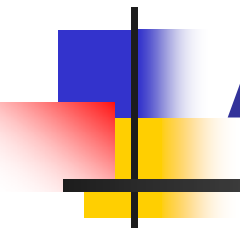
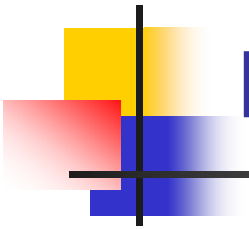


Allocations vs Announcements

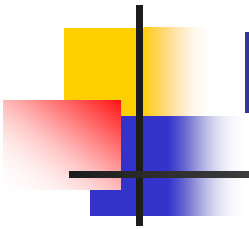
A comparison of RIR IPv4 Allocation Records with Global Routing Announcements

Geoff Huston
May 2004
(Activity supported by APNIC)



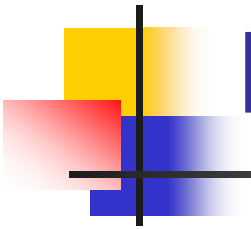
BGP Prefix Length Filters

- Some years back a number of ISPs introduced prefix length filters on the routes they accepted from their peers
- This practice was taken up by others and is now widespread across the Internet
- The filters are typically based on observations of minimum allocation sizes of RIR allocations within /8 address blocks



Implications

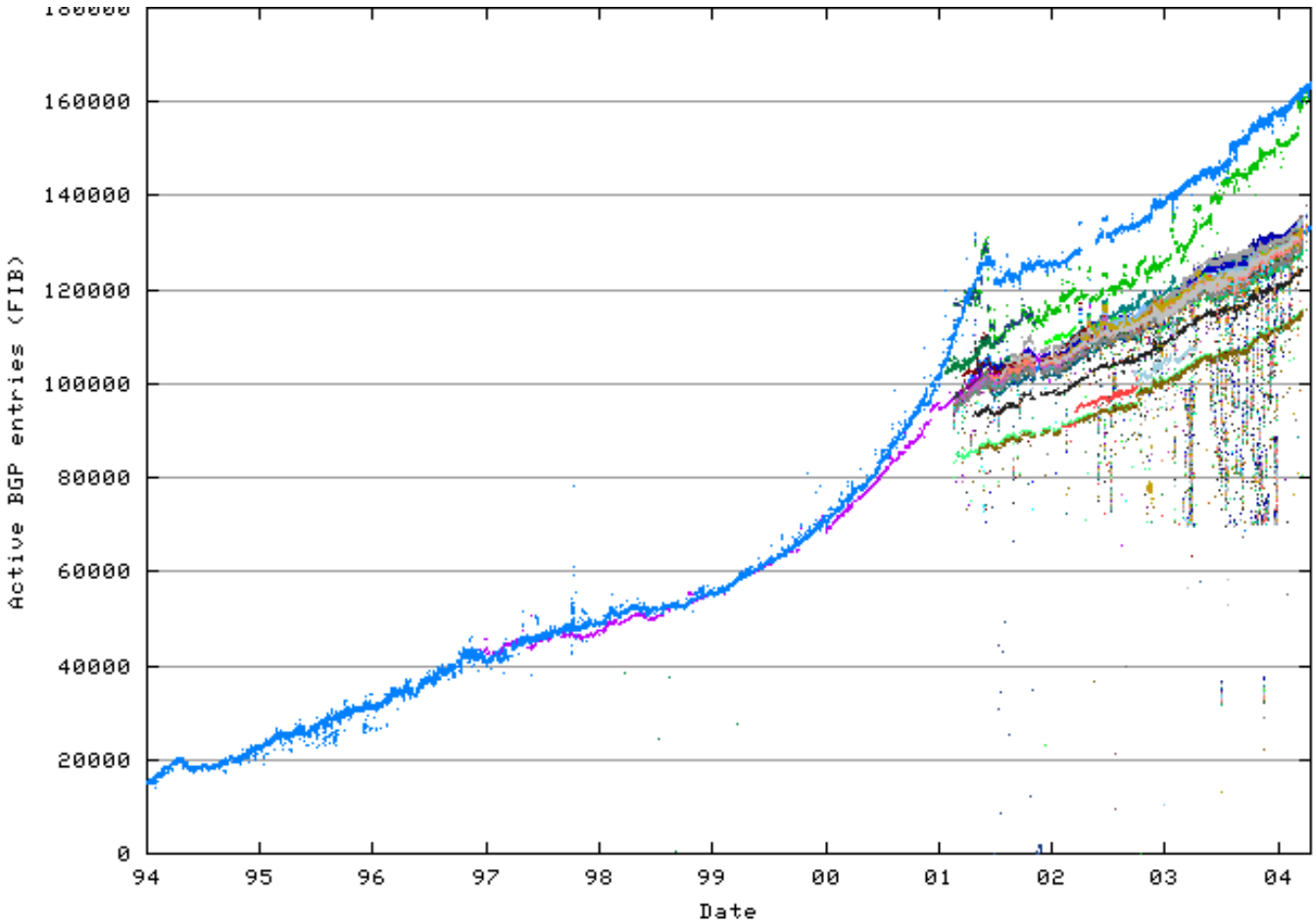
- The generic assumption behind the use of these filters is that:
  - ISPs should globally advertise the RIR allocated address block as a single aggregate
  - If more specific fragments of an RIR allocation are advertised for local resilience and traffic engineering reasons, these fragmentary advertisements should be scoped such that they do not spread globally



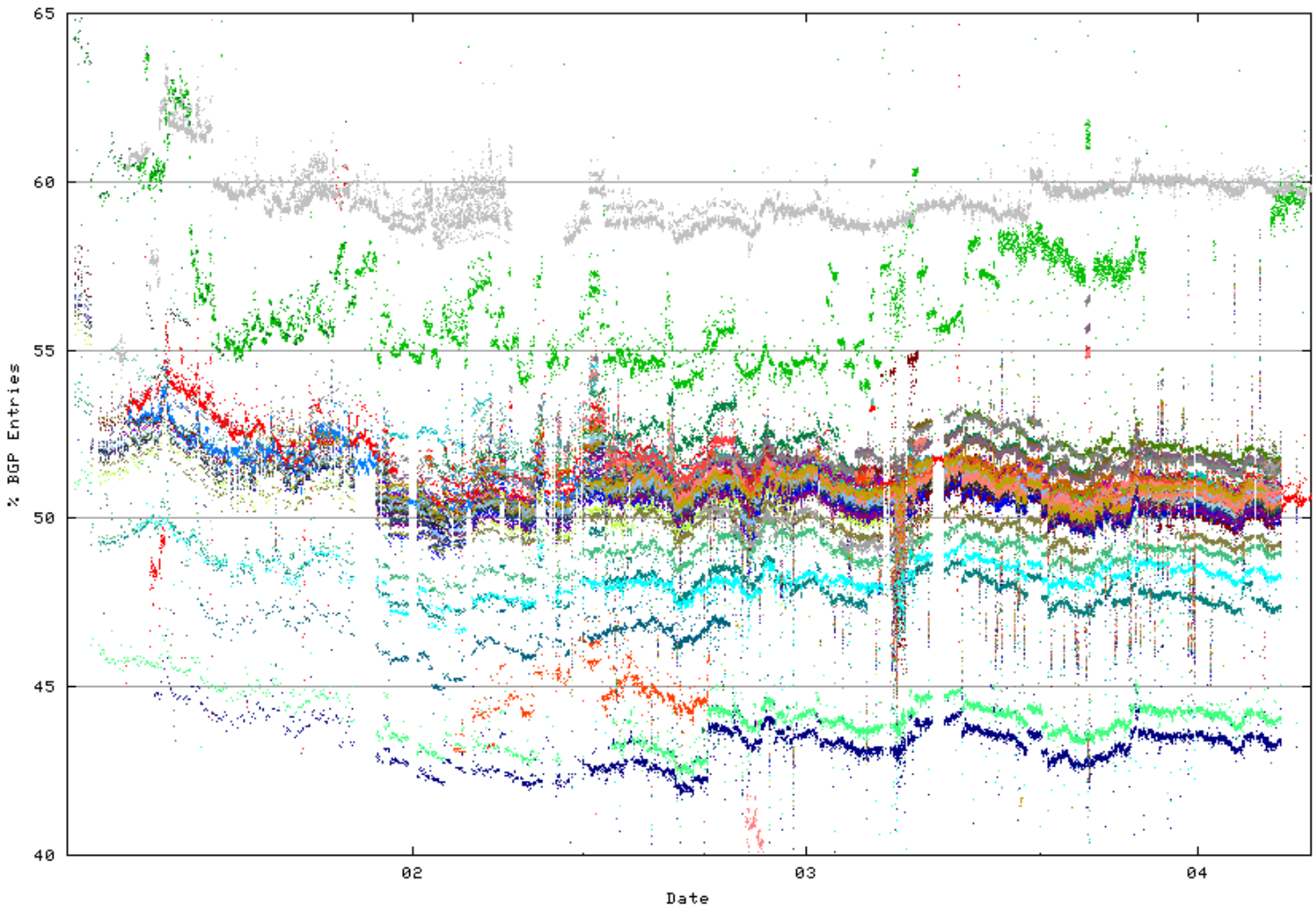
How big is the problem?

- Does prefix filtering help?
- More generally, how “big” are the more specific advertisements in the BGP table?
  - What is the percentage of more specific fragmentary advertisements?
  - How much address space do these more specifics cover?
  - Do they add new routing information?

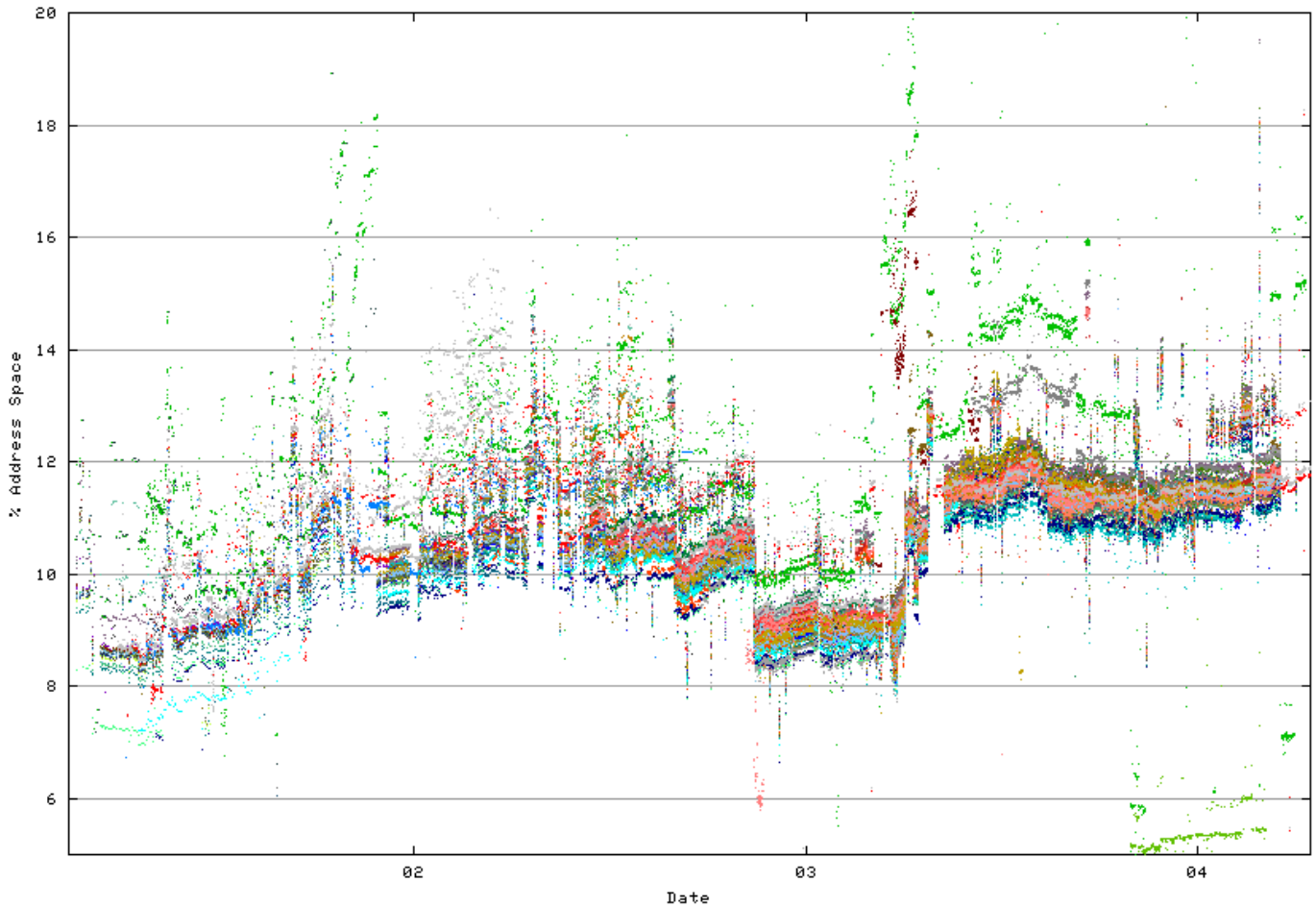
BGP Routing Table history



More Specific Advertisements



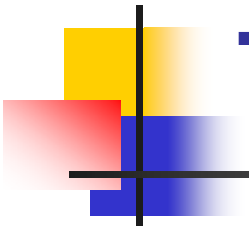
Address Span of Specifics



More Specifics

- Appear to be the ‘noise’ of the BGP table. They account for:
  - 55% of the routing entries,
  - 12% of the advertised address space
  - appear to offer no new route paths

- Is the use of more specifics an artefact of inappropriate address assignment policies?



The Question

- How accurate is this assumption that RIR allocations and advertisements are aligned?
- Has this changed in recent times?

Methodology

- Compare the prefixes listed in the RIR delegated files (a log of allocations) with the prefixes contained in a dump of the BGP routing table

Recent RIR and BGP Data

- **4364** RIR IPv4 allocations
  (1 Jan 2003 - 15 April 2004)
- **907** allocations are NOT announced as yet
- **3457** allocations are announced
- **10874** routing advertisements are used to span these 3457 allocations

- Each RIR allocation generates an average of **3.1** routing advertisements

2003/2004 Data (cont)

3457 RIR allocations are advertised

Of these:….

2776 Advertisements precisely match the RIR Allocation

8027 Advertisements are more specifics of 1163 RIR allocations

- **66%** of RIR allocations are directly advertised as routing advertisements without more specifics
- **34%** of RIR allocations generate more specific advertisements
- Where more specifics are advertised there are **6.9** more specific advertisements for each RIR allocation

Prefix Length Distribution

Allocation		Advertisements															
Size	**Total**	**Total**	**More Specifics**	**/11**	**/12**	**/13**	**/14**	**/15**	**/16**	**/17**	**/18**	**/19**	**/20**	**/21**	**/22**	**/23**	**/24**
/11	**6**	**102**	**98**	**4**					**77**	**5**				**1**	**4**	**3**	**8**
/12	**16**	**729**	**723**		**6**			**4**	**50**	**22**	**66**	**81**	**54**	**60**	**97**	**95**	**194**
/13	35	450	431			19	12	7	50	22	52	59	74	47	54	18	36
/14	51	565	530				32	5	28	15	35	137	109	11	17	49	124
/15	65	713	666					45	21	17	43	55	72	72	84	57	245
/16	204	865	691						171	24	56	74	92	138	64	39	204
/17	157	677	562							112	39	55	82	88	84	44	170
/18	299	1052	836								214	86	85	77	91	63	434
/19	687	1985	1447									531	145	145	156	94	907
/20	1022	2504	1715										739	139	183	152	1241
/21	70	112	50											62	2	2	46
/22	215	332	165												167	22	143
/23	256	313	109													204	109
/24	471	471	0														470
Total	3554	10039	7202	0	0	19	44	57	270	190	439	997	1398	779	902	744	4129

Limiting the sample to 2004

- Is this level of fragmentation of RIR Allocated address blocks getting better or worse in recent times?
- One way to look at this is to use a smaller data pool of very recent data and compare it with the larger pool already presented

2004 Data

- **1232** RIR IPv4 allocations (up to 15 Apr)
- **462** allocations are NOT announced as yet
- **770** allocations are announced
- **1469** routing advertisements are used to span these 770 allocations

  - Each RIR allocation generates an average of **1.9** routing advertisements

2004 Data (cont)

752 RIR allocations are advertised

Of these:…

629 Advertisements precisely match the RIR Allocation

827 Advertisements are more specifics of 197 RIR allocations

- **74%** of RIR allocations are directly advertised as routing advertisements without more specifics
- **26%** of RIR allocations generate more specific advertisements
- Where more specifics are advertised there are **4.2** more specific advertisements for each RIR allocation

2004 Data – Prefix length Distribution

Allocation		Advertisements														
Size	Total	Total	More Specifics	/12	/13	/14	/15	/16	/17	/18	/19	/20	/21	/22	/23	/24
/12	4	31	30	1			3	10	3			4	4	3		3
/13	8	30	23		7	1		6	7	4	3	1		1		
/14	10	37	31			6	2	6	3	3	4	12			4	1
/15	10	43	35				8	4	8		17					2
/16	96	232	146					84	4	14	15	29	56	4		24
/17	30	47	23						24	5	4	8	4	1		1
/18	49	119	82							37	12	14	7	8	2	39
/19	125	225	126								97	24	24	31	9	38
/20	228	468	281									178	18	42	17	204
/21	27	35	10										25		2	8
/22	44	58	25											33	5	20
/23	48	52	12												40	12
/24	89	89														89
Total	768	1466	824		7	7	13	110	49	63	152	270	138	123	79	441

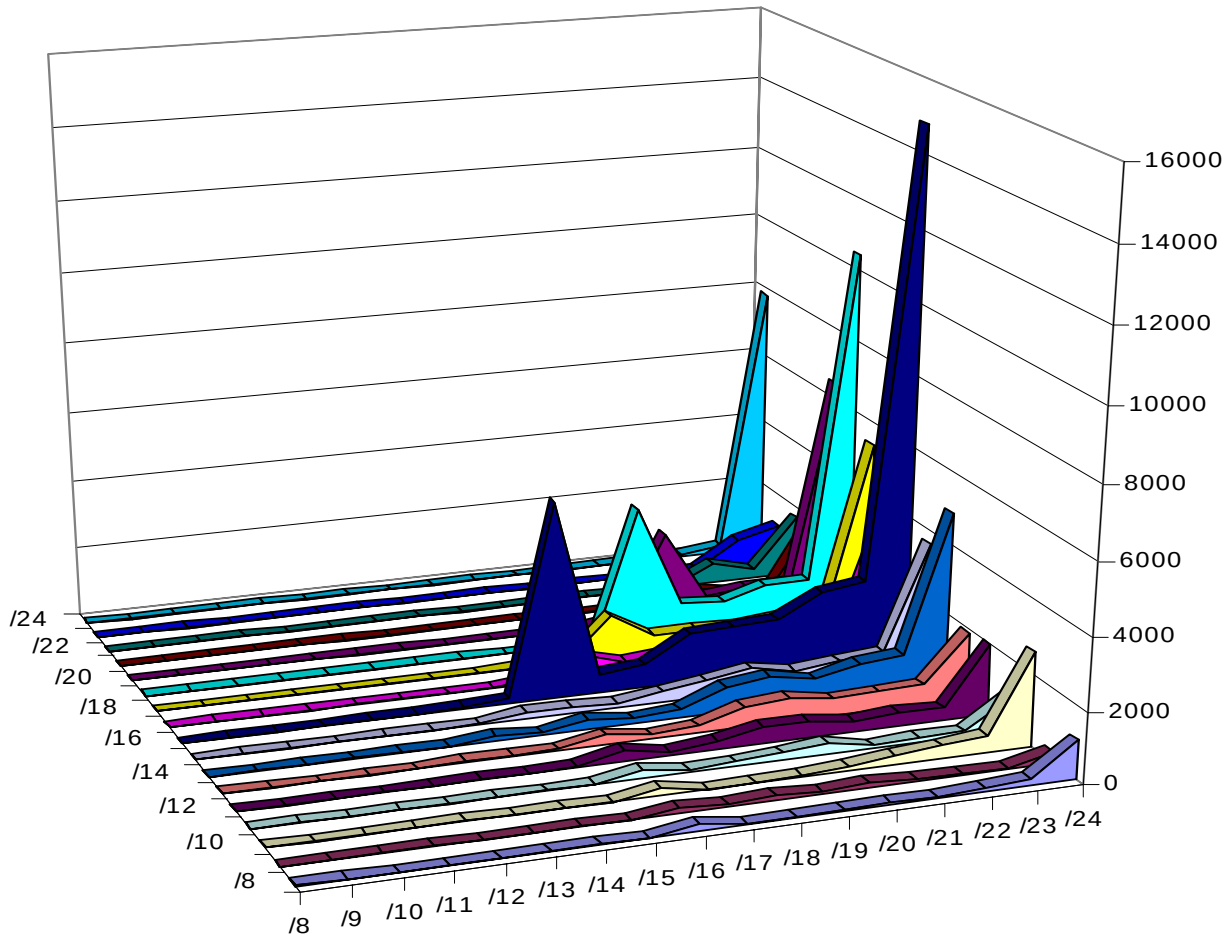
Trends of Fragmentation of Allocations

- The following graphs look at the entire data set of all RIR allocations and compare these to the current state of the routing table. The dates used in the analysis are the dates of the RIR allocation.

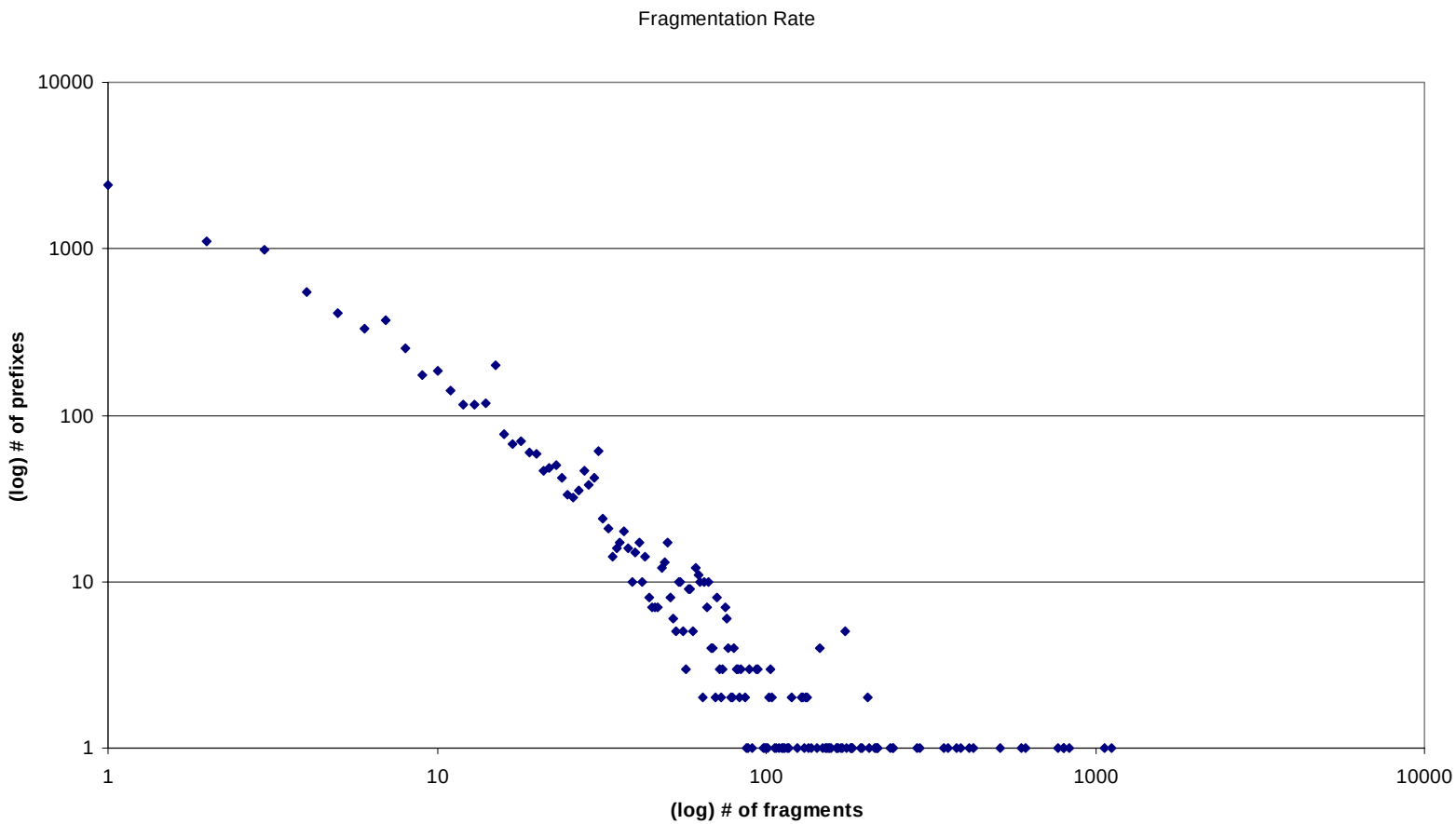
Prefix Length Distribution

Allocation Size	Total	Not Advertised	Advertisements Total	More Specifics	/8	/9	/10	/11	/12	/13	/14	/15	/16	/17	/18	/19	/20	/21	/22	/23	/24	/25	/26	/27	/28	/29	/30	/31	/32
/8	**44**	**13**	**1864**	**1845**	19	4	1	1	7	5	10	10	206	15	24	48	62	49	120	195	1088								
/9	**4**		**1064**	**1064**				1		3		7	132	67	133	80	154	84	62	33	308								
/10	**16**	**2**	**4136**	**4133**			3	2	9	7	6	7	203	6	11	56	124	240	353	476	2632		1						
/11	**33**	**4**	**2202**	**2193**				9	6	3	6	10	248	57	121	192	292	72	129	147	910								
/12	**89**	**14**	**4656**	**4637**					19	13	10	31	323	106	222	466	450	288	379	364	1985								
/13	172	17	**5512**	5460					3	49	39	44	290	119	202	591	676	489	536	576	1897		1						
/14	340	19	**9783**	9629	1				2	6	145	57	266	136	226	707	848	624	893	997	4875								
/15	431	33	**7136**	6927						2	9	198	182	123	283	463	647	412	532	648	3637								
/16	9481	2805	**30361**	24634			2	2	12	16	56	131	5508	516	629	1351	1439	1464	2125	2305	14805								
/17	1227	116	**8261**	7525						1	1	2	87	645	289	423	528	530	957	689	4102		6			1			
/18	2077	257	**9395**	8142								1	9	44	1199	505	515	478	634	666	5343								1
/19	5813	797	**18236**	14354							2	3	3	10	87	3777	855	774	1136	1150	10430			2			4		3
/20	4879	991	**11022**	8328							1		2	1	4	176	2510	542	641	701	6441				1				2
/21	1783	702	**2745**	2397								1	1			4	5	337	181	196	2020								
/22	2425	1011	**2590**	2004										1	1	2	2	2	578	278	1726								
/23	2665	1262	**1875**	1093													1	1	5	775	1093								
/24	27392	19233	**8205**										7	1	3	9	18	43	95	241	7788								
/25	42	39	**3**																	1	2								
/26	29	27	**2**																		2								
/27	21	20	**1**													1													
/28	11	10	**1**															1											
/29	5	5																											
Total	58915	27377	115128	90493	20	4	6	15	58	105	285	502	7467	1847	3434	8851	9126	6430	9356	10438	71084	0	8	2	1	1	4	0	6

Prefix Distribution



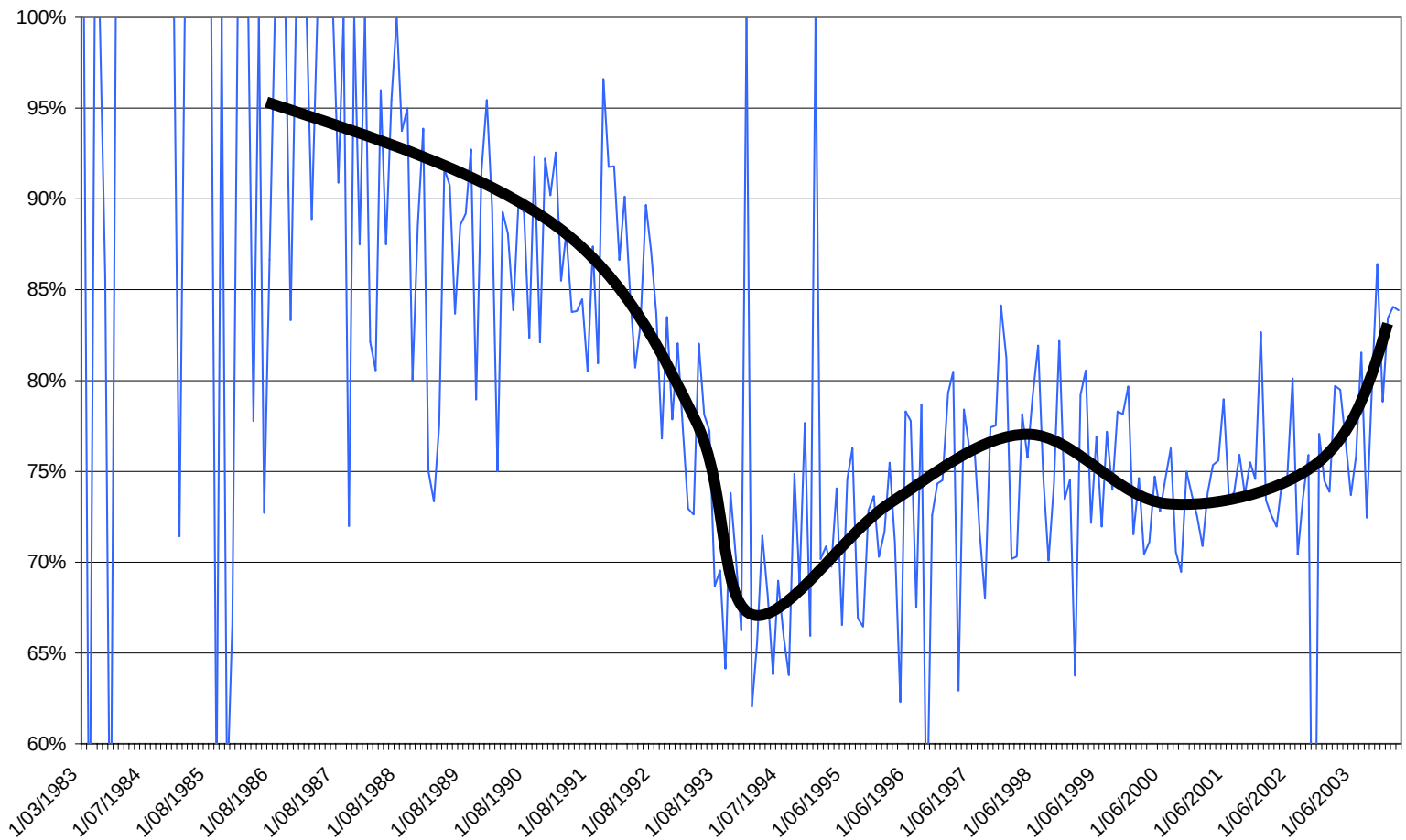
Fragmentation Distribution



Allocations Advertised ‘as is’

- This graph plots the proportion of address allocations that are advertised as allocated. The lower the proportion the greater the amount of allocations that are advertised only as fragments. The higher the number the better (in terms of reduction in advertisement fragmentation)
- This has been improving since August 2000

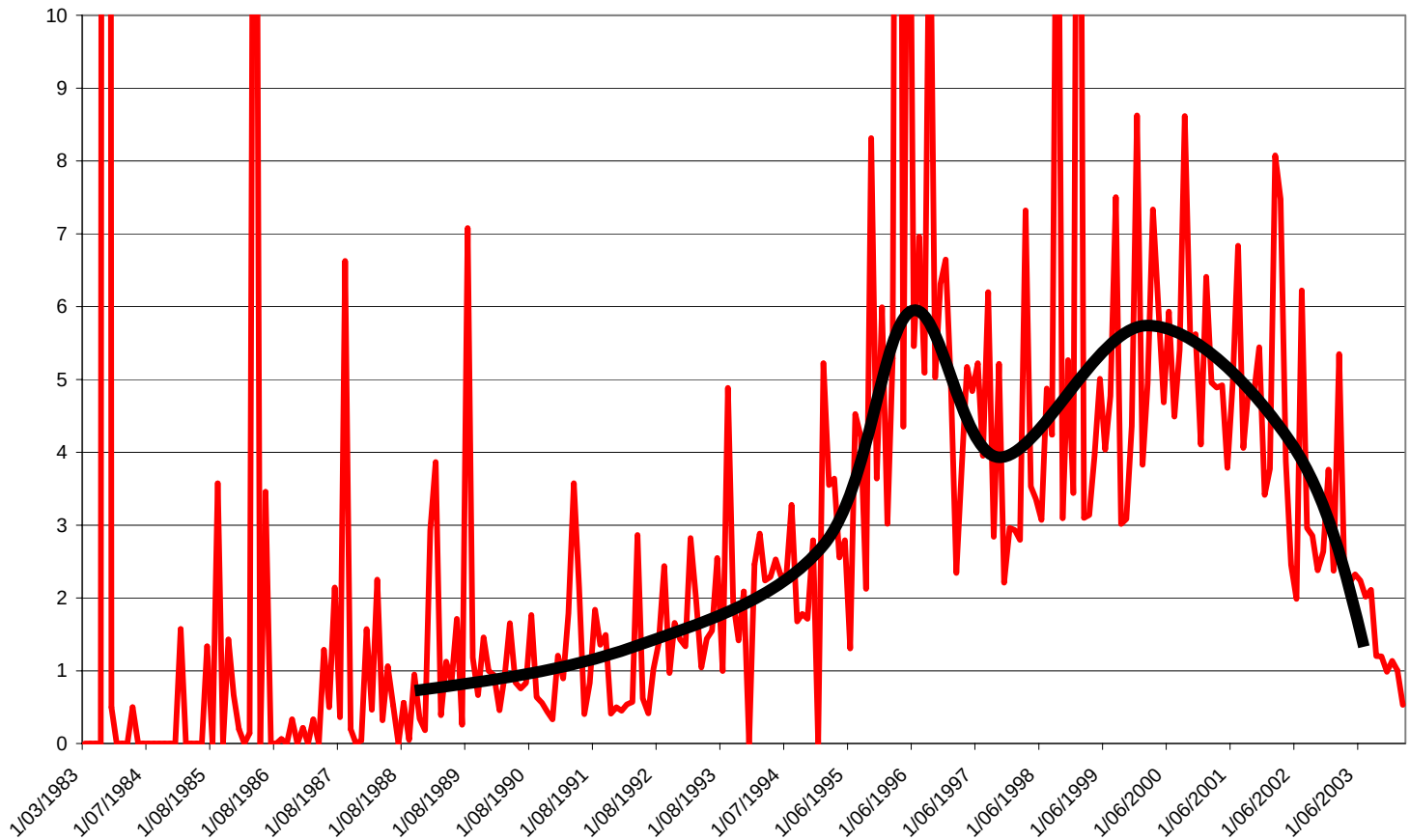
Allocations Advertised ‘as is’



Number of Fragmentary Advertisements as a proportion of Allocations

- This compares the number of fragmentary advertisements to the number of RIR allocations. The lower the number, the better.
- The proportion of fragmentation of allocated blocks has been dropping since August 2000

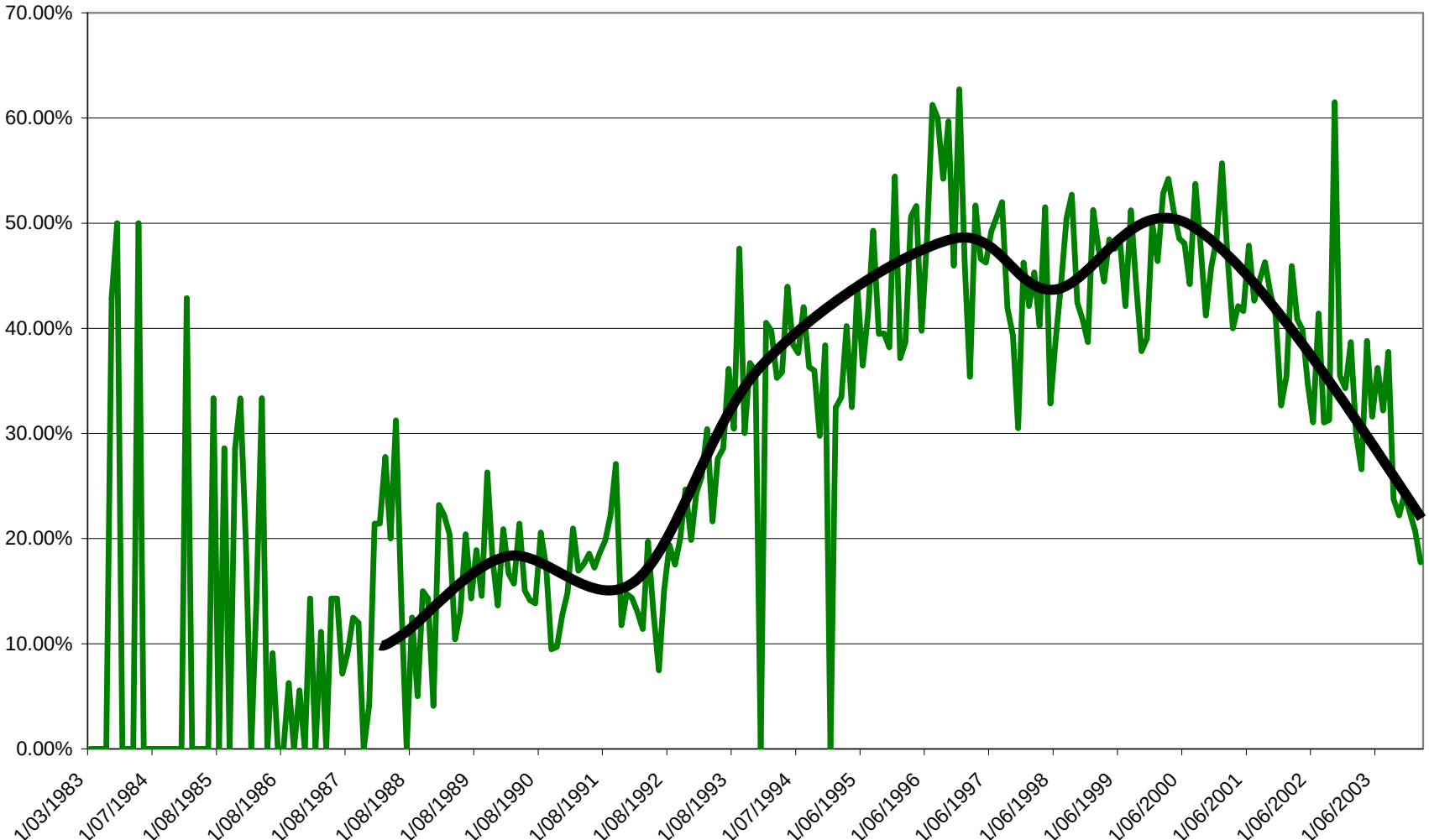
Number of Fragmentary Advertisements as a proportion of Allocations



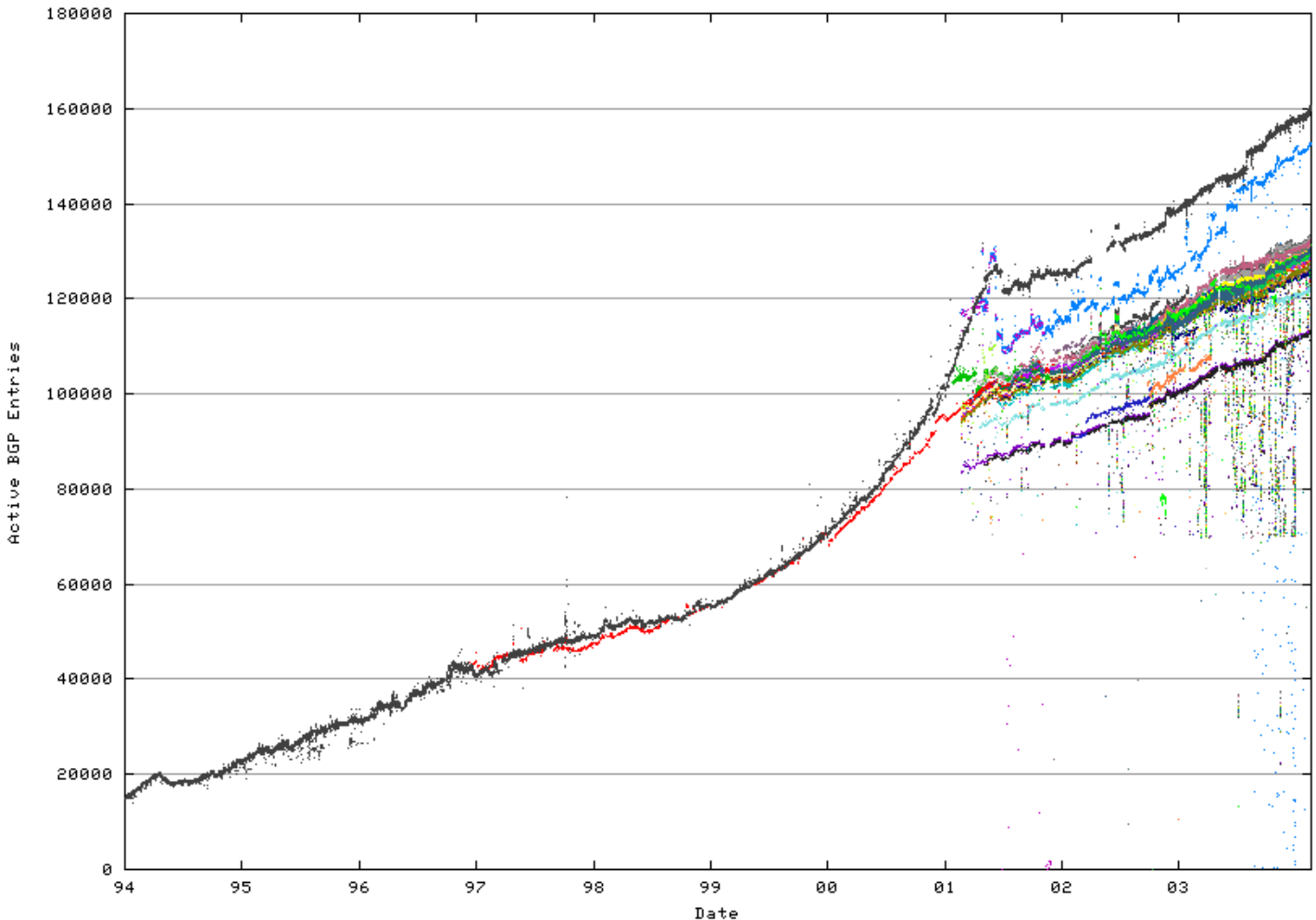
Proportion of Allocations that are advertised in Fragments

- This compares the number of allocations against the number of allocations that are advertised in one or more fragments. The lower the number the smaller the amount of fragmentation of allocations
- Again there is a noticeable decline since August 2000

Proportion of Allocations that are advertised in Fragments



Just a reminder – BGP Routing Table Growth

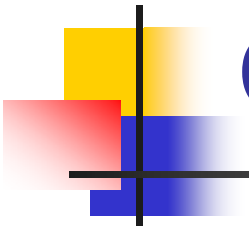


Observations (1)

- It appears that the major contributor to the growth of the routing table is the amount of advertisement fragmentation that occurs in allocated address space.
- This form of advertisement fragmentation peaked from 1997 – 2000
- The levels of advertisement fragmentation have been improving since late 2000.

Observations (2)

- Taking an allocated block and advertising more specific /24 address prefixes is the predominate form of advertising a split allocation block in fragments
  - Many of these more specifics appear to be local (i.e. could be masked with NOEXPORT)



Observations (3)

- One fifth of allocations are fragmented in this fashion, and, on average there are 6.6 additional advertisements of fragments of the address block

Observations (4)

- /21, /22, /23 allocations have proportionately less advertised fragmentation than larger prefix sizes

Observations (5)

- Levels of fragmentation of advertisements have been improving since late 2000, corresponding with a return to linear growth of the BGP routing table size.

Meta-Observations

- The level of fragmentation over time appears to correlate to the ISP activity history (boom, bust and consolidation)

- Renumbering is still hard. Once fragmented, almost never re-consolidated!

Routing Table Growth

- Is a measure of the “fit” of the environment to the underlying dynamics of connectivity requirements
  - Policy Environment: Ensure that the allocation size matches the networking requirement
  - Routing Tools: Provide inter-domain routing tools to allow bounded specific prefix propagation in the presence of covering aggregates