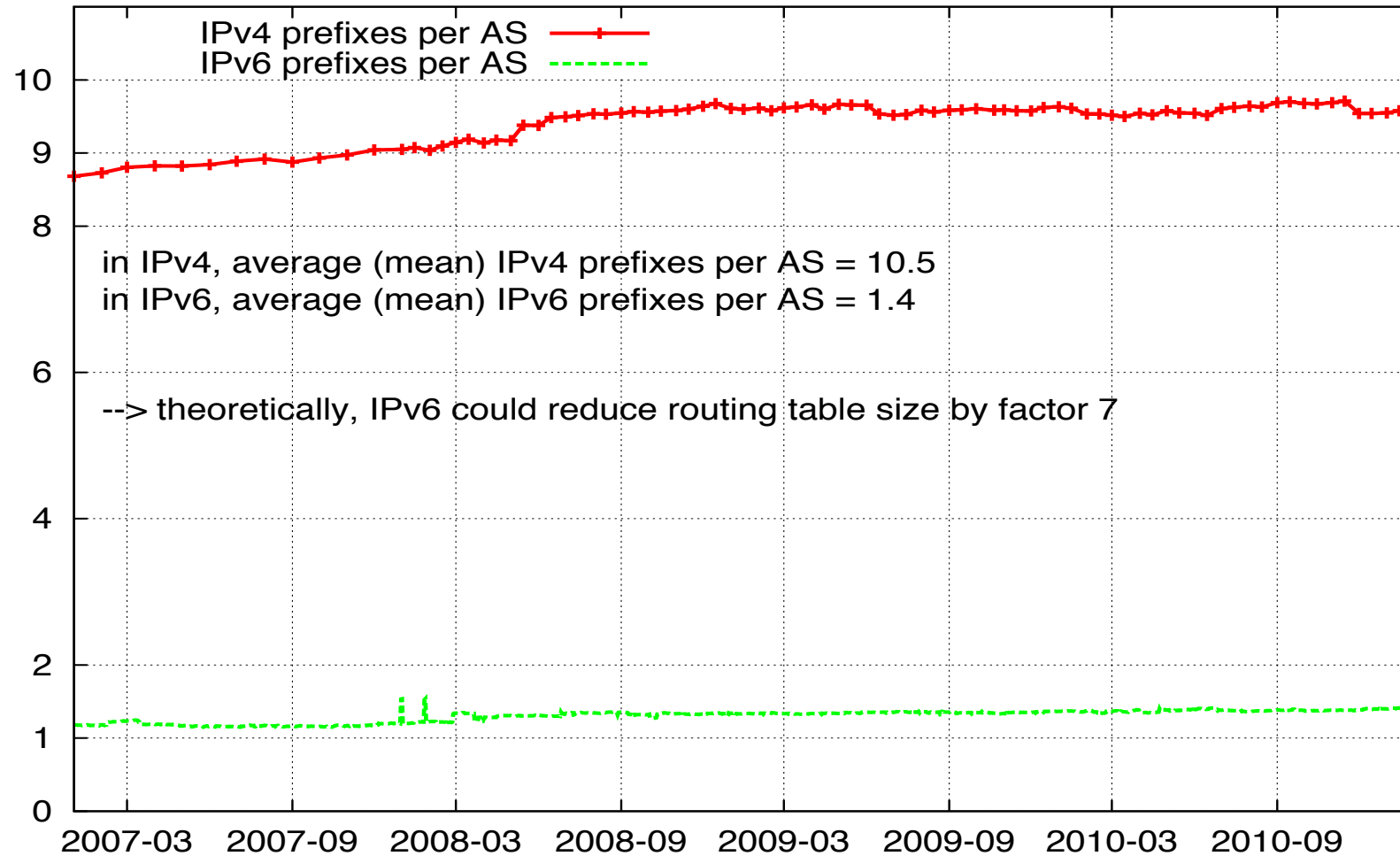
ASes - why are people announcing 2+ prefixes

- /35 to /32 migration: 2 RIR prefixes, *temporary (?)*

```
2001:420::/35          109 i
2001:420::/32          109 i
```

- ISP/LIR address space plus IXP prefixes

```
2001:5000::/21         1273 i    (C&W LIR space)
2001:7F8:2B::/48       1273 i    (IXP: INXS HAM)
2001:7F8:2C::/48       1273 i    (IXP: INXS MUC)
```

- mergers and acquisitions, business units, customer pfxs, ...

```
2001:218::/32          2914 i       NTT JP
2001:418::/32          2914 i       NTT America
2001:500:13::/48       2914 i       ARIN PI
2001:728::/32          2914 i       Verio Europe
```

- networks with multiple sites and multiple PI prefixes

```
2001:500:16::/48       3257 6453 12041 i   Afilias
2001:500:17::/48       12041 i             Afilias
2001:500:18::/48       12041 i             Afilias
2001:500:19::/48       2914 12041 i        Afilias
2001:500:1A::/48       3257 6453 12041 i   Afilias
2001:500:1B::/48       12041 i             Afilias
```

Looking at Prefixes again

Numbers - Prefixes

As of 2011-01-23: 4210 prefixes in total (2009-10-02: 2232)

/n	global	RIPE	APNIC	ARIN	Lacn.	Afri.	oth
/16	1	0	0	0	0	0	1
/19	2	2	0	0	0	0	0
/20..23	14	7	7	0	0	0	0
/24..27	14	9	3	2	0	0	0
/28..31	30	9	8	7	5	0	1
/32	2482	1397	408	528	112	31	6
/33..34	77	36	20	13	8	0	0
/35	54	14	32	8	0	0	0
/36	78	24	36	16	2	0	0
/37..39	13	4	1	6	0	0	0
/40..41	118	19	10	85	3	2	0
/42..47	101	32	21	56	0	0	0
/48	1188	344	282	517	36	8	1
/49..63	11	3	3	5	0	0	0
/64..128	17	10	2	5	0	0	0

Graphics - Prefixes / Size

unsurprisingly, majority of prefixes
is /32 (LIR) and /48 (PI)
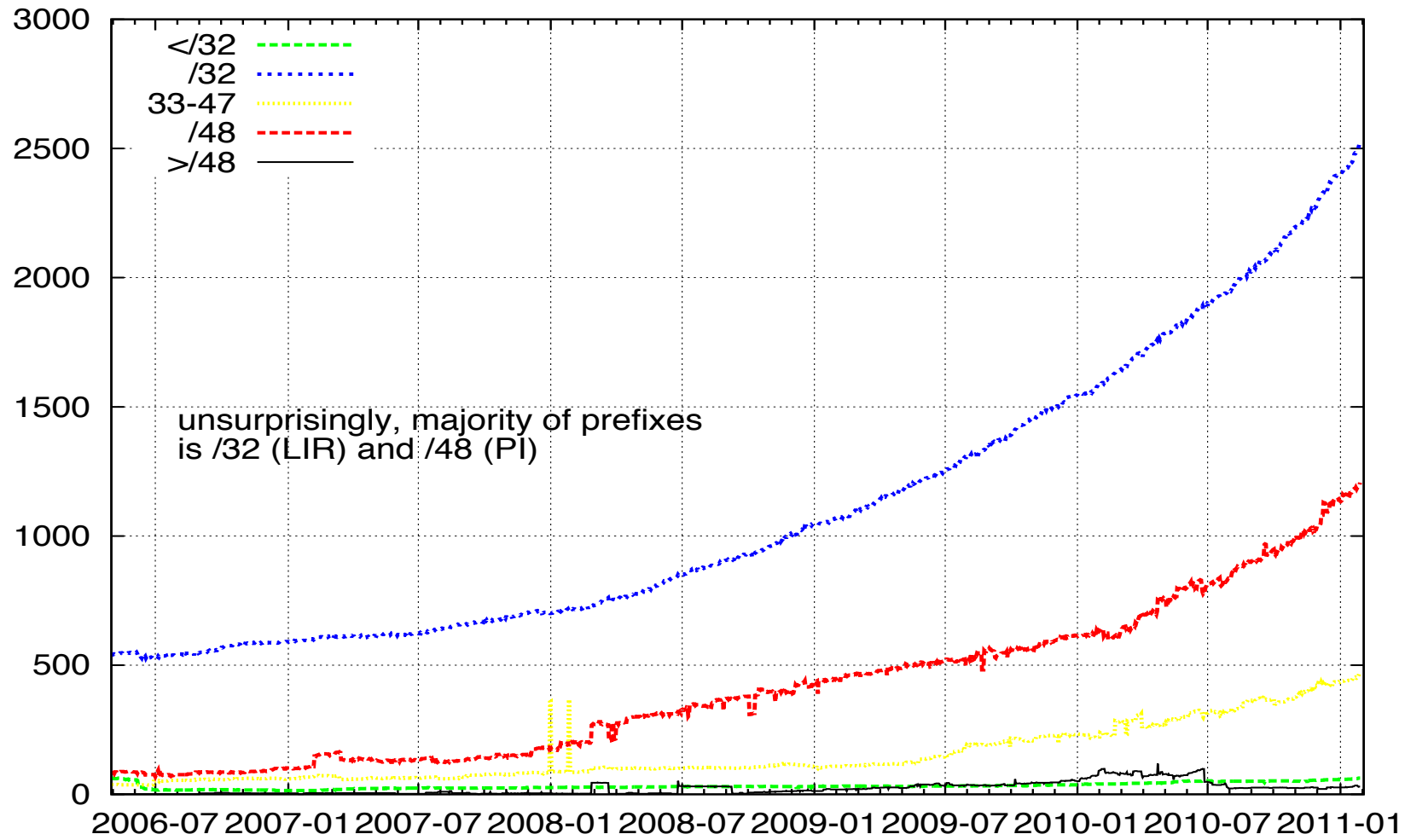
Allocations

Graphics: Allocations over Time

majority is still LIR alloc. (good!)
ARIN PI is catching up fast (good? bad?)
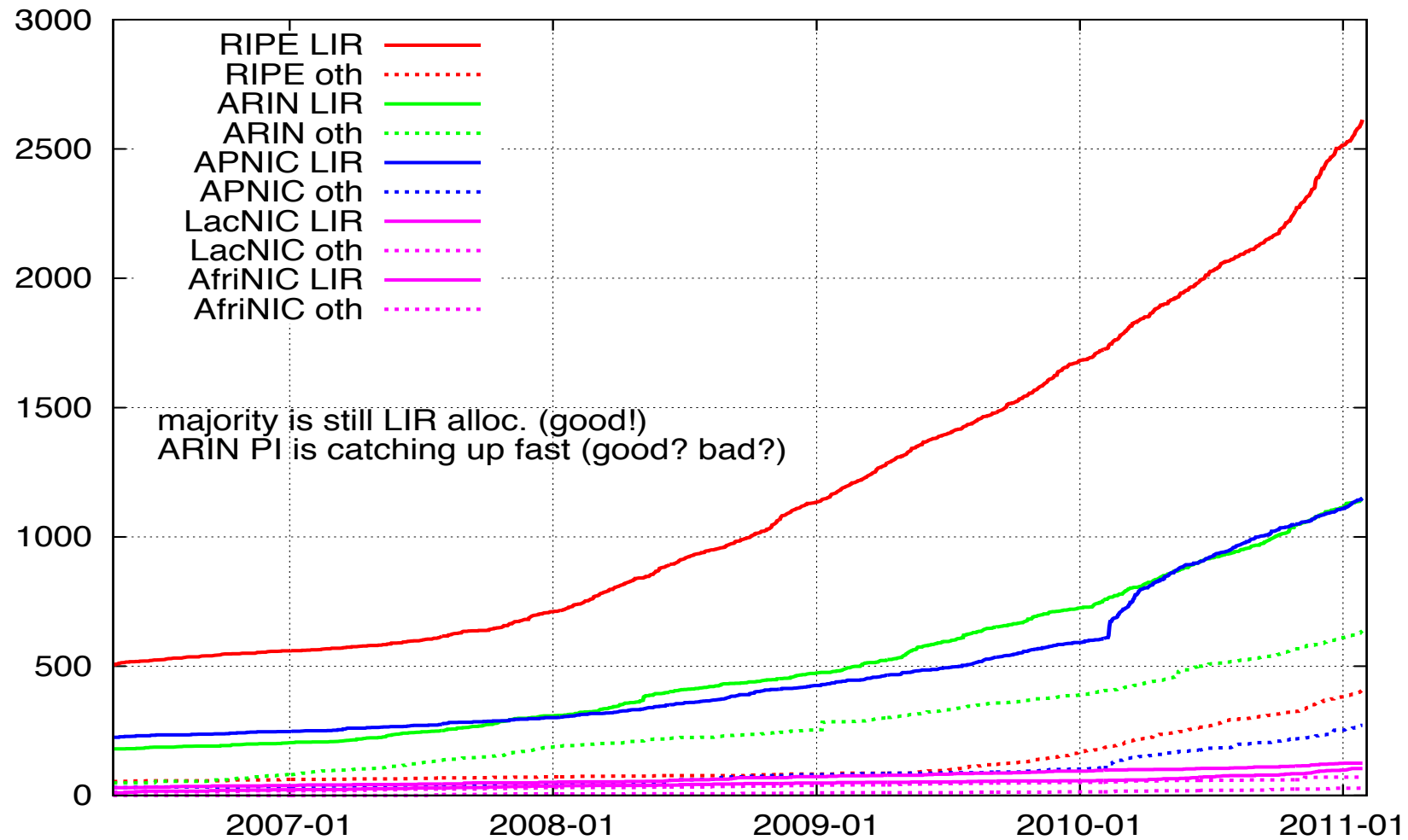
Graphics: Allocated vs. Routed (LIRs)
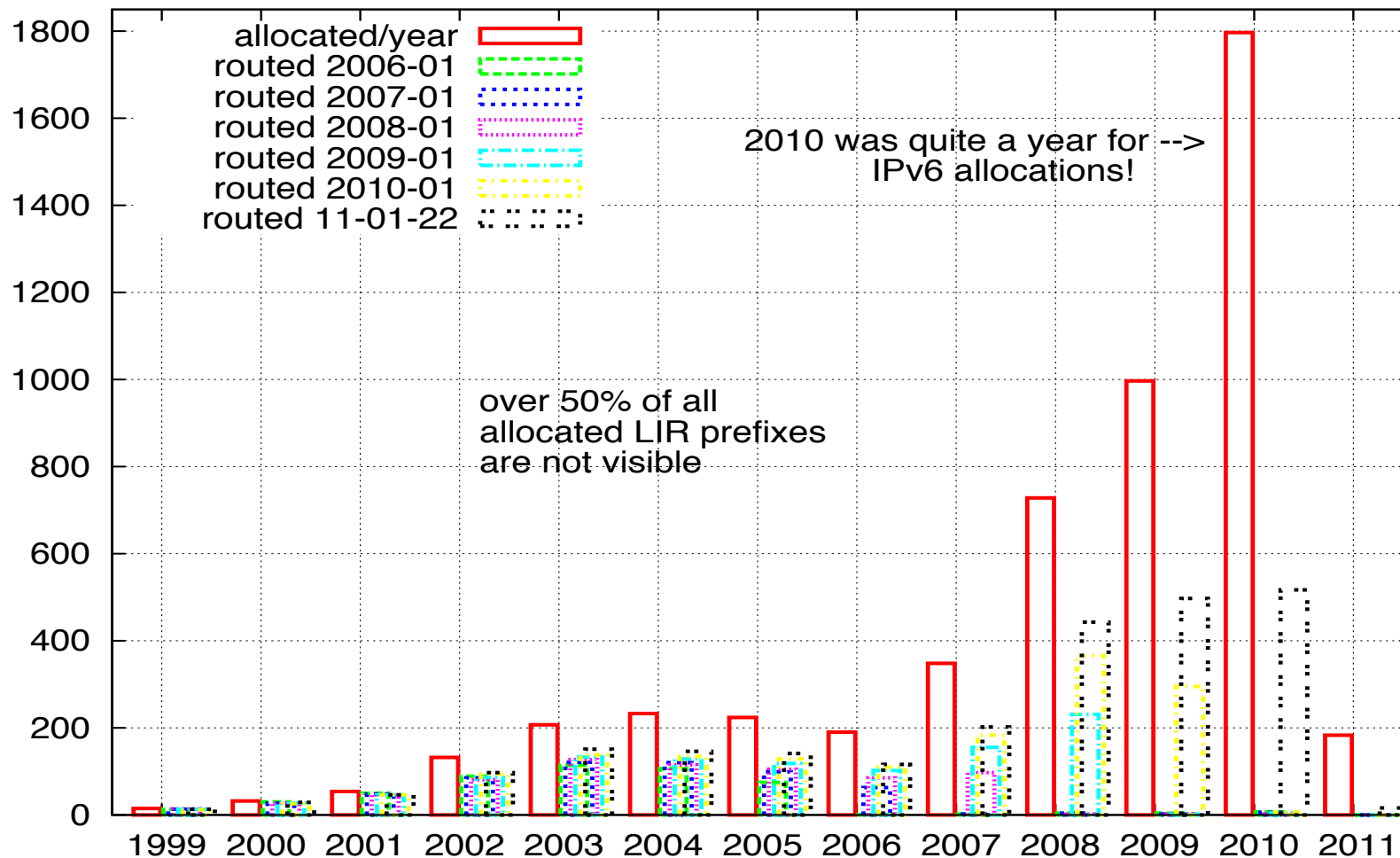
Allocated vs. Routed - by region & class

RIR	type	alloc.	visible	perc.	subnets	
ARIN	LIR	1137	487	43%	430	
	IXP	29	0	0%	0	
	Critical Inf.	122	46	38%	63	
	PI	466	129	28%	492	(*)
APNIC	LIR	1142	414	36%	334	
	IXP	20	1	5%	3	
	PI	248	53	31%	28	(*)
RIPE	LIR	2579	1410	55%	264	
	IXP	94	25	27%	0	
	Anycast DNS	28	19	68%	1	
	PI	273	159	58%	13	
LACNIC	LIR	122	39	32%	89	(NIR)
	Crit.Inf.+PI	74	23	32%	17	
AfriNIC	LIR	104	31	30%	5	
	PI	28	5	18%	0	

Weirdos

- this talk started out of a remark, "hey, there are some weird things in the BGP table, people might want to know about them"

- well, some 9 years later, there *still* are weird things...

Fat Fingers

```
   Network                 Path
 * D000::/8                109 30071 6762 28716 i
 * i                       3257 6762 28716 i
 * i                       1273 6762 28716 i
```

- in Table 2009/11/14-2010/01/15

- D000:* is completely outside IETF assigned unicast space

- upstream provider 6762 happily provides transit

More Fat Fingers

```
   Network                 Path
 *   2008:5A0::/32        109 6939 27792 i
 *                        3320 6939 27792 i
 *>i                      6939 27792 i
```

- in Table 2010/12/10-2011/01/23

- 2008:* is not allocated by IANA to any RIR yet (*bogon!*)

- upstream provider 6939 happily provides transit

Really Fat Fingers

```
   Network                  Path
 *>i1A:F000::/24        3257 174 376 376 376 36786 i
 * i                    3257 174 376 376 376 36786 i
 * i1000::/8            1273 174 376 376 376 i
 *>i                    1273 174 376 376 376 i
 *   10C0:1100::/24     109 6175 1239 174 376 376 376 851 i
 *>i                    1273 174 376 376 376 851 i
```

- in Table 2010/05/15-2010/07/06

- 1***:* is not allocated by IANA to any RIR yet (*bogon!*)

- upstream provider 174 happily provides transit

Do You Need More?

- there's a few more bogon prefixes in the IPv6 BGP table...

- typos at leaf nodes **do** happen

- but open and unfiltered transit setup at upstream ISP should be highly embarrassing - **you** are the experts, don't permit typos to propagate to the world

- prefix filtering for IPv6 BGP customers is straightforward "BGP 101"

- OTOH, the slow start in setting up IPv6 IRRs in most regions wasn't helping things either

- as of today, at least the 3 big RIRs have functional IPv6 IRR-DBs, so *there is no excuse anymore for not filtering incoming customer BGP announcements*
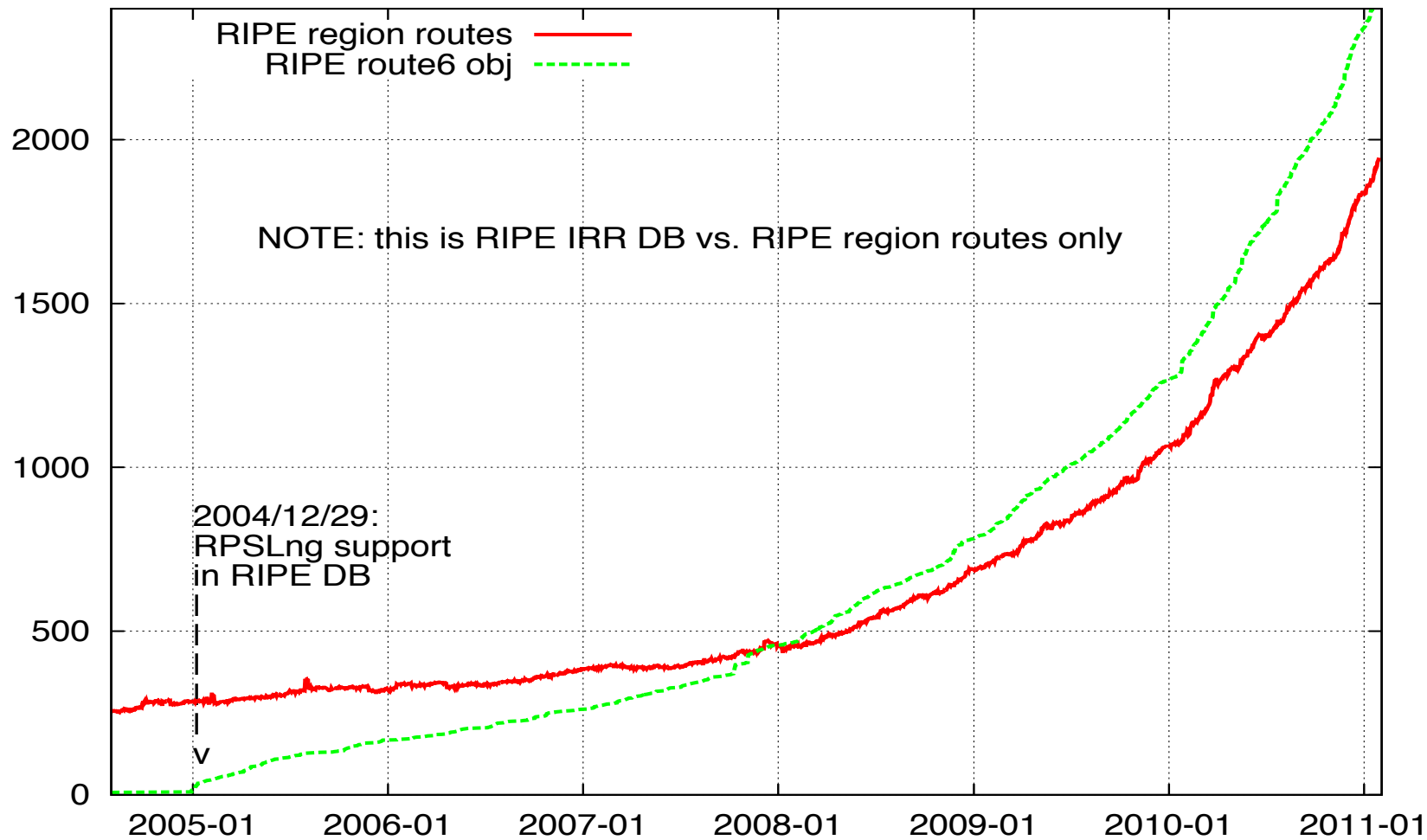
Most Specific Wins

- and the winner is...

```
      Network                   Path
 *  2001:1438:10:5::20/124   13237 8881 8881 196870 i
 *>i                         8881 196870 i
 *> 2A02:28:4:2::/121        13237 8359 i
 *> 2A02:28:4:2::1:0/127     13237 8359 i
 *> 2A02:28:4:2::4:0/125     13237 8359 i
```

- I think the winner is AS196870 - long AS#, *and* long prefix!

- but seriously: whatever the outcome of the discussions about "how much deaggregation is OK?" - the usefulness of prefixes longer than a /48 in the global table is doubtful

- did I mention "filters on customer BGP sessions" already?

Route Registry - route6

Graphics: route6 objects vs. routes seen

RIPE region routes
RIPE route6 obj

NOTE: this is RIPE IRR DB vs. RIPE region routes only

2004/12/29:
RPSLng support
in RIPE DB

route6 correlation (RIPE region)

- on 2011-01-25:

  - 1253 BGP routes from RIPE region

  - 2447 route6: objects in RIPE DB

- correlation?

  - multiple origin route6's (26 2002::/16, 15x 2001::/32, ...)

  - $\Rightarrow$ 2376 route6 objects for *unique* prefixes

  - 108 route6 objects for prefixes from *other* RIRs...

- so...

route6 correlation (2)

- ... and this is what I found:

RIPE prefix, route6 ok	1569	:-)
RIPE prefix, route6 missing	271	!!!
RIPE prefix, route6 origin mismatch	68	
RIPE prefix, BGP inconsistant AS	2	
route6 objects without BGP route	631	???
other region, route6 ok	81	
other region, route6 missing	2192	
other region, route6 origin mismatch	27	
other region, BGP inconsistant AS	16	

- ⇒ close-up view shows "more work needed"

- in other RIR regions, situation is worse (no IRR DBs yet, etc.)

examples: route6 missing (bad!)

- just a few random examples - leaks? - but /32s as well!

```
2001:600:1C0::/48          BGP: 12702 12234
2001:67C:28::/48           BGP: 13237 8954 3943
2001:67C:34::/48           BGP: 6939 39700
2001:688::/32              BGP: 1273 5511
2001:6B8::/32              BGP: 3257 5609
2001:728::/32              BGP: 2914
2001:7F0:1:34::/64         BGP: 13237
2A00:1250::/32             BGP: 13030 48885
2A02:2230:100::/40         BGP: 1273 174 25467
2A02:2230:101::/48         BGP: 1273 174 25467
2A02:2230:1300::/40        BGP: 1273 174 25467
```

examples: route6, but no prefix

- maybe prefixes announced with limited scope only?

```
2001:648:2050:1000::/52  University of the Aegean Chios
2001:648:2050:2000::/52  University of the Aegean Samos
2001:648:2050:3000::/52  University of the Aegean Rhodes
2001:648:2050:4000::/52  University of the Aegean Syros
2001:648:2050:5000::/52  University of the Aegean Lemnos
2001:648:2050:6000::/52  University of the Aegean Athens
```

- these could be preparations for "soon to be announced"...?

```
2001:4C38::/32  AS15435, changed: 20071003
2001:4CE8::/32  AS250,   changed: 20060316
2001:4D20::/32  AS39290, changed: 20070315
2001:4D58::/32  AS25186, changed: 20051028
2001:4D80::/32  AS5606,  changed: 20051018
2001:4D98::/32  AS12429, changed: 20051026
```

examples: route6 origin mismatch (BAD!)

```
2001:8D0:2000::/35   BGP: 3320 1299 4589 20707
                     route6: origin: AS16210
2001:930::/32        BGP: 6939 1299 20965 8517 8517 8517
                     route6: origin: AS8386
2001:1AD0:8000::/33  BGP: 3257 24953
                     route6: origin: AS43556
2001:1B20::/32       BGP: 21385
                     route6: origin: AS8665
2A02:18::/32         BGP: 6939 5577 42652
                     route6: origin: AS44569
2A02:1668::/328      BGP: 6939
                     route6: origin: AS51088
2A02:24D8::/32       BGP: 13237 3356 21473
                     route6: origin: AS15945
```

route6 object example

- it's as easy as this...

```
route6:        2001:608::/32
descr:         DE-SPACE-2001-0608
descr:         SpaceNET AG, Munich
origin:        AS5539
notify:        noc@space.net
mnt-by:        SPACENET-N
changed:       gert@space.net 20041230
source:        RIPE
```

- strongly recommended, helps upstream/peer ASes build decent BGP filters, based on IRR data

route6 usage example

- it's as easy as this...

```
gert@moebius$ bgpq3 -l small-customer-in -6 AS5539
no ipv6 prefix-list small-customer-in
ipv6 prefix-list small-customer-in permit 2001:608::/32

gert@moebius$ bgpq3 -l large-customer-in -6 AS-SPACENET-V6
no ipv6 prefix-list large-customer-in
ipv6 prefix-list large-customer-in permit 2001:500:66::/48
ipv6 prefix-list large-customer-in permit 2001:608::/32
...
ipv6 prefix-list large-customer-in permit 2001:1488::/32
ipv6 prefix-list large-customer-in permit 2001:14d8::/32
...

(then copy-paste to router, or use in provisioning scripts)
```

- building filters is not hard (provided route6s are registered)

- http://snar.spb.ru/prog/bgpq3/

Questions?

gert@space.net

... and to answer the question from the title page:
NO, we are **not** growing fast enough!