

Have We Reached 1000 Prefixes Yet?

A snapshot of the global IPv6 routing table

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RIPE 55, Amsterdam

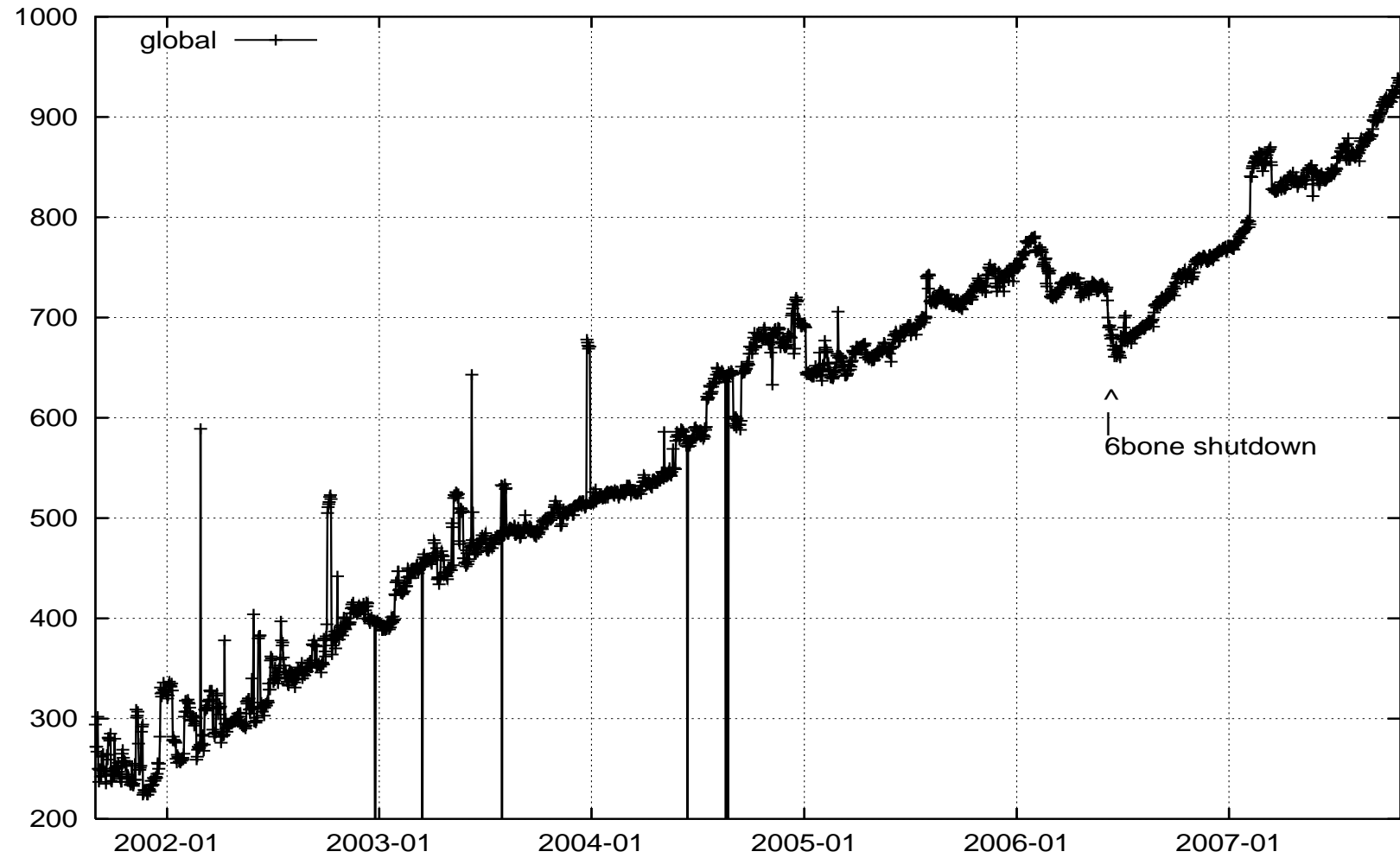
Overview

- pictures & trends
- the end of the 6bone
- numbers...
- references

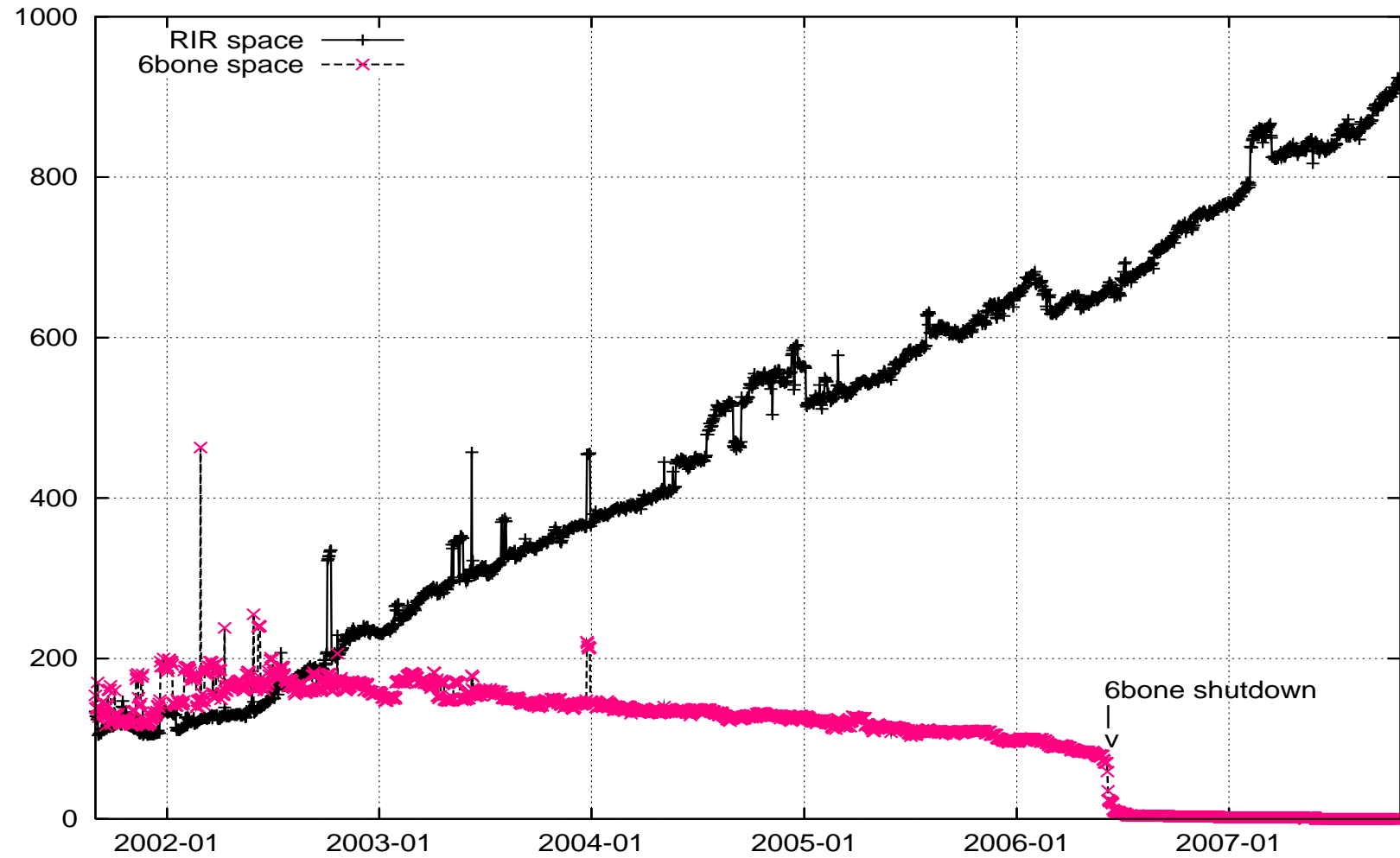
Slides online at:

<http://www.space.net/~gert/RIPE/RIPE55-v6-table/>

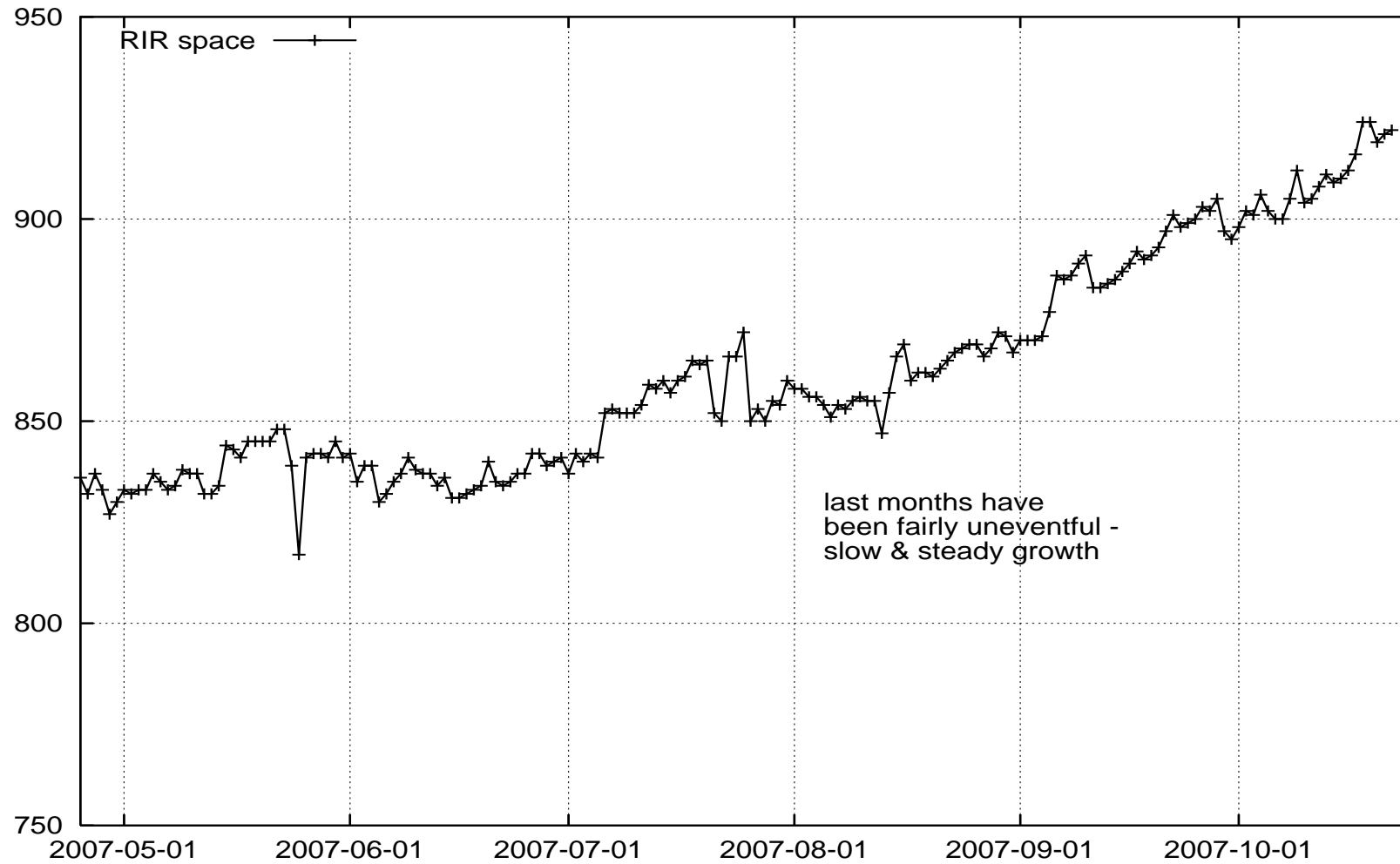
Graphics: Total Prefixes - 6 years



Graphics: RIR vs. 6Bone Prefixes - 6 years



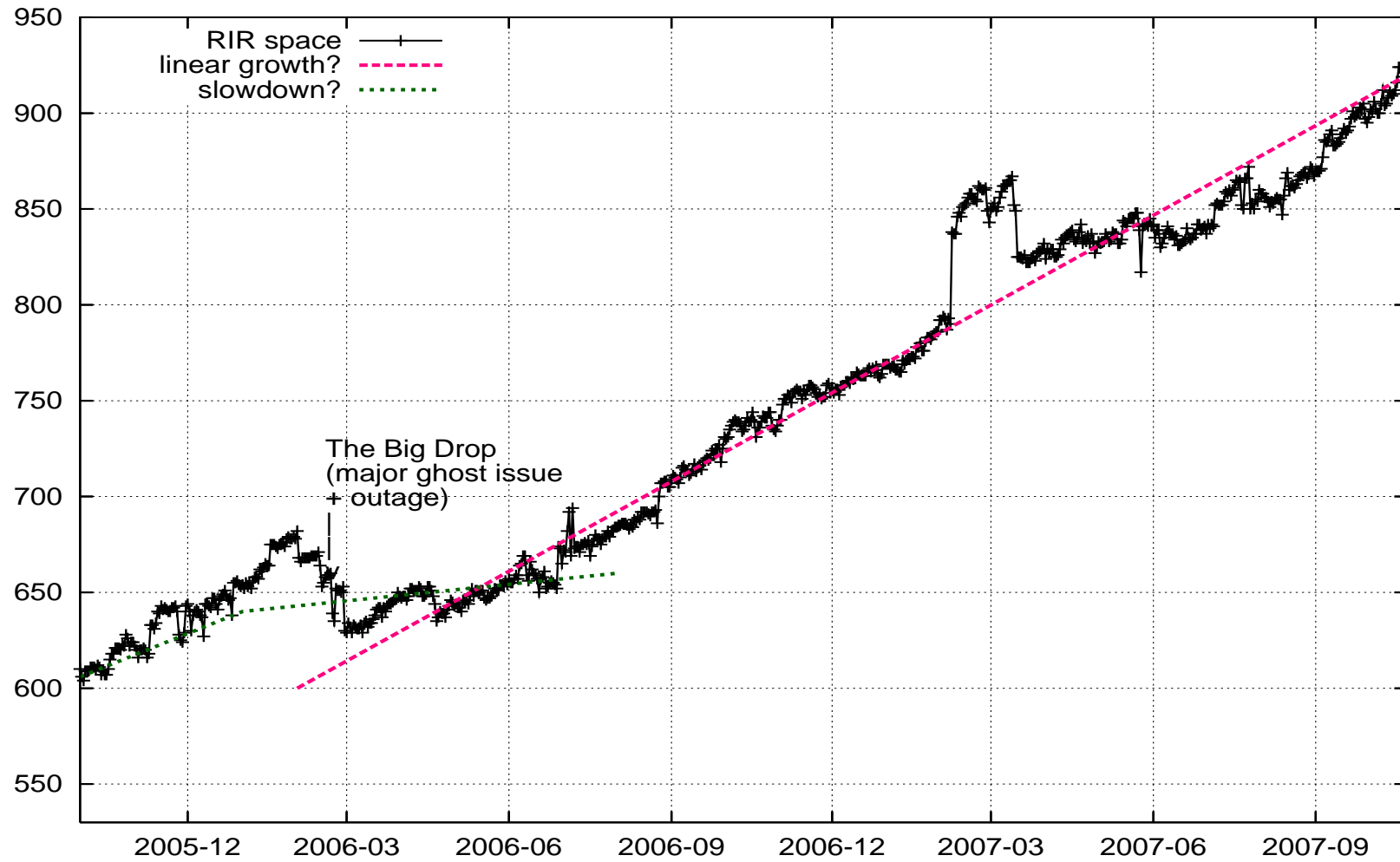
Graphics: zoom into last 6 months



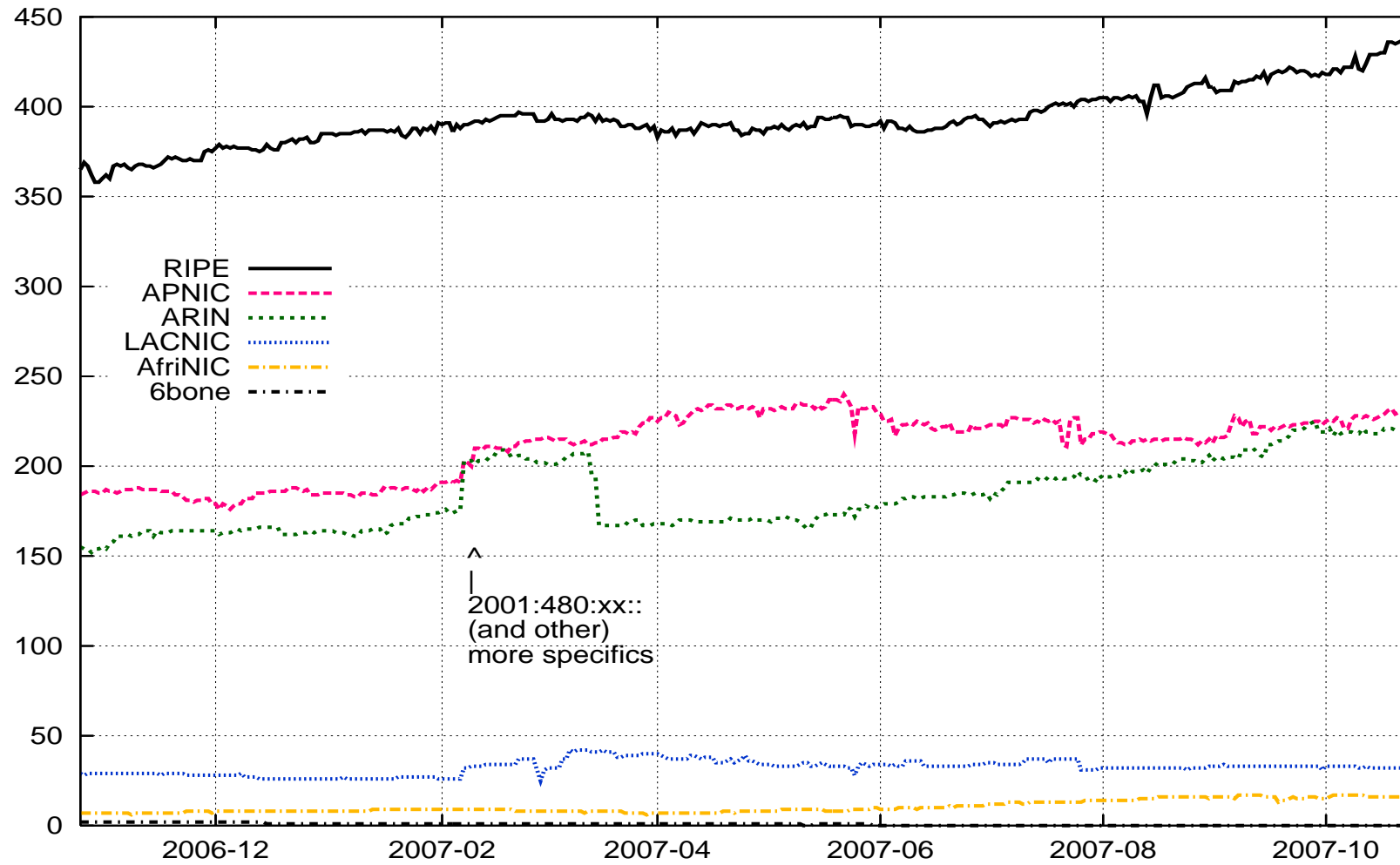
The End Of The 6bone

- on 06/06/06, the 3FFE addresses allocated to the 6Bone test network have been returned to ICANN/IANA (rfc3701)
- this means: there are no official address holders from 3FFE anymore, anybody still announcing space is an address hijacker
- at AS 5539, there are no 3FFE prefixes visible anymore :-)
- GRH (grh.sixxs.net) still sees one single path:
 - * 3FFE::/24 2A01:B8::E 8978 5609 4555 i
- 8978 = vatican.it, 5609 = cselt.it – out of clue error?
- still relevant: please stop using 3FFE transfer networks
- please *STOP* giving transit to 3FFE announcements!

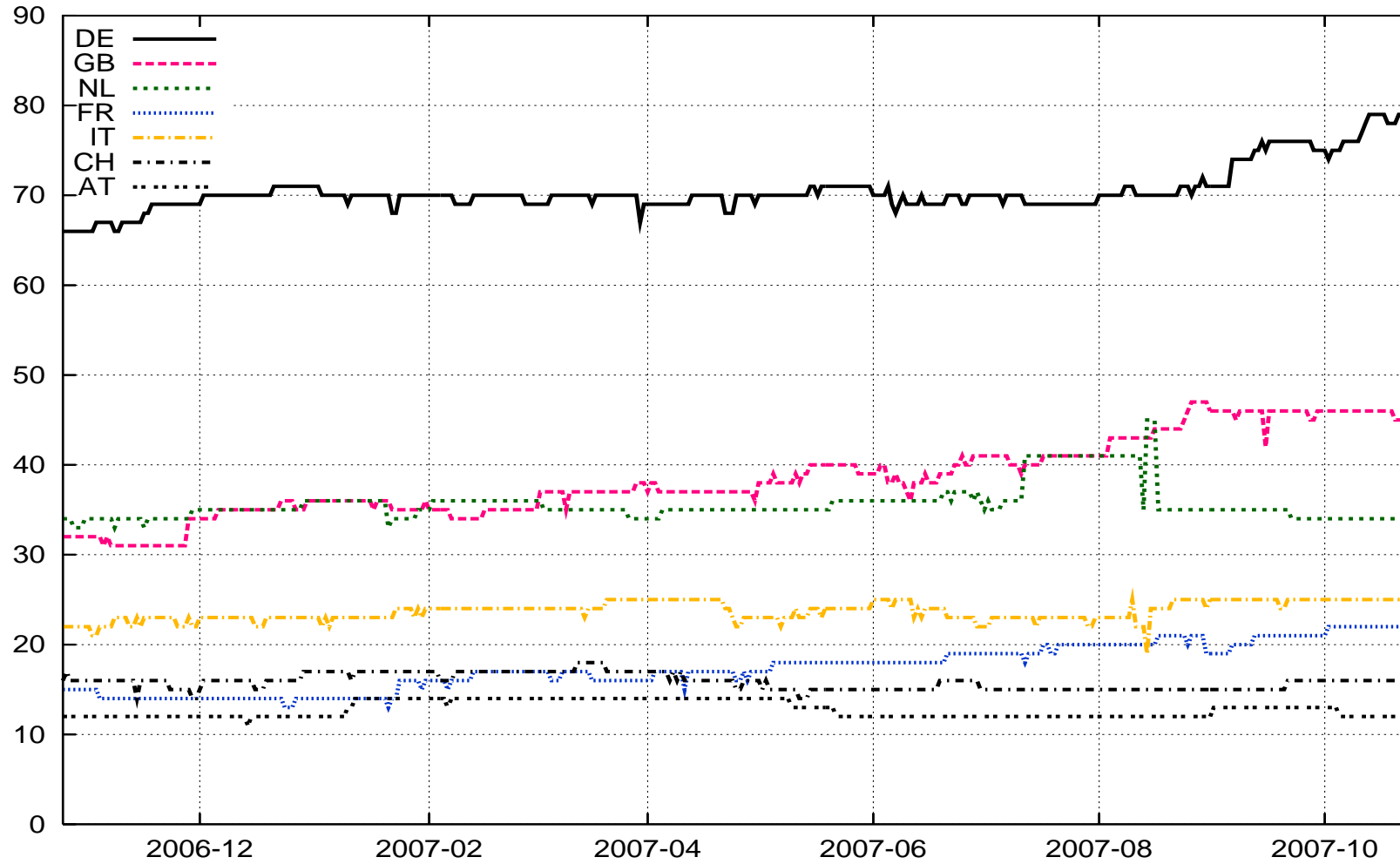
Graphics: trends? (RIR prefixes, 24 months)



Graphics: prefixes by RIR region



Graphics: prefixes by country (RIPE)



Numbers - AS numbers

- as of 2007-10-22: 798 unique AS numbers visible (2007-05: 720)
 - 549 origin-only ASes (no transit paths seen) (488)
 - 215 ASes originate & give transit (200)
 - 34 transit-only ASes (e.g. 57, 2153, 5549, 6667, ...) (32)
- different number of prefixes announced
 - 0 ASes originate 6Bone (3ffe) prefixes (*hooray!*)
 - 672 ASes originate 1 RIR prefix (604)
 - 55 ASes originate 2 RIR prefixes (3 due to /32+/35)
 - 21 ASes originate 3 RIR prefixes
 - 16 ASes with “more than that”, maximum is 14 (6) prefixes
- 3 ASes still announce their prefix as /32 and /35
- note: all paths observed from AS5539

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
2001:49F0::/32	2914 i	FDCServers
2001:728::/32	2914 i	Verio Europe
2610:150::/32	2914 i	Sharktech Internet
2610:F8::/32	2914 i	Command Information Inc.

- networks with multiple sites and multiple PI prefixes

2001:502:100E::/48	2914 12008 i	UltraDNS
2001:502:2EDA::/48	2914 12008 i	UltraDNS
2001:502:4612::/48	2914 12008 i	UltraDNS
2001:502:AD09::/48	2914 12008 i	UltraDNS
2001:502:D399::/48	2914 12008 i	UltraDNS
2001:502:F3FF::/48	2914 12008 i	UltraDNS

ASes - 32 bit ASNs showing up

- sidetrack: some 32 bit AS numbers already active

Network	Next Hop	Path
*> 2001:7fb:fd00::/48	::ffff:194.97.146.46	5539 1273 12859 12654 3.7 i
*> 2001:df0:2::/48	::ffff:194.97.146.46	5539 3257 2497 2.3 i
*> 2001:4810:2000::/35	::ffff:194.97.146.46	5539 1273 29748 33437 6.3 i

Total number of prefixes 3

- this needs Quagga or IOS XR to see – others will see “2-byte tunnel AS” 23456:

* 2001:7FB:FD00::/48	2001:420:0:7FF0::1	109 30071 6939 12859 12654 23456 i
*	2001:470:1FFF:2::	6939 12859 12654 23456 i
* i	2001:7F8::CB9:0:1	3257 12859 12654 23456 i
*	::FFFF:203.14.5.7	1221 30071 6939 12859 12654 23456 i
* i	2001:5001:100:16::1	1273 12859 12654 23456 i

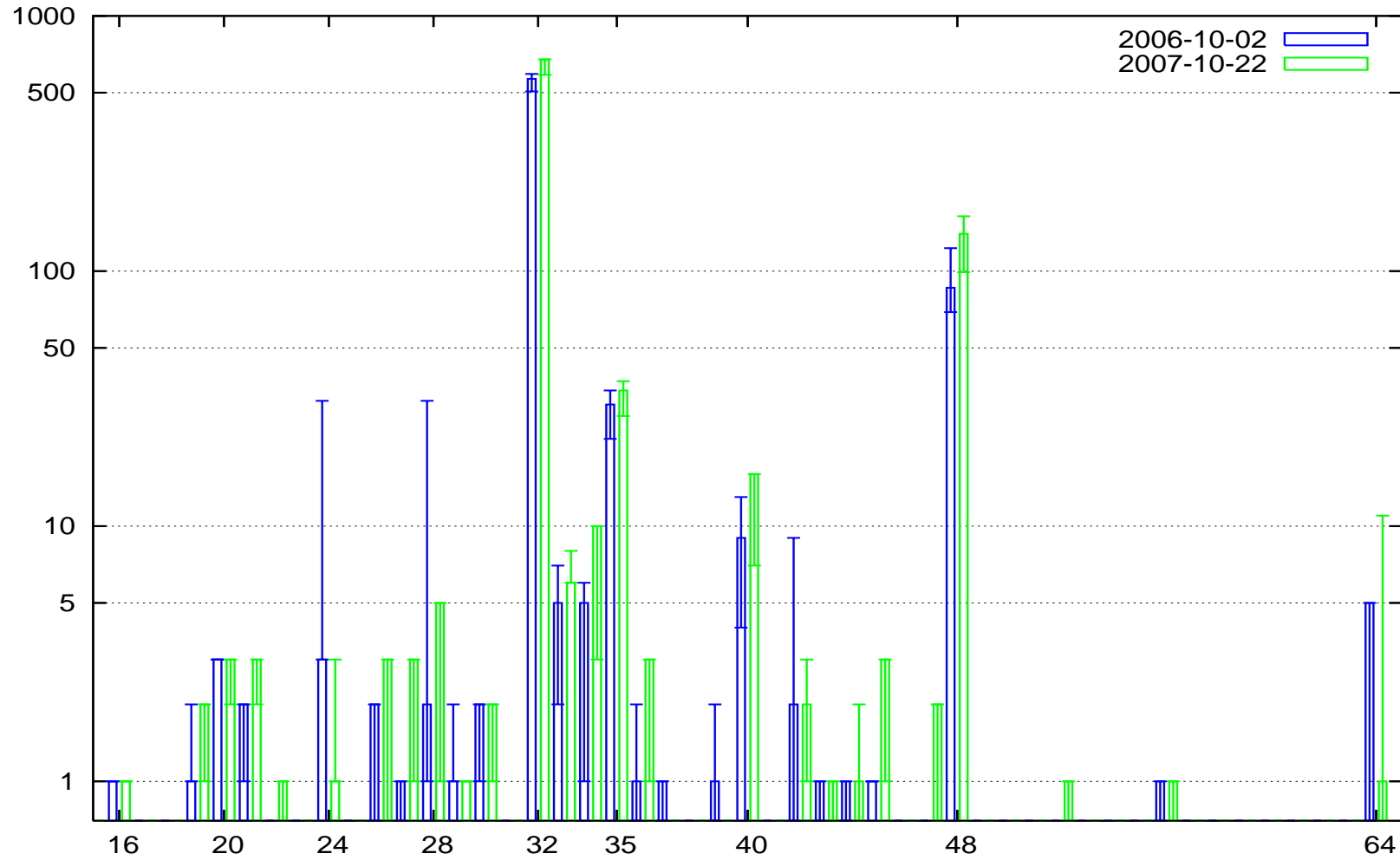
- see RFC 4893 for the details (and bug your vendor)

Numbers - Prefixes

As of 2007-10-22: 937 prefixes in total (2007-05-06: 838)

/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	7	3	4	0	0	0	0
/24..27	7	2	4	1	0	0	0
/28..31	8	1	4	0	3	0	0
/32	677	355	161	118	29	13	1
/33..34	16	5	4	7	0	0	0
/35	34	8	20	6	0	0	0
/36	3	2	0	1	0	0	0
/40	16	7	4	4	0	1	0
/42	2	2	0	0	0	0	0
/43	1	0	0	1	0	0	0
/44..47	6	2	0	4	0	0	0
/48	155	45	29	77	0	2	2
/49..63	2	0	1	1	0	0	0
/64..128	0	0	0	0	0	0	0

Graphics - Prefixes



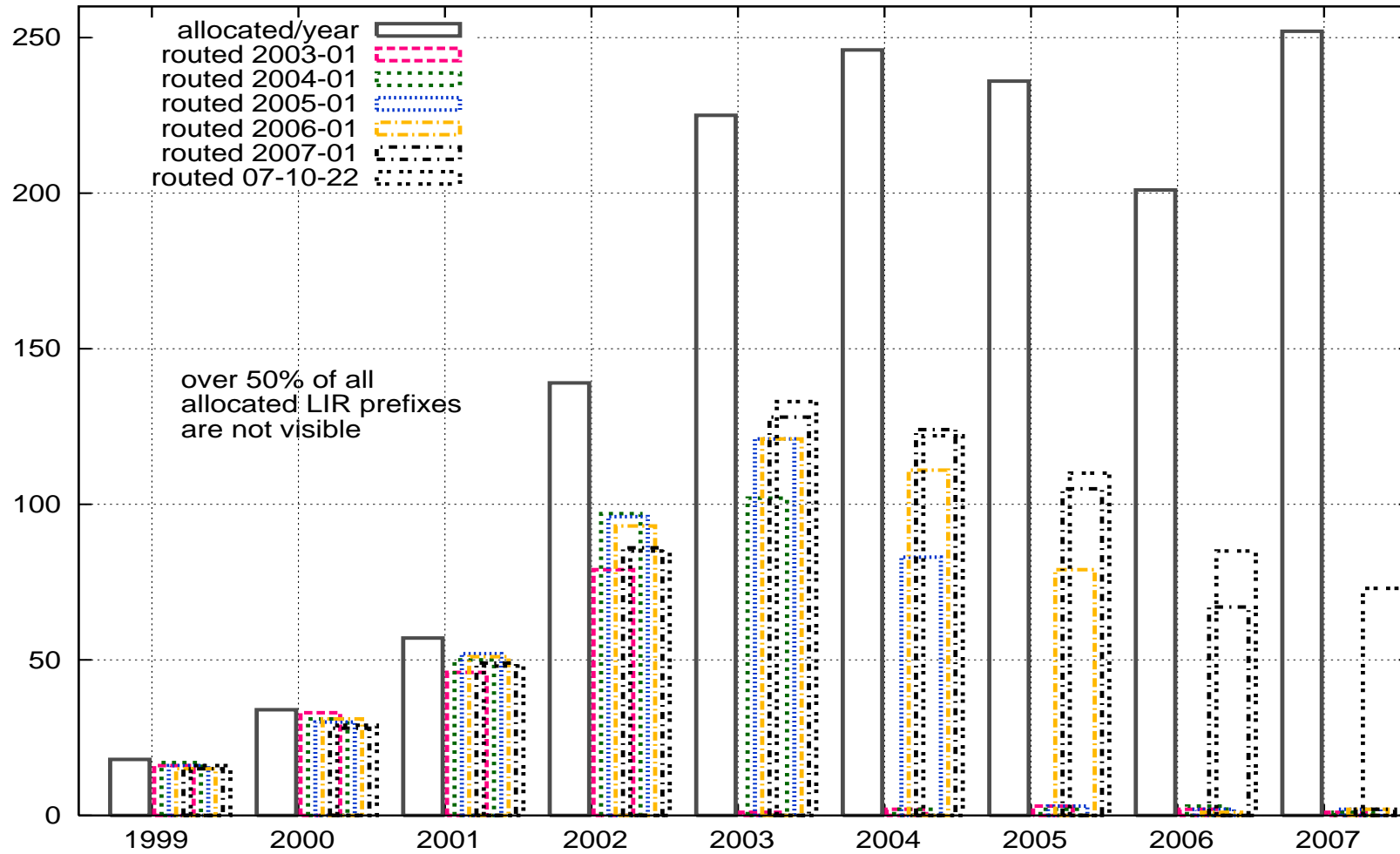
Numbers: RIRs, Allocations, ...

- On 2007-10-13, 1433 LIR blocks (2000:: $/4$) allocated by RIRs:

RIR	alloc.	members	perc.	on 2007-05-06
ARIN	312	~ 2901	10.8%	247 (+26%)
APNIC	315	~ 2561	12.3%	287 (+10%)
RIPE	682	~ 5217	13.1%	617 (+11%)
LACNIC	86	~ 718	12.0%	74 (+16%)
AfriNIC	38	~ ??	??	28 (+36%)

- note: not counting $/48$ microallocs and $/35 \Rightarrow /32$ extentions
- actual *percentage* with IPv6 similar among regions
- 689 (R54: 547) allocations visible in routing table (*only 48%!)*

Graphics: Allocated vs. Routed



Allocated vs. Routed - by region & class

RIR	type	alloc.	visible	perc.	subnets
ARIN	LIR	303	119	39%	56
	IXP	20	0	0%	0
	Critical Inf.	43	20	47%	8
	Internal Inf.	2	0	0%	0
	PI	94	16	17%	1
APNIC	LIR	313	172	55%	52
	IXP	21	1	5%	0
	PI	7	4	57%	0
RIPE	LIR	685	361	53%	61
	IXP	64	11	17%	0
	Anycast DNS	6	3	50%	0
LACNIC	LIR	85	29	34%	3
	Critical Inf.	4	0	0 %	0
AfriNIC	LIR	37	13	35%	1
	PI	5	2	40%	0

Allocated vs. Routed - reasons?

- “early adopters” already losing interest in IPv6?
- “prepare for the future” allocations?
- “for internal use” allocations? (some, yes)
- distribution of non-announced prefixes does not show any specific characteristic, like “academia” vs. “commercial networks” etc.
- some delay between prefix allocation and announcement is to be expected (expect some more statistics in this space...)
 - but this cannot explain effects seen on 2003+2004 allocations – about 40% don’t show up after over 3 years...

Numbers: notable allocations - PI news

- 6 IPv6 PI networks from APNIC (2 in BGP)
 - 2001:DE8::/48 Triple T Global Net, TH
 - 2001:DD8::/48 University of the South Pacific, Fiji
 - 2001:DF0::/47 University of Auckland, NZ
 - 2001:DF0:2::/48 Quadnet, NTT Laboratory Network, JP
 - 2001:DF0:3::/48 Crown Research Institute, NZ
 - 2001:DF0:4::/48 University of Waikato, NZ
- 5 IPv6 PI networks from AfriNIC (2 in BGP)
 - 2001:43F8::/48 Tanzania Internet Exchange, TZ
 - 2001:43F8:10::/48 KENIC
 - 2001:43F8:20::/48 Ubuntunet Alliance, ZA
 - 2001:43F8:30::/48 UniForum, ZA
 - 2001:43F8:40::/48 descr: Testing Reachability for PI /48s
- 90 “direct” assignments (PI) from ARIN so far, 15 in BGP
- ⇒ **check your BGP filters!!**

Numbers: notable allocations (2)

- (a few) more “very large” allocations seen:
 - 2a00:2000::/22 British Telecom, UK (2007-08-29)
 - 2401:6000::/20 Australian Govt Dpt. of Defense (2007-08-10)

- Allocations ICANN \Rightarrow RIRs since RIPE 52

Prefix	RIR	Date	Comment
2400:0000::/12	APNIC	2006-10-03	
2600:0000::/12	ARIN	2006-10-03	
2800:0000::/12	LACNIC	2006-10-03	
2A00:0000::/12	RIPE NCC	2006-10-03	
2C00:0000::/12	AfriNIC	2006-10-03	

- <http://www.iana.org/assignments/ipv6-unicast-address-assignments>

Interesting Observations (1) - DTAG hijack?

```
Network          Next Hop          Path
* 2003::/19      2001:420:0:7FF0::1 109 5511 3320 i
*                2001:470:1FFF:2:: 6939 2497 3257 3320 i
*                2001:7F8:2:8001::2 1752 3320 i
*>i             2001:7F8:2C:1000:0:A500:3320:1
*                3320 i
*                2001:608:0:3::9   3320 i
*> 2003:8FE:0:A012::/64
*                2001:470:1FFF:2:: 6939 5623 7018 2386 ?
```

- This really doesn't look "right" - no inet6num, no route6 object, AS path through completely unrelated ASes.
- 5623, 7018, 2386 = AT&T, 6939 = Hurricane Electric
- only paths via 6939 are visible at GRH looking glass
- ⇒ please *check* what you give transit for!
- (This was cleared up on 2007-10-18 after NANOG/ARIN...)

Interesting Observations (2) - Ghost Busting

```

Network          Path
2007-05-09:
* i2001:18B0::/32 3257 6939 1280 3557 3741 i
*                1752 2914 3557 3557 3557 3741 i
*                1221 30071 3557 3741 i
*                6939 1280 3557 3741 i
*                109 30071 3557 3741 i

2007-05-10 .. 2007-05-22:
* 2001:18B0::/32 1752 3356 3257 6939 2516 7660 2500 2497 1273
                    3303 2914 3557 3557 3741 i
*>i                3303 2914 3557 3557 3741 i
*                  6939                    2516 7660 2500 2497 1273
                    3303 2914 3557 3557 3741 i
*                  109 6453 8002            2516 7660 2500 2497 1273
                    3303 2914 3557 3557 3741 i

```

- Ghosts = BGP withdrawal bug, caused by *buggy software*. Long paths can stay *mostly unchanged* in the table for weeks.
- don't confuse with BGP count-to-infinity (= paths *change*).
- Cisco has been able to reproduce & fix bug: CSCsc59089

Interesting Observations (3) - Accidental “Hijack”

```

Network          Path
*>i2001:200::/32  2914 2500 i          <<< normal path
*                1221 30071 3557 2500 i

* 2001:6E0::/32   1221 30071 6175 2497 2500 i
*>i              3257 8954 i

* 2001:740::/32   1221 30071 6175 17715 6435 278 6939 2516 7660 2500 i
*                6939 2516 7660 2500 2914 8472 i
*>i              1273 8472 i

* 2001:808:E000::/35 1221 30071 6175 17715 6435 278 6939 2516 7660 2500 i
* 2001:AA8::/32     1221 30071 6175 17715 6435 278 6939 2516 7660 2500 i
* 2001:1450::/32    1221 30071 6175 2497 2500 i
* 2001:1498::/32    1221 30071 6175 2497 2500 i
...
* 2001:1820::/32    1221 30071 6175 2497 2500 i
* 2001:1B70::/32    1221 30071 6175 17715 6435 278 6939 2516 7660 2500 i
* 2001:4130::/32    1221 30071 6175 4555 6939 2516 7660 2500 i
* 2001:4B20::/32    1221 30071 6175 17715 6435 278 6939 2516 7660 2500 i

```

- this has happened before, but the cause is unknown
- theory: combination of ghosting and AS path truncation

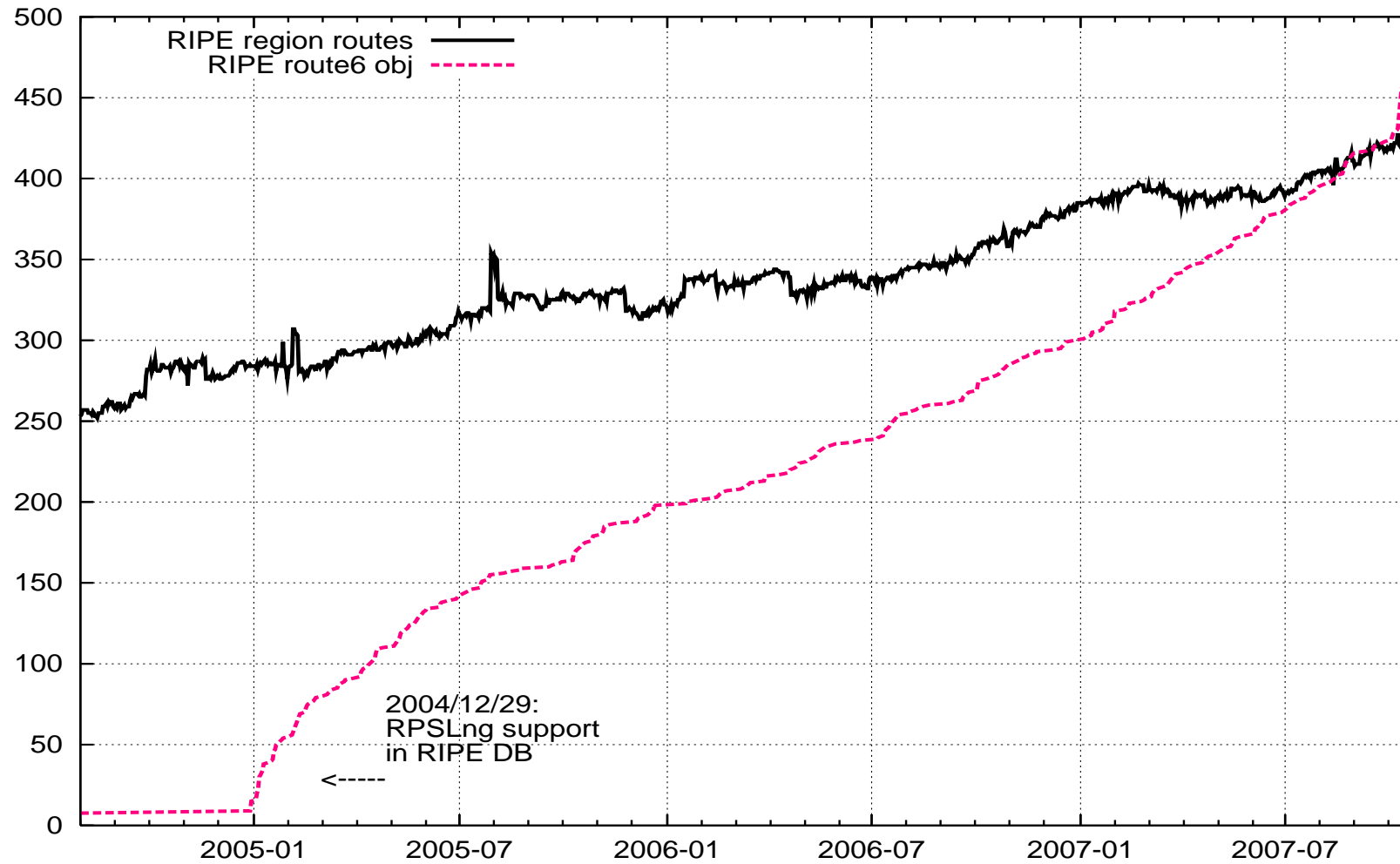
Something for the Routing Police...

HOST: svr02.teleport-iabg.de	Loss%	Snt	Last	Avg	Best	Wrst	StDev
1. backbone2-gige-0-3-15.telepo	0.0%	20	0.7	4.6	0.5	47.3	11.8
2. mchn-s1-rou-1030.DE.euroring	0.0%	20	2.5	2.6	2.2	2.8	0.2
3. hmb-s2-rou-1030.DE.eurorings	0.0%	20	17.5	17.4	17.0	17.8	0.2
4. sl-bb1v6-nyc-t-28.sprintv6.n	0.0%	20	108.4	108.4	107.9	108.9	0.2
5. sl-bb1v6-rly-t-1003.sprintv6	0.0%	20	184.3	184.5	184.1	185.8	0.4
6. 2001:ca0:1::1:1	5.0%	20	495.6	495.6	488.4	499.5	2.9
7. tunnel-cht1-lavanoc.lava.ne	5.0%	20	500.1	496.2	489.8	500.1	2.6
8. 3ffe:8070:1:13::1	15.0%	20	608.5	570.0	558.8	608.5	13.0
9. 2001:1228:11b:90a::1	10.0%	20	811.2	819.2	790.9	974.5	39.6
...							
17. 2001:1338:ffff::2	21.1%	19	656.5	700.2	650.3	1032.	108.4
18. ns1.nic.ve	15.8%	19	666.0	705.0	651.1	976.8	102.8

Network	Path
2001:1338::/32	8767 3549 6175 17715 6435 278 18592 27750 27807 20312 i
2001:410::/32	8767 3549 6175 17715 6435 278 18592 27750 6509 i
	286 1273 6830 6830 6830 6830 6939 6939 6939 6939 2516
	7660 22388 11537 6509 i

- some NRENs “do not need” reasonable-quality IPv6 upstream
- global connectivity happens via “tunnel full-table leaks”
- net result is extremely poor user experience

Graphics: route6 objects vs. routes seen



route6 correlation (RIPE region)

- on 2007-10-04:
 - 421 BGP routes from RIPE region
 - 425 route6: objects in RIPE DB
- correlation?
 - multiple origin route6's (9x 2002::/16, 5x 2001::/32, ...)
 - ⇒ 409 route6 objects for *unique* prefixes
 - 274 route6: objects exactly matching BGP prefixes
 - * (origin AS not checked yet, only prefix match)
 - 135 route6: objects without BGP prefix (?!)
 - 147 BGP prefixes without route6: object :-)
- ⇒ close-up view shows “more work needed”
- in other RIR regions, situation is worse (no IRR DBs yet, etc.)

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

References

- Ghost Route Hunter: <http://www.sixxs.net/tools/grh/>
- List of IPv6 blocks allocated by the RIRs:
<http://www.ripe.net/rs/ipv6/stats/index.html>
- MIPP (minimum peering policy) project:
<http://ip6.de.easynet.net/ipv6-minimum-peering.txt>
- IPv6 sample prefix filter page
<http://www.space.net/~gert/RIPE/ipv6-filters.html>
- Slides are available at:
<http://www.space.net/~gert/RIPE/RIPE55-v6-table/>

Questions?

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