RTMA Working Group Agenda

- Overview
- Speakers
- Discussion

Speakers

- Speakers
  - Bill Woodcock – Packet Clearinghouse
  - Philip Smith – Cisco Systems
  - Scott Marcus – Genuity/ARIN Board
  - Abha Ahuja – Arbor Networks
  - Vijay Gill – MFN

RTMA Overview

- The global routing table is growing.
- IP address policies may or may not impact that growth.
- The growth may or may not impact the ability for the Internet to scale.
- Other factors may impact scaling as well?

Discussion

- What other measurements should be done?
- Is CIDR really not having any affect anymore?
- If CIDR is really obsolete should the registries change their policies to reflect that?
- Volunteers?
- Next Steps?

RTMA Info

- Mailing list: rtma@arin.net
- Subscribe rtma-request@arin.net
- RTMA archive?

Internet Routing Table Analysis Update

Philip Smith

pfs@cisco.com

ARIN VII, San Francisco, April 2001

Internet Routing Table Analysis

- Thanks to APNIC for support
- Full view taken from NSPIXP2 in Tokyo
- Full BGP table
  - no filters, no flap damping
- Snapshot at 4am (+10GMT) every day

Internet Routing Table Analysis

- **All three Regional Internet Registry address and AS ranges analysed:**

  http://www.isi.edu/in-notes/iana/assignments/as-numbers
  http://www.isi.edu/in-notes/iana/assignments/ipv4-address-space

- **Exhaustive search of utilisation of former B space included**

  If not in any of the 3 registry databases, it is unallocated

- **Historical AS allocations by InterNIC distributed between three regions**

  Assumes organisations use AS in the region of registration

Internet Routing Table Analysis

- **Results on APNIC web page**

  http://www.apnic.net/stats/bgp

- **Results to mailing lists**

  daily:

  bgp-stats@lists.apnic.net

  weekly:

  apops@lists.apnic.net

  routing-wg@ripe.net

  rtma@arin.net

Some Definitions

- **“available” address space**

  everything except draft-manning-dsua-06.txt which lists:

  0/8, 10/8, 127/8, 169.254/16, 172.16/12, 192.0.2/24, 192.168/16 and 224/3

- **“allocated” address space**

  everything from “available” which isn’t “IANA reserved”

  currently this amounts to 50% of address space (or 108 /8s)

30th March summary

Global

```
BGP routing table entries examined:                                  102113
Origin ASes present in the Internet Routing Table:                    10430
Origin ASes announcing only one prefix:                                3741
Transit ASes present in the Internet Routing Table:                    1375
Average AS path length visible in the Internet Routing Table:           5.3
    Max AS path length visible:                                          15
Illegal AS announcements present in the Routing Table:                   17
Non-routable prefixes present in the Routing Table:                       0
Prefixes being announced from the IANA Reserved Address blocks:           3
Number of addresses announced to Internet:                       1214667866
    Equivalent to 72 /8s, 102 /16s and 92 /24s
    Percentage of available address space announced:                   32.8
    Percentage of allocated address space announced:                   64.3
    Percentage of available address space allocated:                   51.0
```

30th March summary

APNIC region

```
Prefixes being announced by APNIC Region ASes:                    15583
Prefixes being announced from the APNIC address blocks:           14173
APNIC Region origin ASes present in the Internet Routing Table:    1211
APNIC Region origin ASes announcing only one prefix:                435
APNIC Region transit ASes present in the Internet Routing Table:    198
Average APNIC Region AS path length visible:                        5.1
    Max APNIC Region AS path length visible:                         15
Number of APNIC addresses announced to Internet:                 69169775
    Equivalent to 4 /8s, 31 /16s and 114 /24s
    Percentage of available APNIC address space announced:           68.0

APNIC AS Blocks         4608 - 4864, 7467 - 7722, 9216 - 10239,
                        17408 - 18431
APNIC Address Blocks    61/8, 202/7, 210/7 and 218/8
```

30th March summary

ARIN region

```
Prefixes being announced by ARIN Region ASes:                    70655
Prefixes being announced from the ARIN address blocks:           47994
ARIN Region origin ASes present in the Internet Routing Table:    6353
ARIN Region origin ASes announcing only one prefix:               1858
ARIN Region transit ASes present in the Internet Routing Table:    651
Average ARIN Region AS path length visible:                        5.2
    Max ARIN Region AS path length visible:                         14
Number of ARIN addresses announced to Internet:                179855217
    Equivalent to 10 /8s, 184 /16s and 95 /24s
    Percentage of available ARIN address space announced:          82.5

ARIN AS Blocks          1 - 1876, 1902 - 2042, 2044 - 2046, 2048 - 2106
                        2138 - 2584, 2615 - 2772, 2823 - 2829, 2880 - 3153
                        3354 - 4607, 4865 - 5119, 5632 - 6655, 6912 - 7466
                        7723 - 8191, 10240 - 12287, 13312 - 15359
                        16384 - 17407, 18432 - 20479
ARIN Address Blocks     63/8, 64/7, 66/8, 199/8, 200/8, 204/6, 208/7 and
216/8
```

30th March summary

RIPE NCC region

```
Prefixes being announced by RIPE Region ASes:                       15858
Prefixes being announced from the RIPE address blocks:              12560
RIPE Region origin ASes present in the Internet Routing Table:       2866
RIPE Region origin ASes announcing only one prefix:                  1448
RIPE Region transit ASes present in the Internet Routing Table:       524
Average RIPE Region AS path length visible:                           6.0
    Max RIPE Region AS path length visible:                            15
Number of RIPE addresses announced to Internet:                  93806295
    Equivalent to 5 /8s, 151 /16s and 94 /24s
    Percentage of available RIPE address space announced:             79.9

RIPE AS Blocks          1877 - 1901, 2042, 2047, 2107 - 2136, 2585 - 2614
                        2773 - 2822, 2830 - 2879, 3154 - 3353, 5377 - 5631
                        6656 - 6911, 8192 - 9215, 12288 - 13311,
                       15360 – 16383, 20480 - 21503
RIPE Address Blocks     62/8, 193/8, 194/7, 212/7 and 217/8
```

APNIC Region per AS prefix count summary

ASN	No of nets	/19 equiv	Description
1221	2083	692	Telstra
703	451	264	UUNET Technologies, Inc.
2764	429	139	connect.com.au pty ltd
2907	373	892	SINET Japan
4755	296	110	VSNL India
4538	244	1032	China Education and Research
9269	206	24	Hong Kong CTI
7474	195	86	Optus Communications
4134	182	603	Data Communications Bureau
4763	179	35	Telstra New Zealand
4766	178	626	KORnet Powered BY Korea Telec
1237	168	71	System Engineering Research I
7657	164	12	The Internet Group Limited
7545	150	10	TPG Internet Pty Ltd
4740	145	10	Ozemail
3462	138	205	Data Communications Institute
4786	128	7	NetConnect Communications Pty
4713	126	427	NTT-OCNET
7539	124	38	Delegated to TWNIC for subseq
7617	123	46	One.Net Pty Ltd

ARIN Region per AS prefix count summary

ASN	No of nets	/19 equiv	Description
701	2442	3623	UUNET Technologies, Inc.
705	1183	55	UUNET Technologies, Inc.
1	968	4504	BBN Planet
7018	948	3057	AT&T
7046	803	544	UUNET Technologies, Inc.
1239	636	1600	Sprint ICM-Inria
2914	610	1222	Verio, Inc.
174	582	2777	PSINet Inc.
3561	558	1240	Cable & Wireless USA
3549	540	496	Global Crossing
4293	477	52	Cable & Wireless USA
209	450	723	Qwest
690	404	64	Merit Network
2548	397	514	Digital Express Group, Inc.
3908	378	270	Supernet, Inc.
8112	370	64	Bell Atlantic Internet Soluti
4323	338	136	Time Warner Communications, I
8151	329	191	UniNet S.A. de C.V.
11371	329	49	Rhythms NetConnections
3967	328	222	Exodus Communication

RIPE NCC Region per AS prefix count summary

ASN	No of nets	/19 equiv	Description
702	417	624	UUNET Technologies, Inc.
3301	395	329	TeliaNet Sweden
1257	287	248	Swipnet AB
1270	276	455	UUNET Germany
680	208	913	Deutschef Forschurgsnetz
3215	202	227	RAIN
5515	191	335	Sonera Finland
719	190	146	LANLINK
786	183	959	JANET IP Service
3320	157	454	Deutsche Telekom AG
1849	149	255	UUNET UK (formerly PIPEX)
517	128	134	Xlink
3303	124	298	Swisscom
5400	124	33	Concert Internet Plus Europea
2856	122	388	BTnet UK Regional network
8708	105	5	Romania Data System
1901	99	77	EUnet Austria
1267	98	979	IUnet S.p.A
2830	95	38	UUNET UK (formerly PIPEX)
1290	85	205	PSINet UK Ltd.

Global per AS prefix count summary

ASN	No of nets	/19 equiv	Description
701	2442	3623	UUNET Technologies, Inc.
1221	2083	692	Telstra
705	1183	55	UUNET Technologies, Inc.
1	968	4504	BBN Planet
7018	948	3057	AT&T
7046	803	544	UUNET Technologies, Inc.
1239	636	1600	Sprint ICM-Inria
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2764	429	139	connect.com.au pty ltd
702	417	624	UUNET Technologies, Inc.
690	404	64	Merit Network
2548	397	514	Digital Express Group, Inc.
3301	395	329	TeliaNet Sweden
3908	378	270	Supernet, Inc.

List of Illegal AS's

Bad AS	Designation	Network	Transit AS	Description
2027	UNALLOCATED	150.185.0.0/16	10530	Interpacket Group, I
2027	UNALLOCATED	150.185.128.0/18	8143	Publicom Corp.
2027	UNALLOCATED	150.186.0.0/16	10530	Interpacket Group, I
2027	UNALLOCATED	150.187.0.0/16	10530	Interpacket Group, I
2027	UNALLOCATED	150.188.0.0/16	10530	Interpacket Group, I
2027	UNALLOCATED	150.189.0.0/16	10530	Interpacket Group, I
1877	UNALLOCATED	192.108.196.0/24	1800	SPRINT
1877	UNALLOCATED	192.108.209.0/24	1880	Stupi, house man's
1877	UNALLOCATED	192.108.210.0/24	1880	Stupi, house man's
1877	UNALLOCATED	192.108.214.0/24	1800	SPRINT
5757	UNALLOCATED	192.239.13.0/24	701	UUNET Technologies,
5757	UNALLOCATED	207.19.224.0/24	701	UUNET Technologies,
65008	PRIVATE	193.48.190.0/24	2200	INRIA-Rocquencourt
65008	PRIVATE	193.49.4.0/24	2200	INRIA-Rocquencourt
65008	PRIVATE	194.167.0.0/24	2200	INRIA-Rocquencourt
65535	PRIVATE	203.24.169.0/24	17486	Swiftel Communicatio
65500	PRIVATE	203.166.86.0/24	10084	Western Australian I

UUNET are aware of AS5757 and will resolve ASAP

RIPE NCC and Peter are aware of 1877 and will fix ASAP

ARIN are aware of AS2027 - no more news

Advertised IANA Reserved Addresses

Network	Origin AS	Description
91.16.23.0/24	11770	Net56
106.1.1.0/24	5705	Sirius Solutions, Inc.
106.1.2.0/24	5705	Sirius Solutions, Inc.

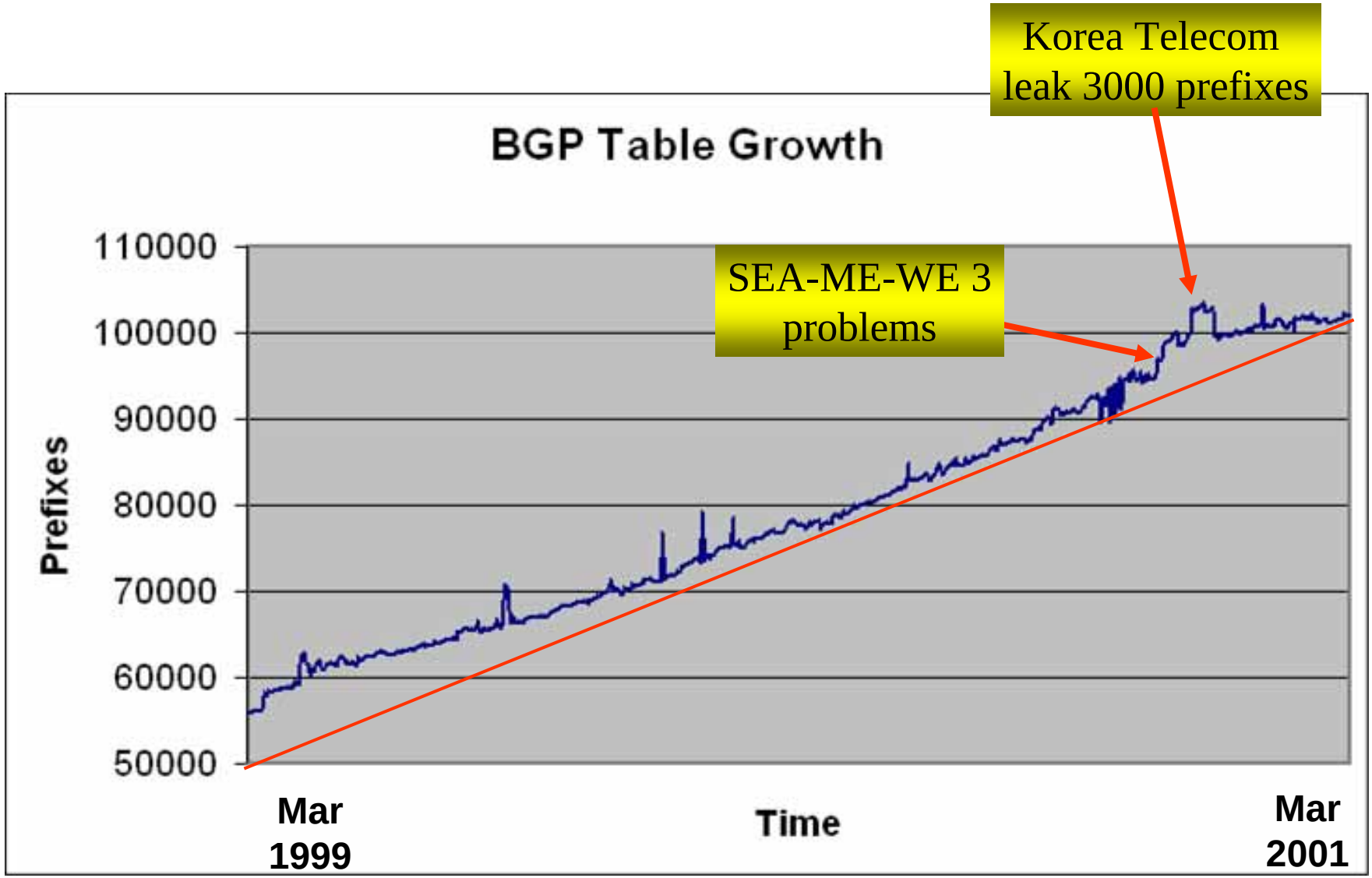
Number of prefixes announced by prefix length

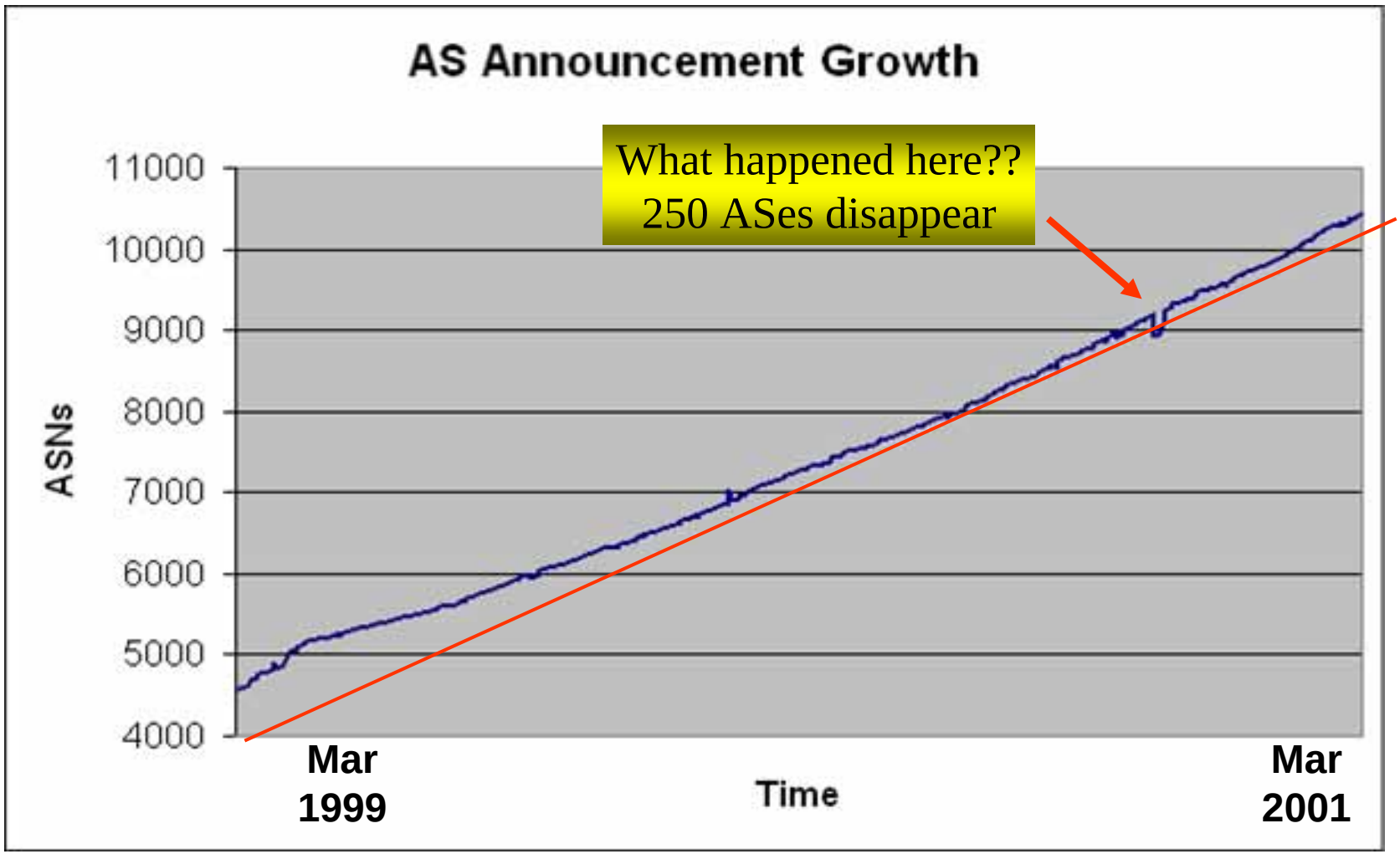
/1:0	/2:0	/3:0	/4:0	/5:0	/6:0
/7:0	/8:21	/9:4	/10:4	/11:9	/12:30
/13:64	/14:202	/15:328	/16:6907	/17:1108	/18:2079
/19:6515	/20:4962	/21:4391	/22:6761	/23:8638	/24:58825
/25:269	/26:345	/27:146	/28:111	/29:73	/30:160
/31:1	/32:160				

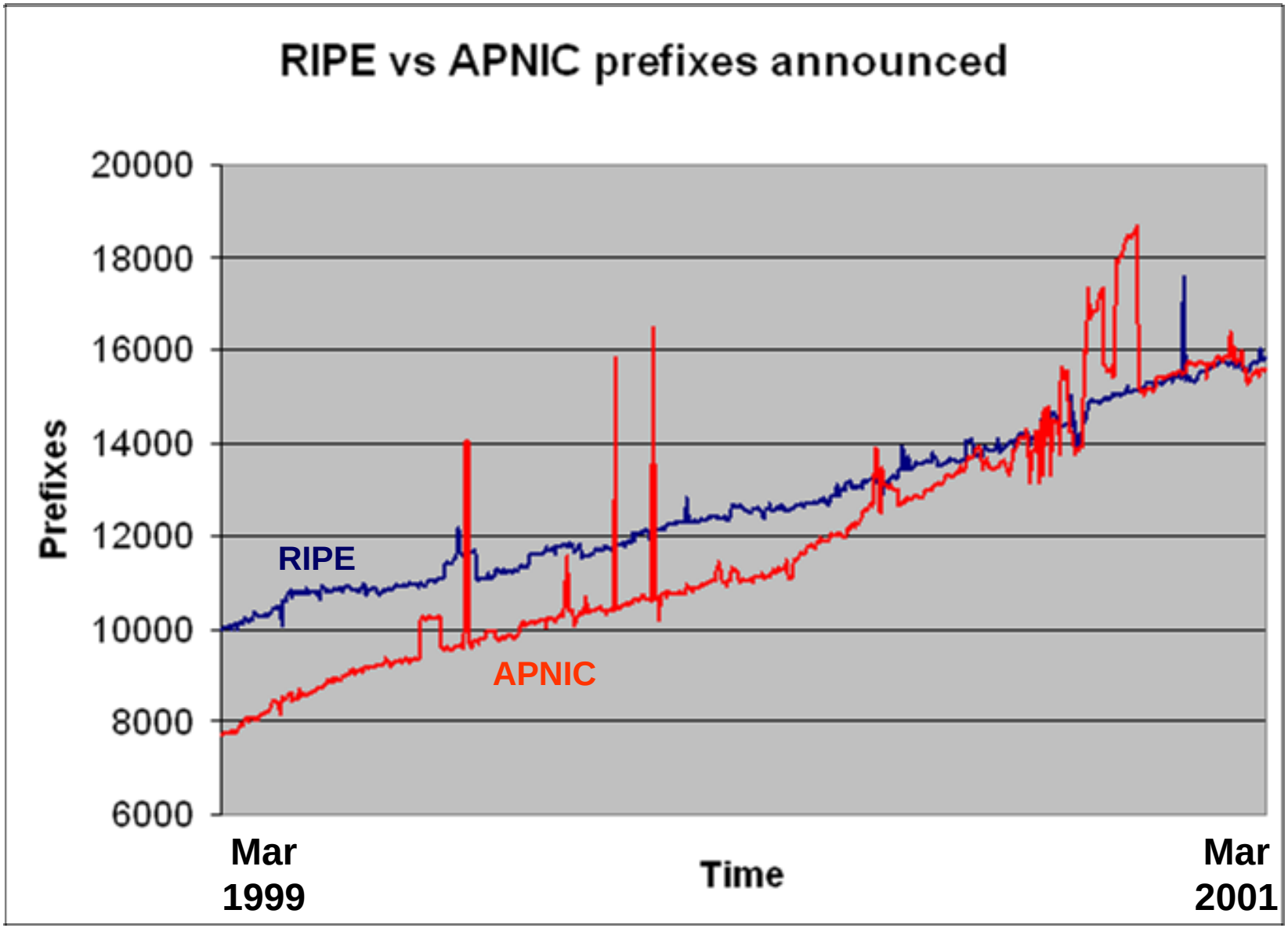
64.209.239.216/31 1221 16779 1 3967 18996

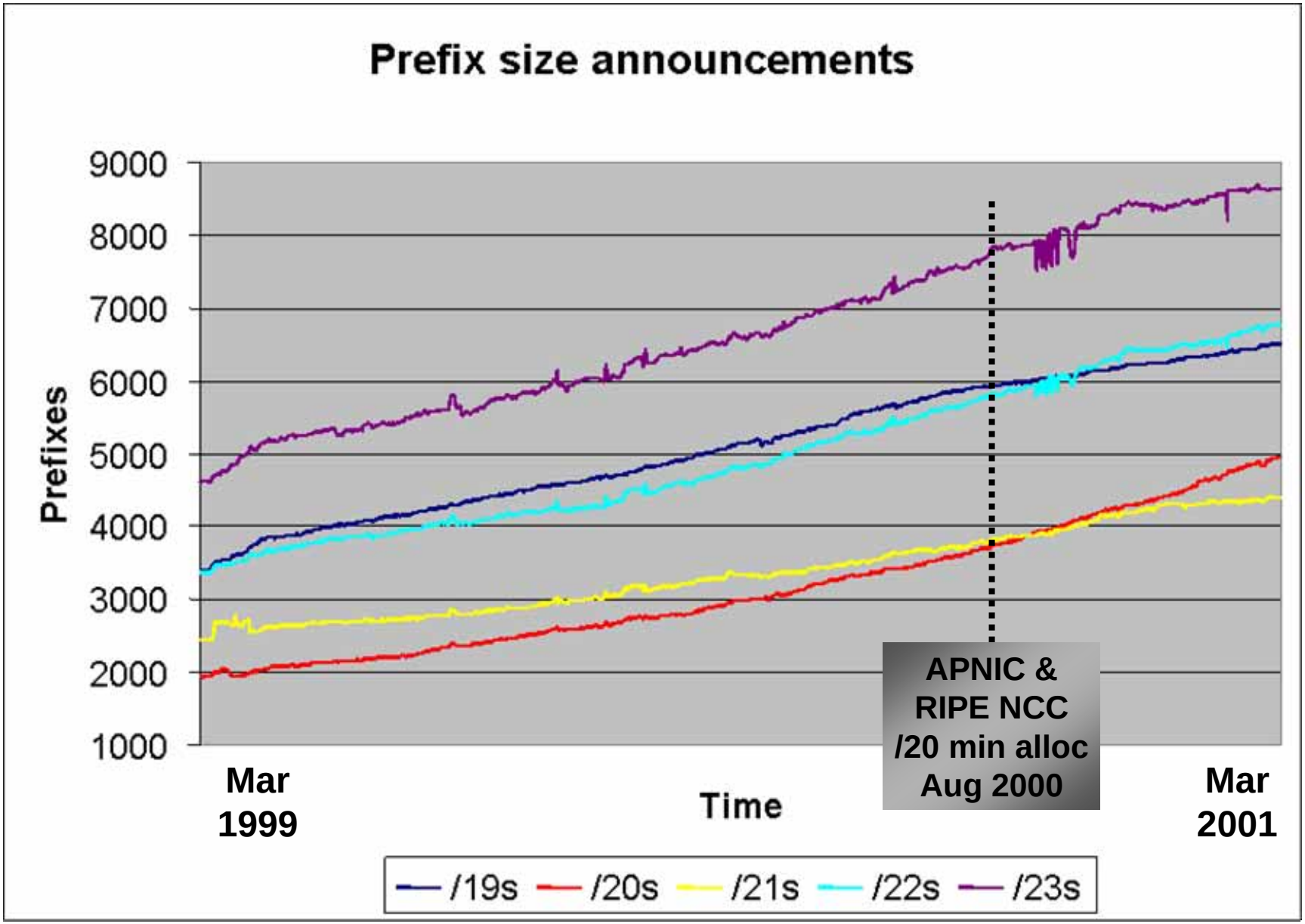
Number of /24s announced by per /8

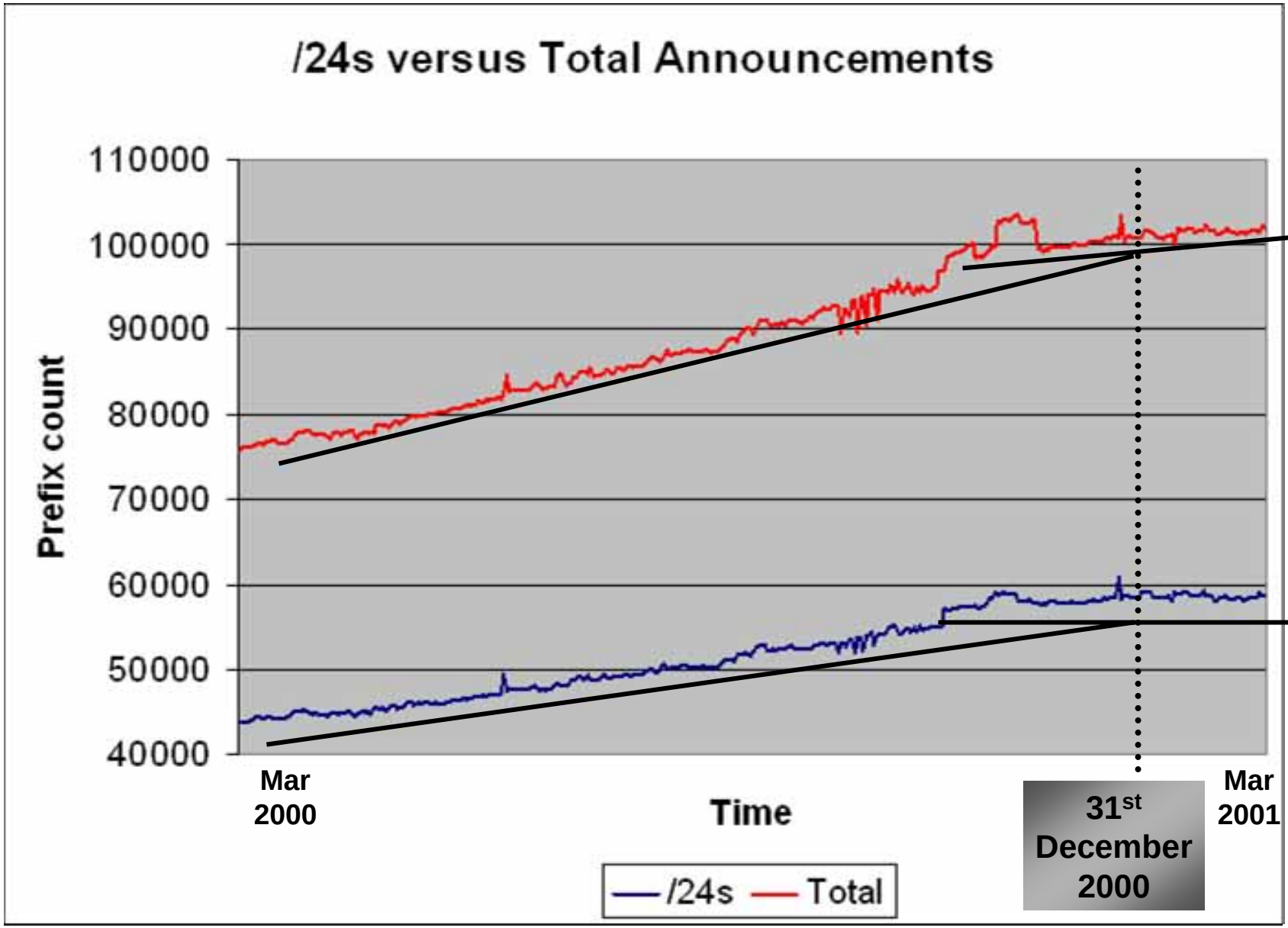
9:3	12:340	13:10	15:1	17:1	24:687
26:1	32:10	38:7	44:3	47:1	53:2
55:1	57:9	61:41	62:134	63:1883	64:1429
65:541	66:209	91:1	106:2	128:31	129:122
130:21	131:24	132:11	133:1	134:147	135:8
136:16	137:114	138:246	139:52	140:106	141:174
142:55	143:150	144:35	145:11	146:134	147:92
148:143	149:136	150:25	151:362	152:968	153:33
154:13	155:75	156:37	157:107	158:59	159:79
160:17	161:56	162:90	163:134	164:134	165:118
166:173	167:90	168:81	169:31	170:220	171:2
192:5350	193:1827	194:2038	195:774	196:381	198:3619
199:3364	200:1876	202:2435	203:4976	204:3374	205:2241
206:2747	207:2793	208:2932	209:3183	210:487	211:169
212:810	213:351	214:8	215:11	216:2865	217:165

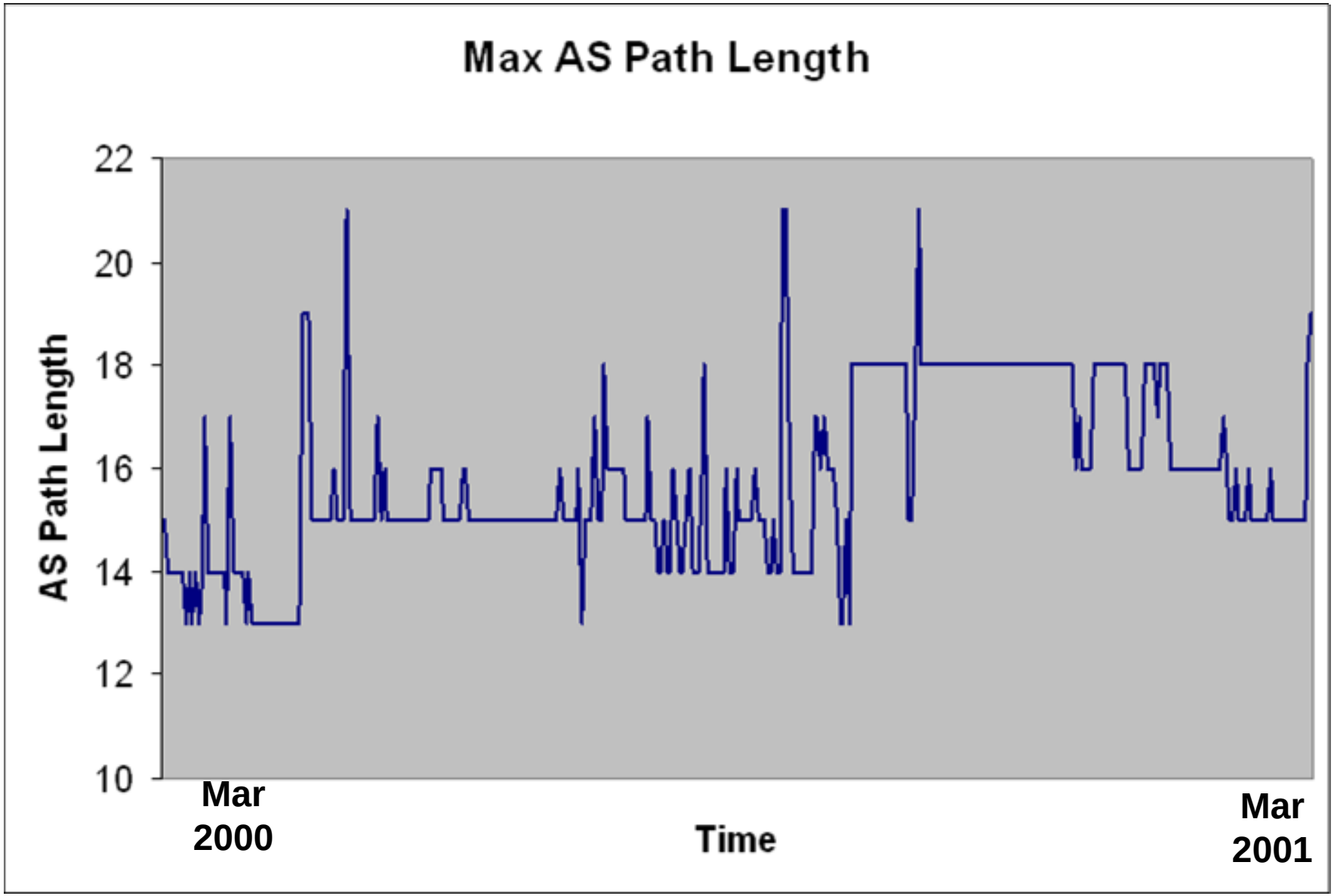

Korea Telecom
leak 3000 prefixes
BGP Table Growth
SEA-ME-WE 3
problems
110000
100000
90000
80000
70000
60000
50000
Prefixes
Mar
1999
Time
Mar
2001


AS Announcement Growth
What happened here??
250 ASes disappear
11000
10000
9000
8000
7000
6000
5000
4000
ASNs
Mar
1999
Time
Mar
2001


RIPE vs APNIC prefixes announced
20000
18000
16000
14000
12000
10000
8000
6000
Prefixes
RIPE
APNIC
Mar
1999
Time
Mar
2001


Prefix size announcements
9000
8000
7000
6000
5000
4000
3000
2000
1000
Prefixes
Mar 1999
Time
APNIC & RIPE NCC /20 min alloc Aug 2000
Mar 2001
/19s
/20s
/21s
/22s
/23s


/24s versus Total Announcements
110000
100000
90000
80000
70000
60000
50000
40000
Prefix count
Mar 2000
Time
31st December 2000
Mar 2001
/24s
Total


Max AS Path Length
AS Path Length
22
20
18
16
14
12
10
Mar 2000
Time
Mar 2001

Final Slide...

- **What other stats would be interesting?**
- **Any comments/discussion?**

IPv4 Address Space Usage Trends

April 3, 2001

Frank Solensky — Gotham Networks

J.Scott Marcus — Genuity

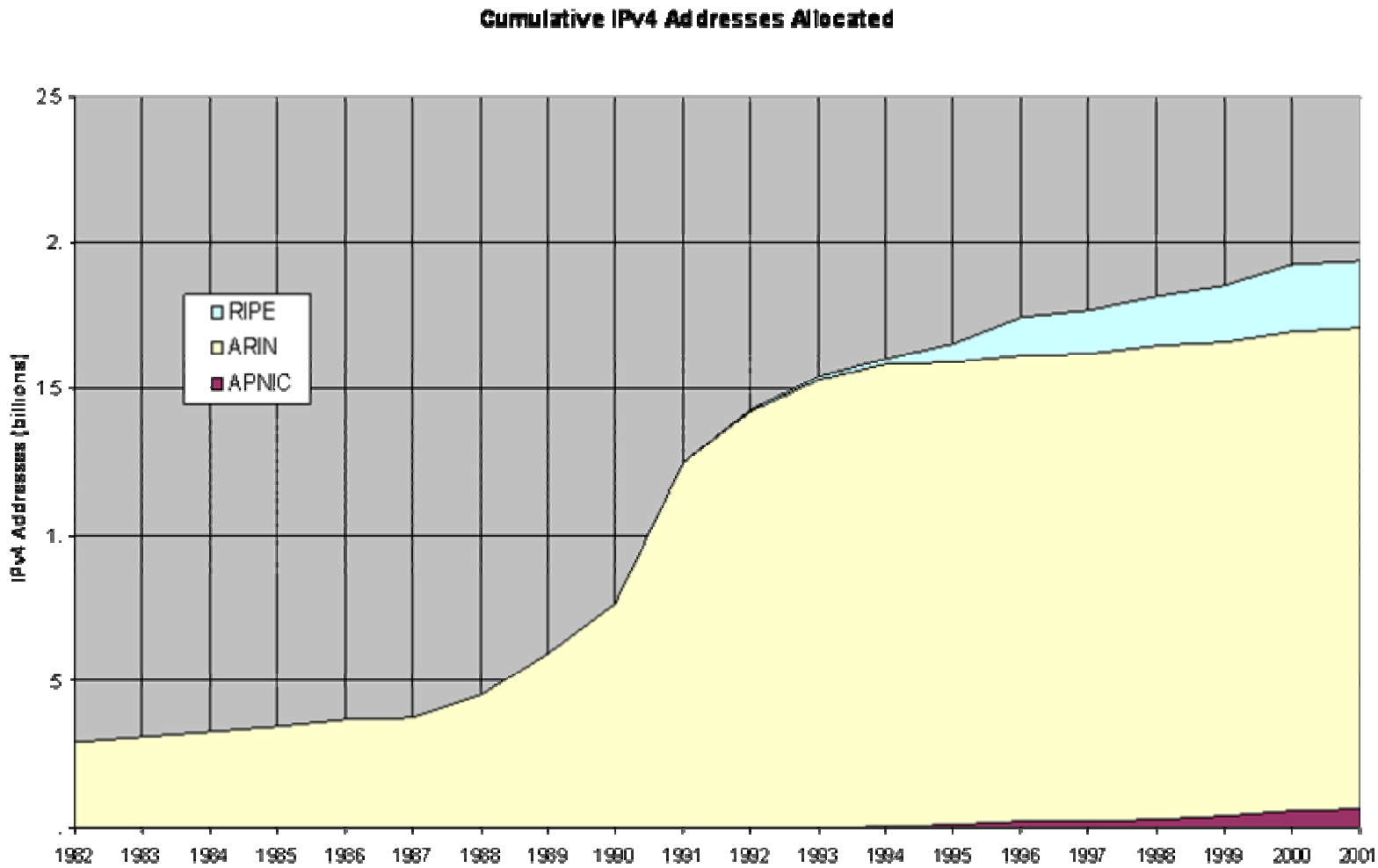
kc claffy — CAIDA

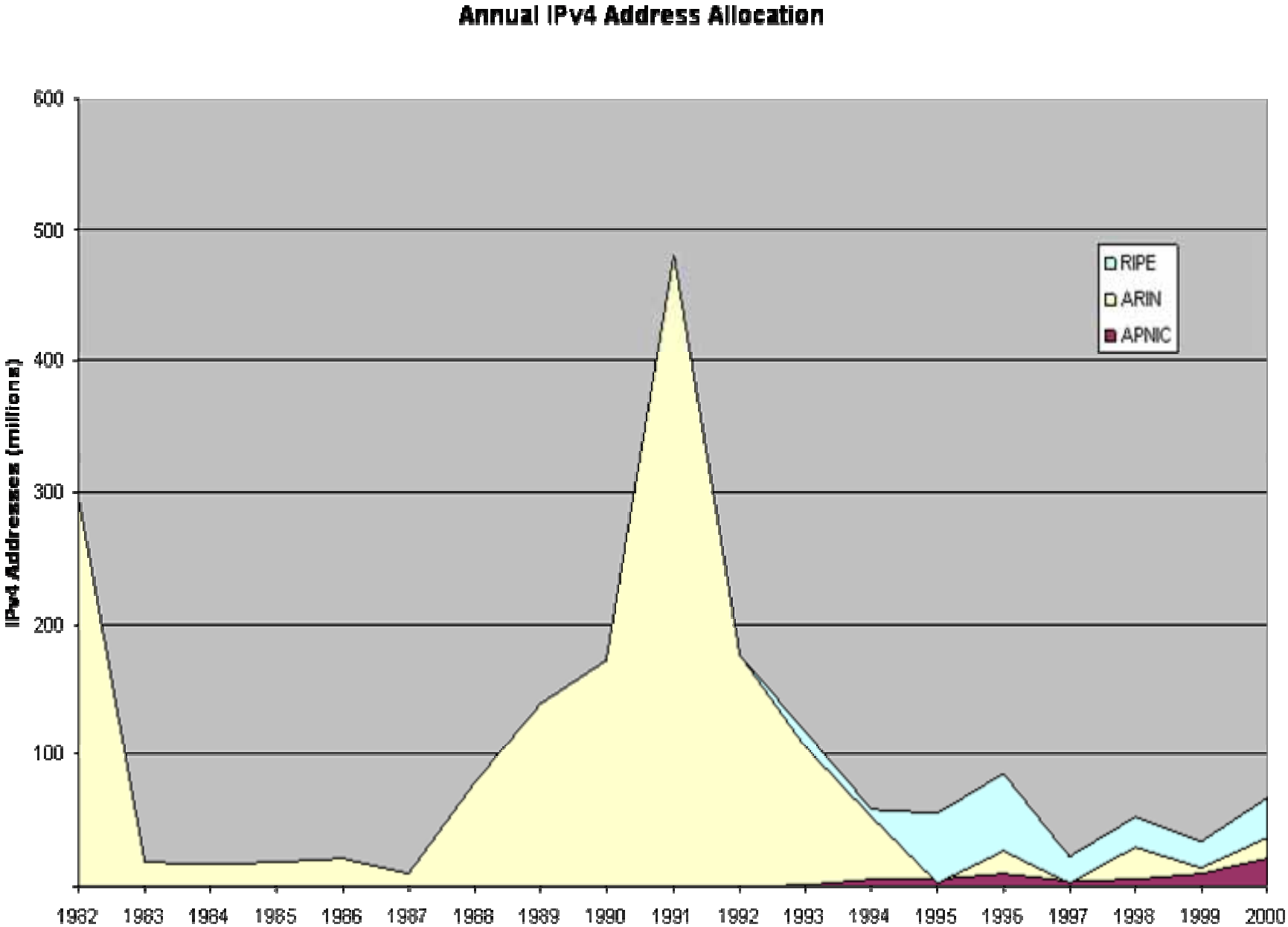
Goals (and Non-Goals)

- Formally and regularly:
  - Gather address deployment data from RIRs
  - Perform statistical analysis
  - Make allocation data available for independent analysis
- Non-goals:
  - ‘Blue sky’ theorizing
  - Estimating NAT utilization (for now)

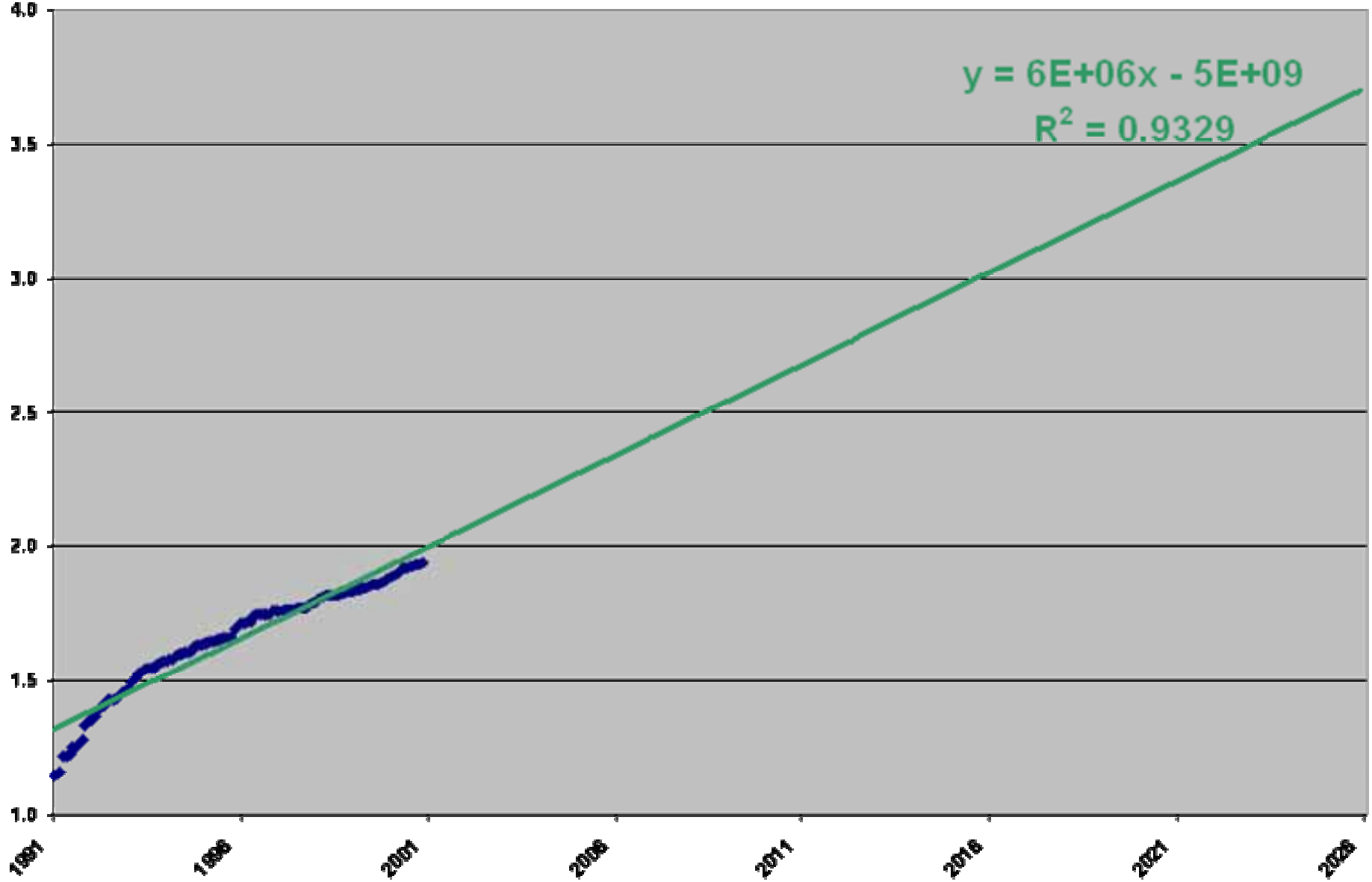
The Team

- Assembled by ARIN
  - Frank Solensky — Gotham Networks
  - KC Claffy — CAIDA
  - Scott Marcus — Genuity
- Active contributions and support by APNIC and RIPE NCC

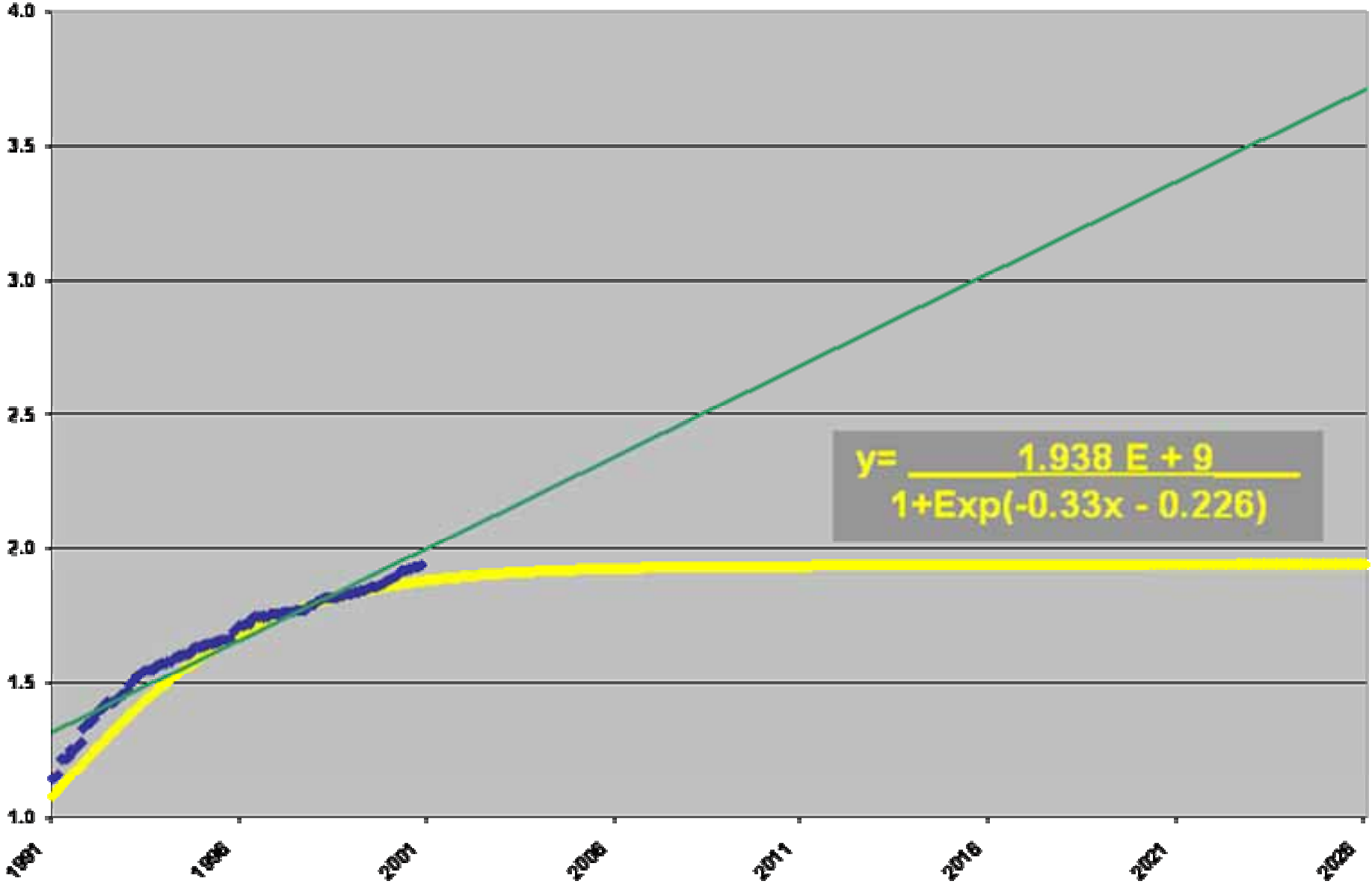

Cumulative IPv4 Addresses Allocated
IPv4 Addresses [billions]
25
2.
15
1.
5
.
RIPE
ARIN
APNIC
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001


Annual IPv4 Address Allocation
IPv4 Addresses (millions)
600
500
400
300
200
100
RIPE
ARIN
APNIC
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000

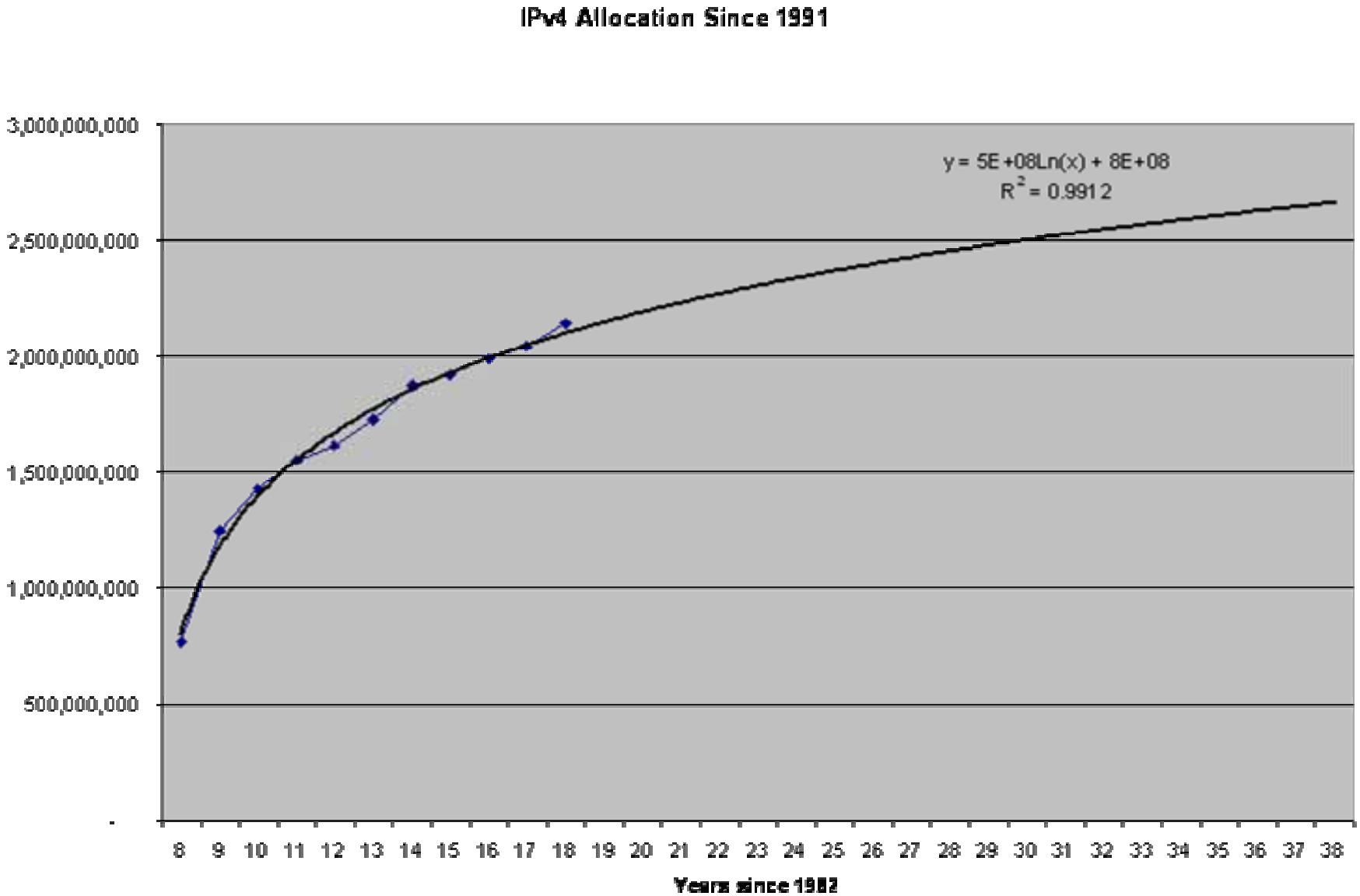
IPv4 Address Allocations: Linear Fit



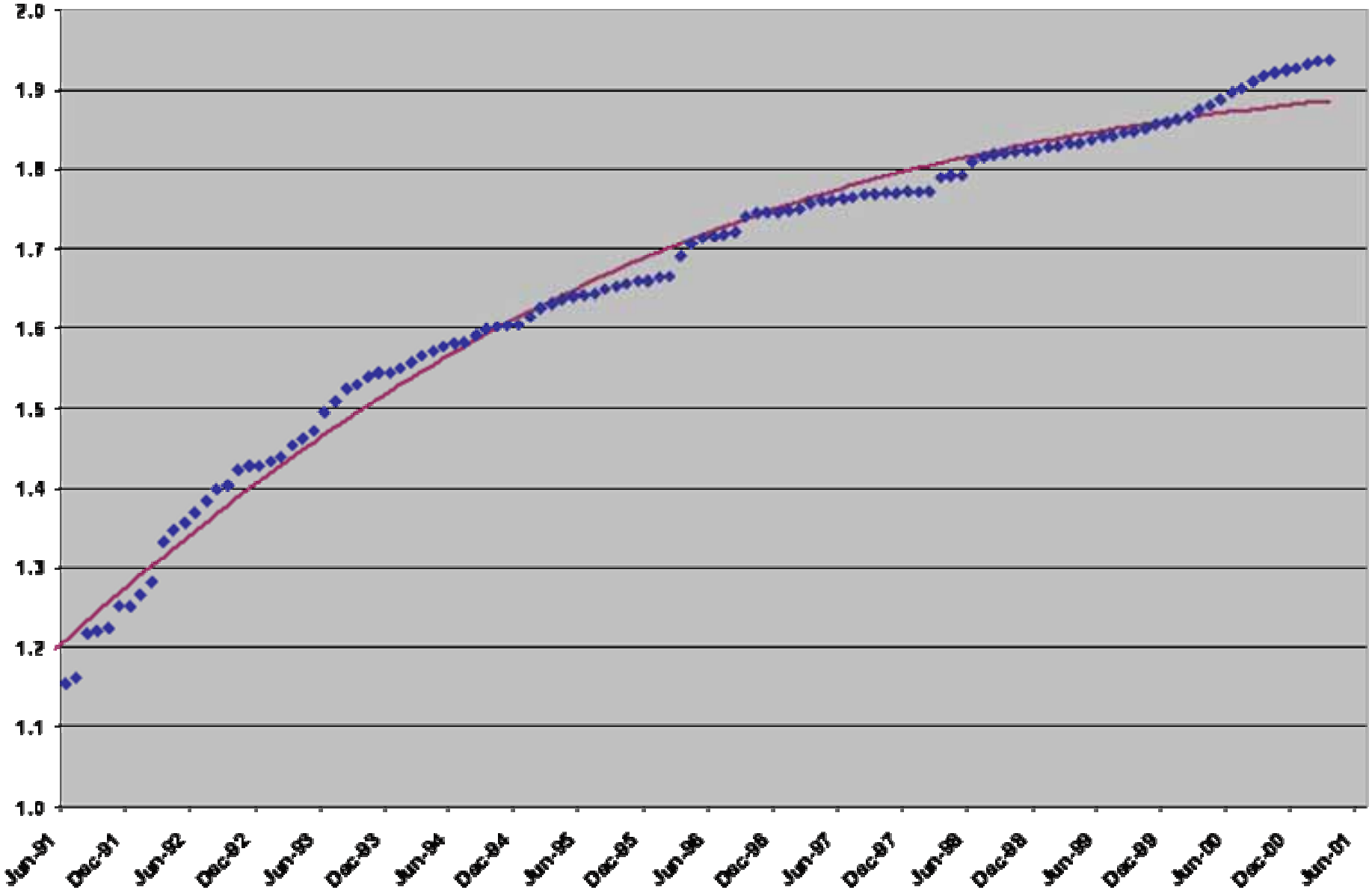
Address Allocations: Logistic Fit



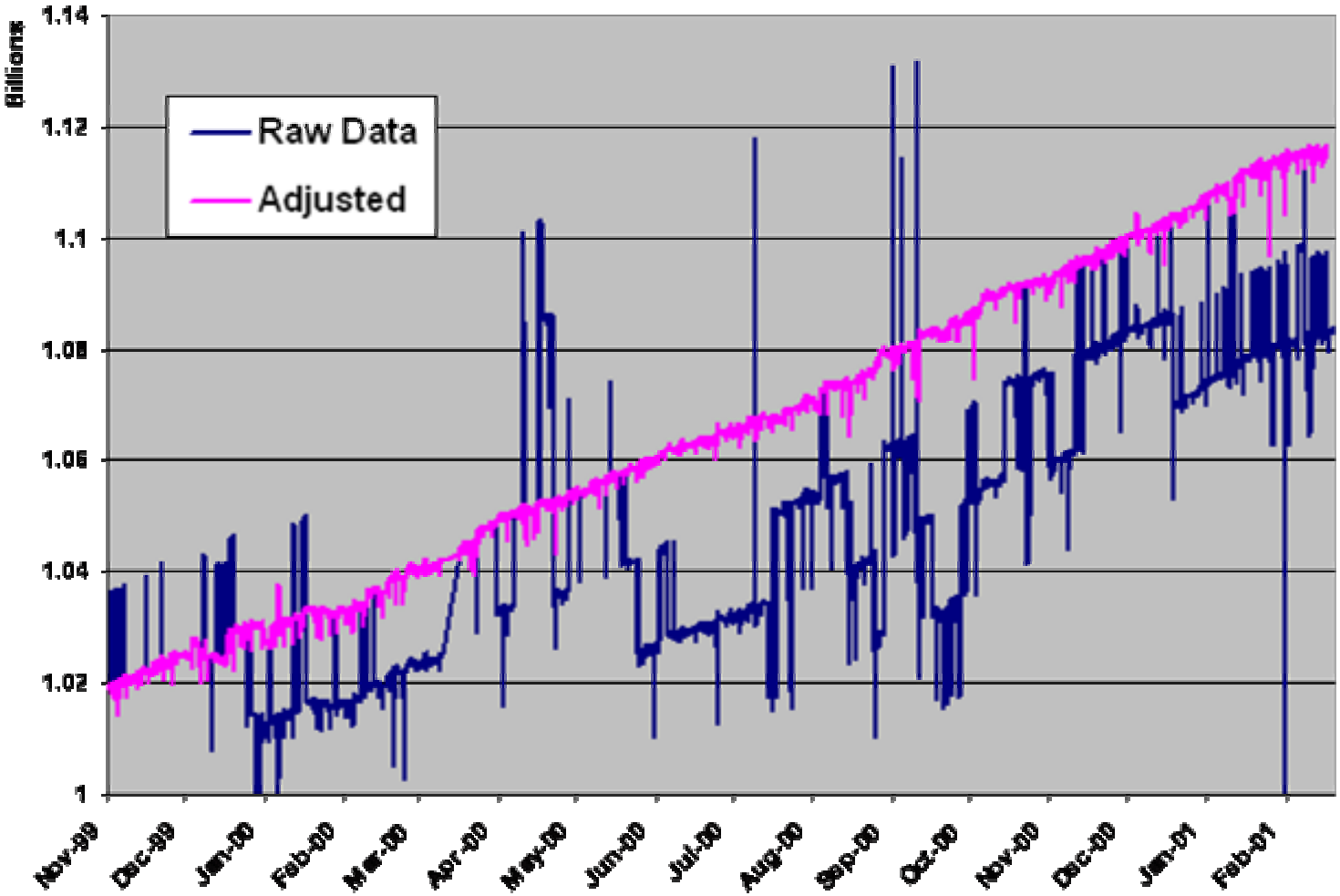
Address Allocations: Logarithmic Fit



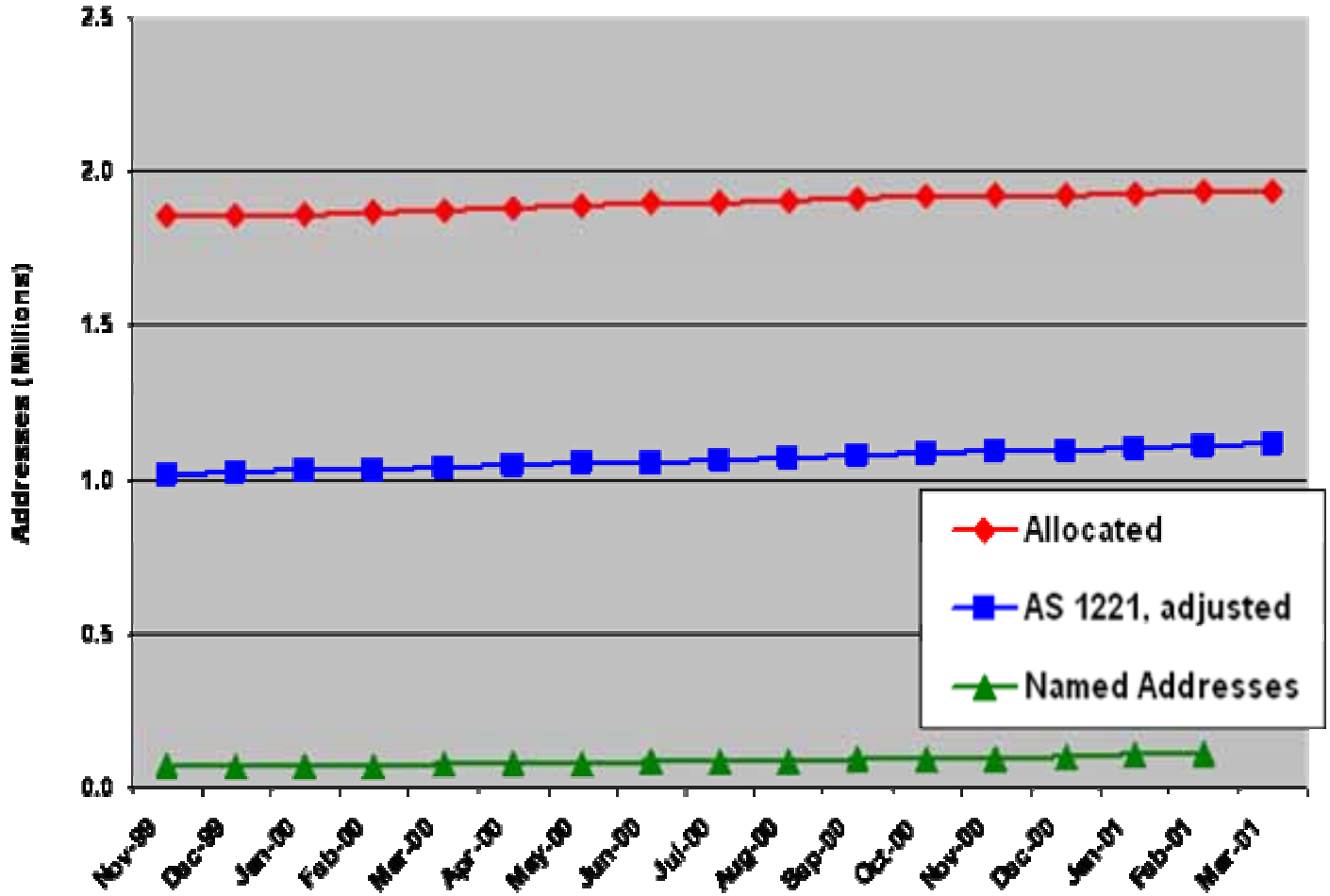
A Closer Look - Logistic Curve



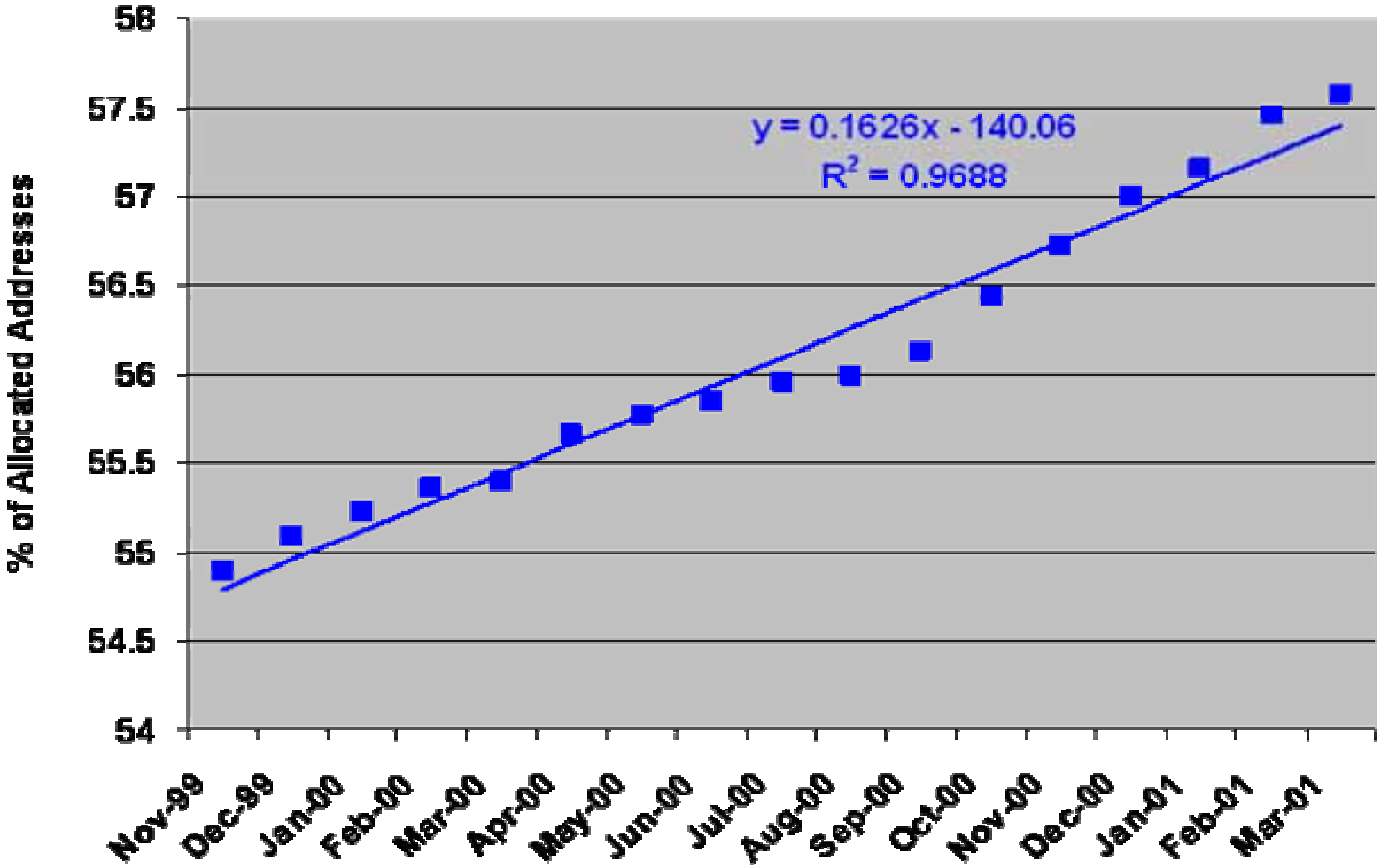
Addresses Seen by AS1221



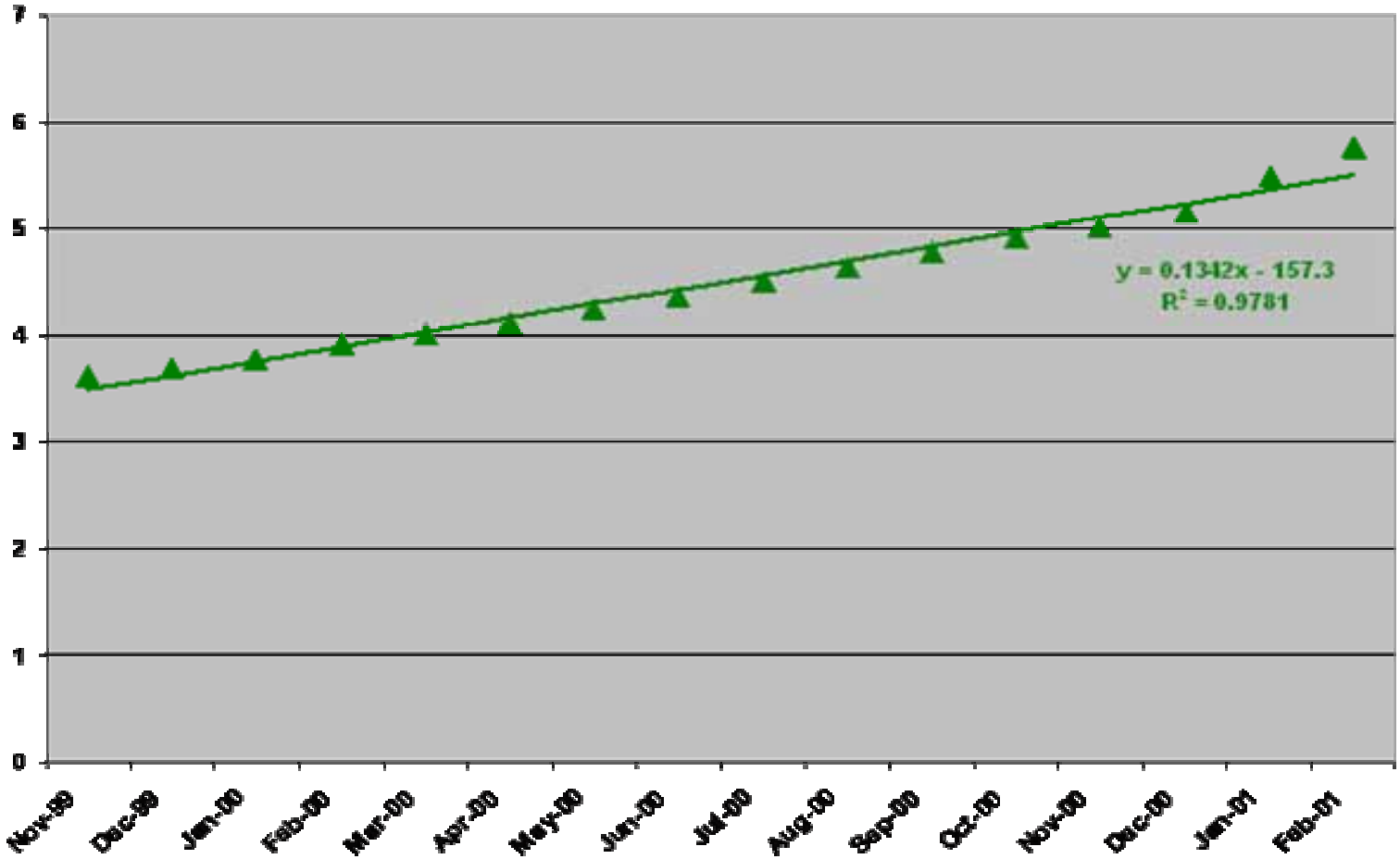
Addresses in Use



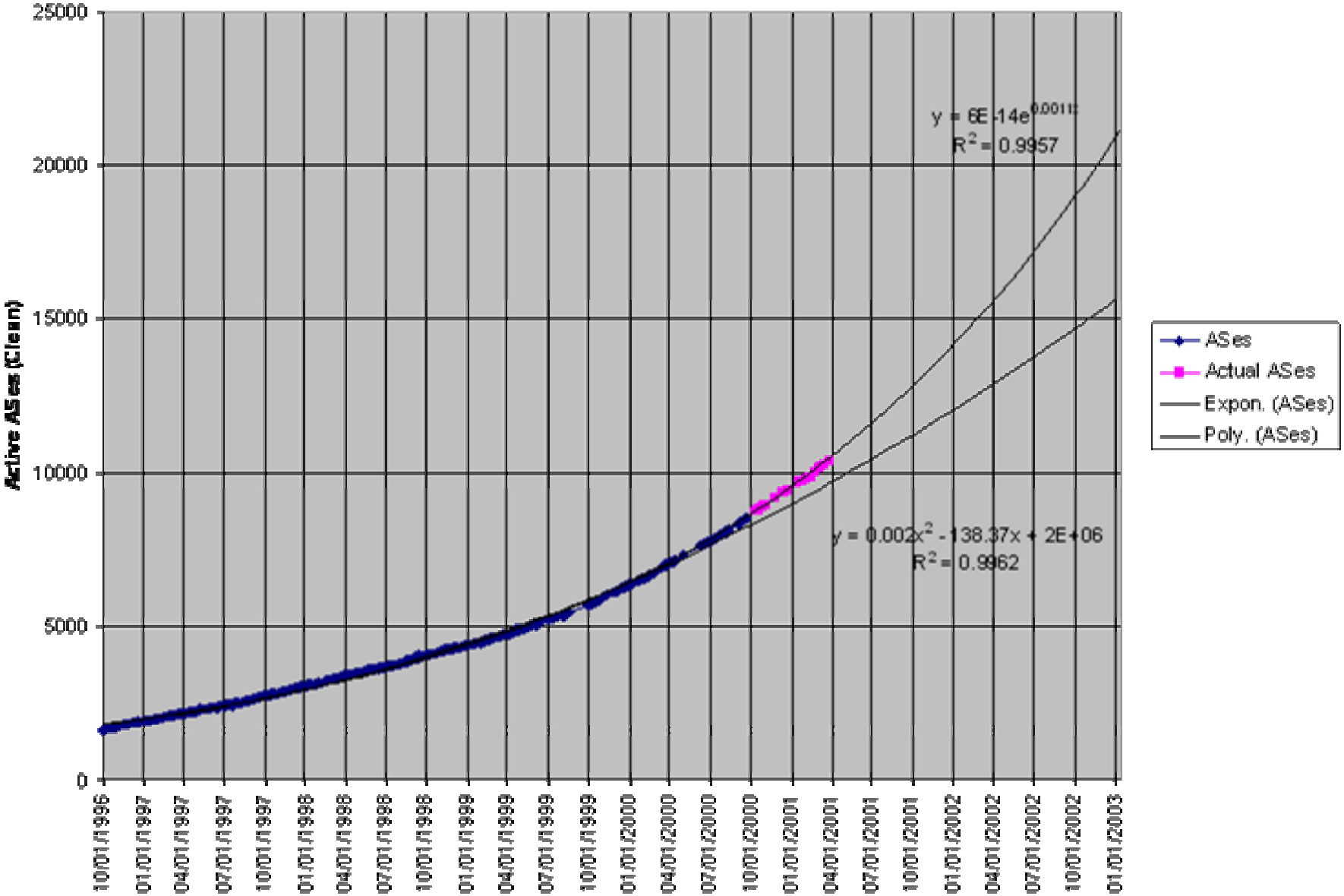
AS1221 Address Growth



Reverse Name Address Growth



AS Numbers Redux



Kudos

- Cathy Murphy, ARIN
- Paul Wilson, APNIC
- Axel Pawlik, RIPE NCC
- Mirjam Kuehne, RIPE NCC
- Mark Kosters, Verisign
- Geoff Huston, Telstra
- Christian Huitema, Microsoft