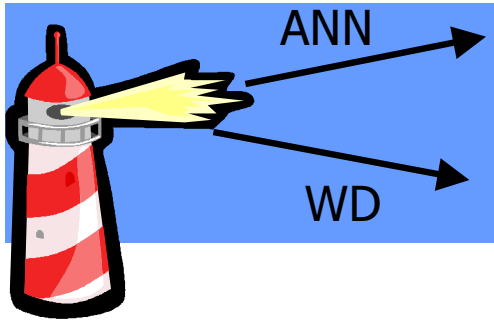


BGP Beacons

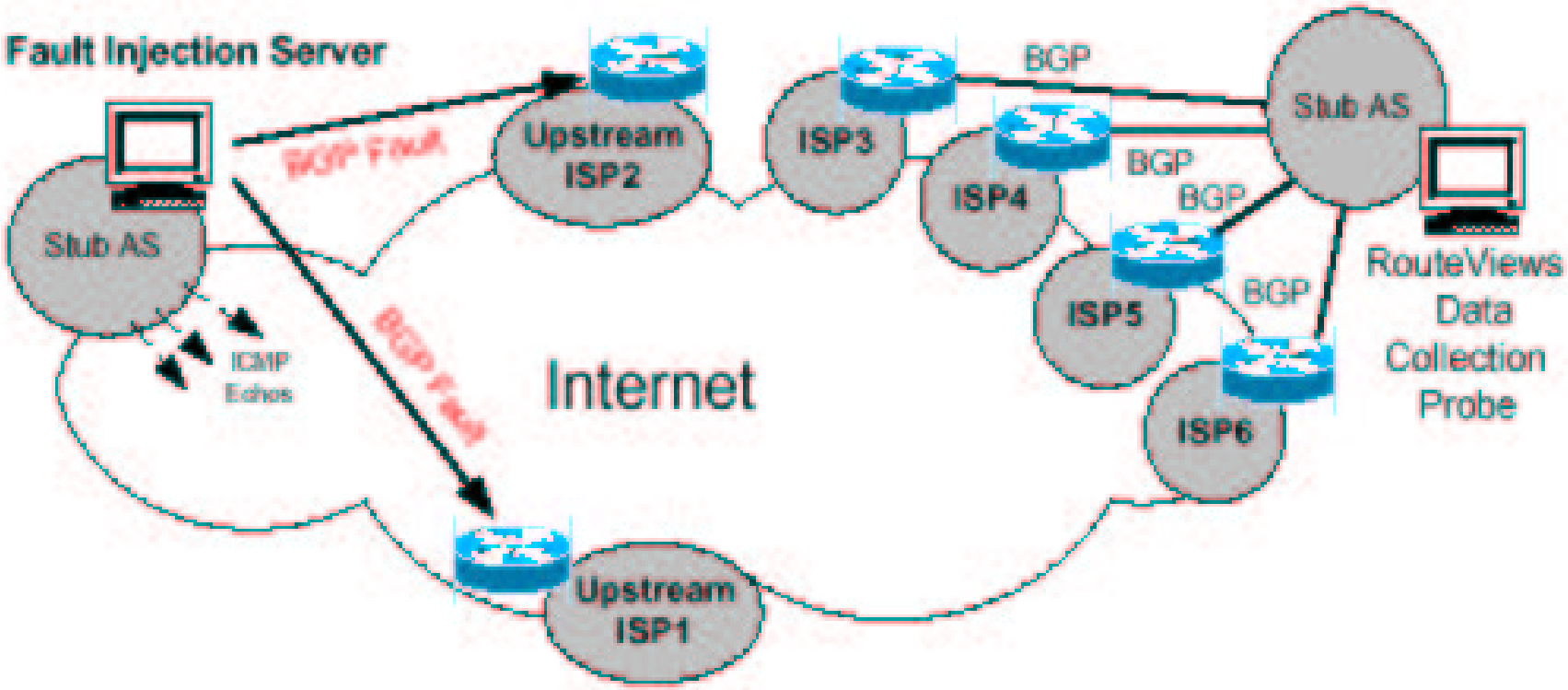
Leiden 2002

Tim Griffin (AT&T Research)
Z. Morley Mao (UC Berkeley)

Inspiration from Abha and Craig

- Pioneer work by Ahuja, Labovitz, et al. [sigcomm 2000]
  - "250,000 routing faults into geographically and topologically diverse peering sessions with five major commercial Internet Service Providers" (over 2 years)
    - E.g., Mae-West
  - Fault impact observed by active and passive measurements
    - End to end probing and BGP updates analysis

Ahba and Craig's BGP testbed



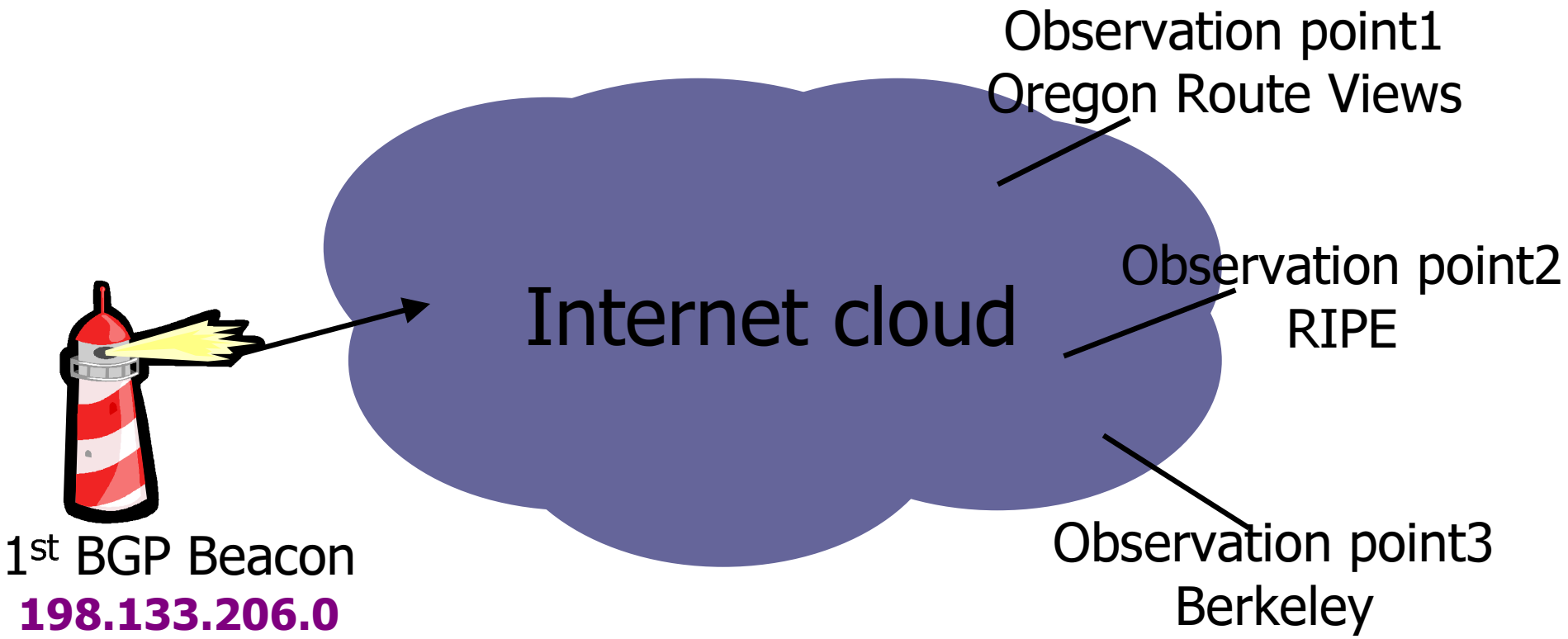
Picture taken from "Delayed Internet Routing Convergence", Sigcomm 2000

This motivates public BGP Beacons

- What is a BGP Beacon?
  - An unused prefix with **well-defined** announcement/withdrawal schedule
  - For research purposes to study BGP dynamics
    - Serve to calibrate and interpret BGP updates
  - Can be useful to network operators
    - Adjust configuration parameters: e.g., route flap damping settings
- Semi-permanent, publicly documented

Where to observe BGP Beacons?

- Use publicly available BGP update data
  - E.g., Route-views, RIPE



Existing BGP Beacons

Prefix	Source AS	Start date	Upstream Providers	Beacon Host
198.133.206.0/24	3927	8/10/02	AS2914, AS1	Randy Bush
192.135.183.0/24	5637	9/4/02	AS3701, AS2914	David Meyer
203.10.63.0/24	1221	9/25/02	AS1221	Geoff Huston

- Announced and withdrawn with a fixed period

(2 hours) between updates

- 1st daily ANN: 3:00AM GMT
- 1st daily WD: 1:00AM GMT

RIPE Routing Beacons

- http://www.ripe.net/ris/beacon.html
- Since Sep 30th 2002

Prefix	RRC	Location
195.80.224.0/24	RRC00-RIPE NCC	Amsterdam, NL
195.80.225.0/24	RRC01-LINX	London, UK
195.80.226.0/24	RRC02-SFINX	Paris, FR
195.80.227.0/24	RRC03-AMS-IX	Amsterdam, NL
195.80.228.0/24	RRC04-CIXP	Geneva, CH
195.80.229.0/24	RRC05-VIX	Vienna, AT
195.80.230.0/24	RRC06-NSPIXP2	Otemachi, JP
195.80.231.0/24	RRC07-Netnod-IX	Stockholm, SE
195.80.232.0/24	RRC08-MAE-WEST	San Jose, CA, US

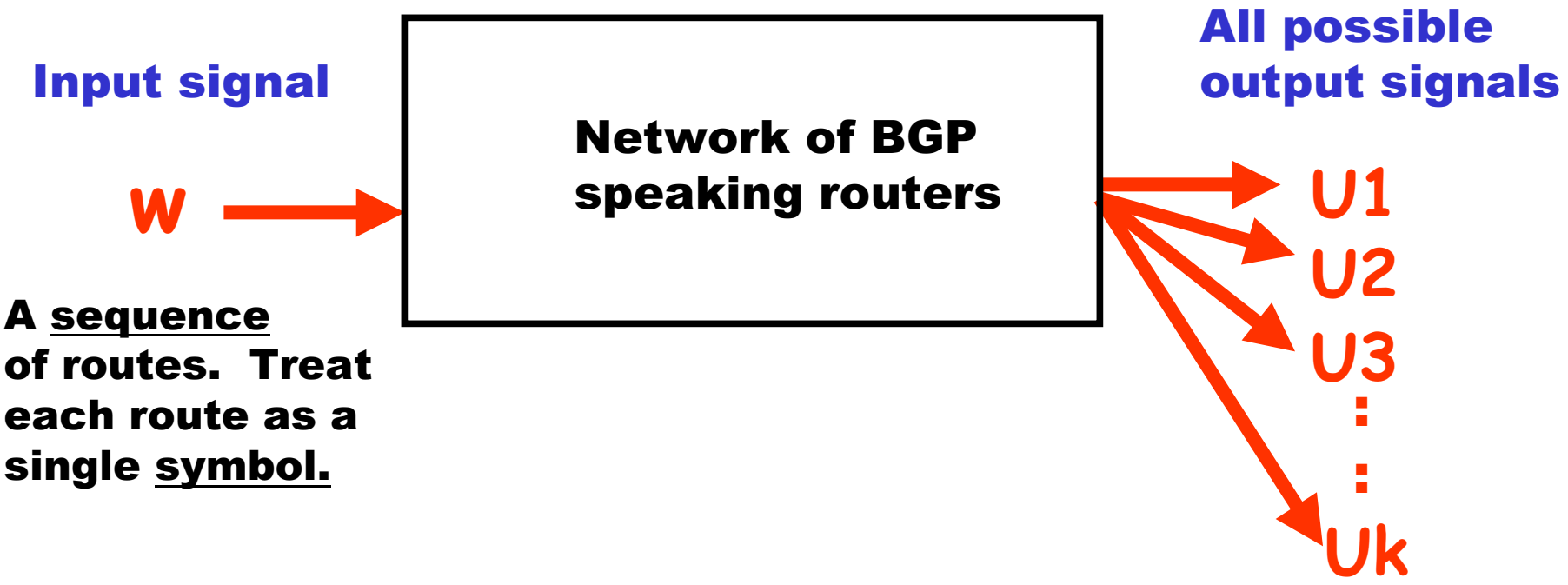
Soliciting new Beacons

- How can you help to set up a BGP Beacon?
  - Need an unused prefix accepted by upstream provider
  - Software available to automatically inject routes into BGP session
    - Modified based on bgpd.pl
    - Contact zmao@eecs.berkeley.edu

Preliminary Beacon analysis

- Basic statistics on "Beacon noise"
  - Based on viewing network as signal translator
- Case study of route flap damping
  - Looking withdraw- and announce-triggered route suppression

Think of BGP network as a transducer of signals….



Tim Griffin: "What is the sound of one route flapping" and "A Model of BGP Update Propagation" models BGP network With a network of non-deterministic Finite State Transducers (FSTs).

Example (RIPE RIS data)

RIPE data (from AT&T) for prefix 193.230.121.0/24 for a 20 minute period on Feb. 6 2002 was associated with these routes:

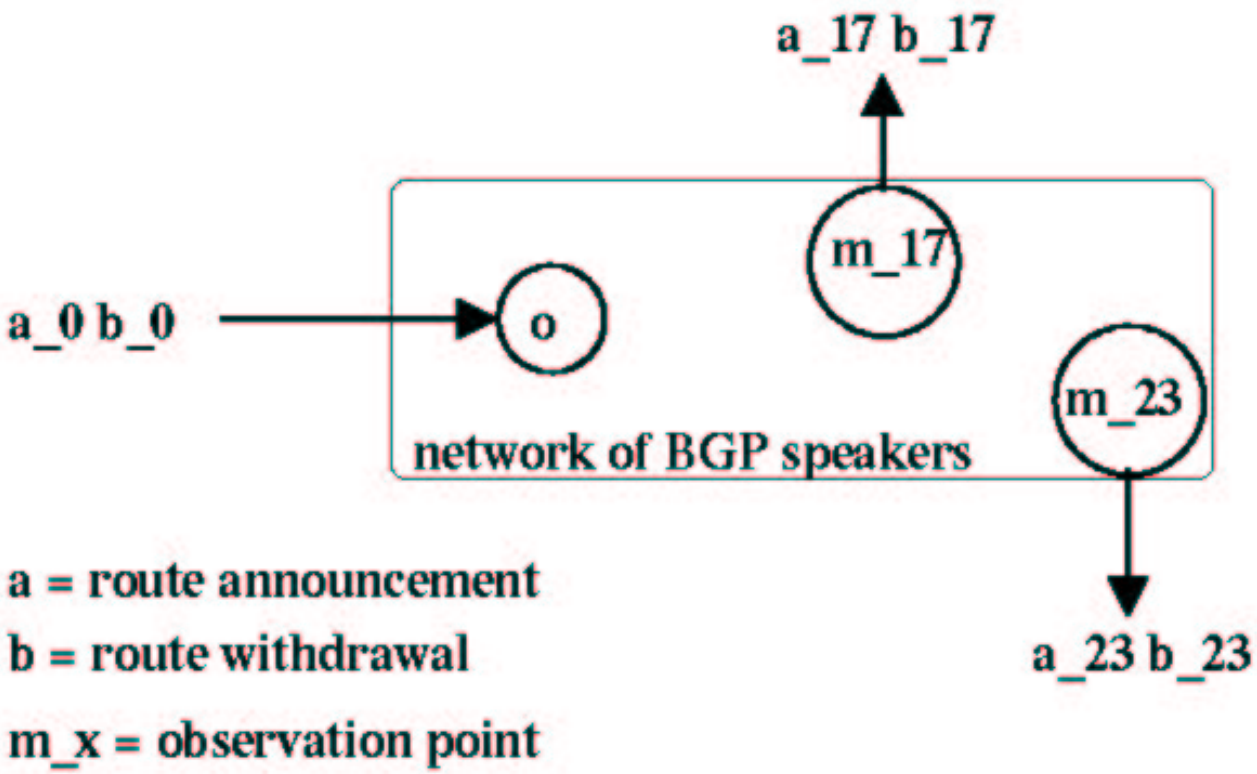
route with AS path	A	W
7018 701 702 8708 13181	a_1	b_1
7018 1299 5483 8708 13181	a_2	b_2
7018 3320 5483 8708 13181	a_3	b_3
7018 1239 3320 5483 8708 13181	a_4	b_4
7018 701 1299 1299 1299 5483 8708 13181	a_5	b_5

Using these symbols, represent the 20 minutes update stream as

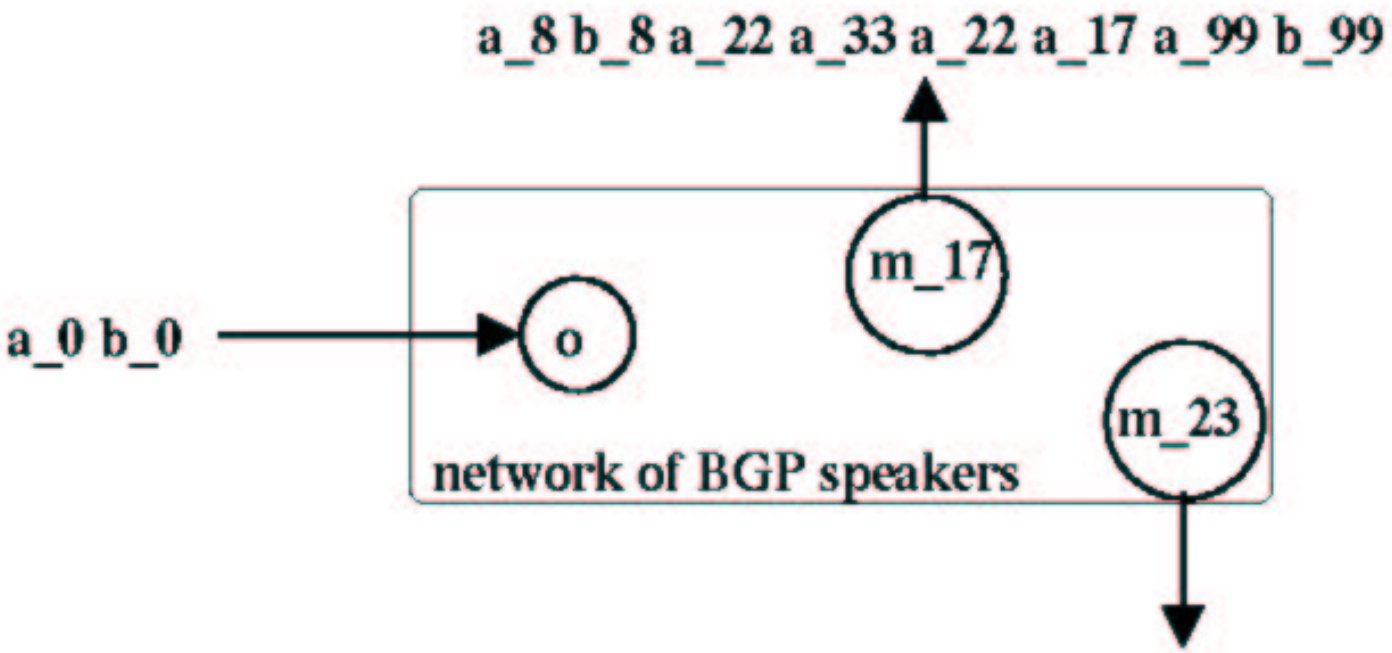
$$a_1 b_1 a_2 a_3 a_1 a_2 a_3 a_1 a_2 a_3 a_1 a_4 b_4 a_1 a_2 a_3 b_3 a_5 a_2 a_3 a_1 b_1$$

Question: What input symbol could have caused this?

The Naïve View

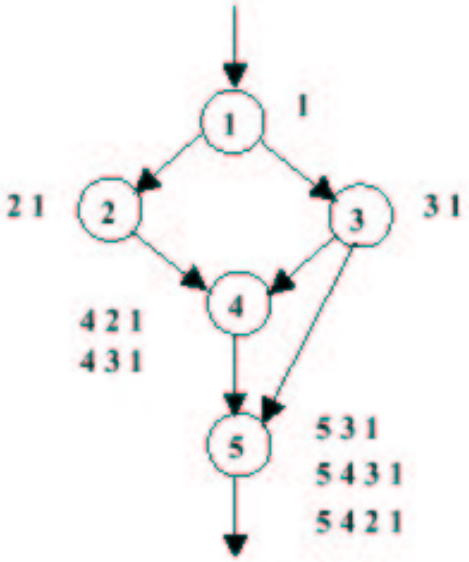


… reality is a wonderful thing



No wonder I'm going crazy trying to interpret those BGP updates ....

It is easy to construct a 5 node BGP system where a simple Announce/Withdraw signal (a_0 b_0) at one node can produce any of these 52 output signals at another…



0:
1: 1
2: 2 1
3: 3 1
4: 4 2 1
5: 4 3 1
6: 5 3 1
7: 5 4 3 1
8: 5 4 2 1

A path enumeration

a_6b_6	$a_7a_6b_6$	$a_8a_6b_6$	$a_8a_6a_8b_8a_7b_7$
$a_6a_7b_7$	$a_7a_6a_7b_7$	$a_8a_6a_7b_7$	$a_8a_7a_6a_7a_8b_8$
$a_6a_8b_8$	$a_7a_6a_8b_8$	$a_8a_6a_8b_8$	$a_8a_7a_8a_6a_8b_8$
$a_6a_7a_8b_8$	$a_7a_8a_6b_6$	$a_8a_7a_6b_6$	$a_8a_7a_8b_8a_6b_6$
$a_6a_8a_7b_7$	$a_7b_7a_6b_6$	$a_8b_8a_6b_6$	$a_8b_8a_6b_6a_7b_7$
$a_6b_6a_7b_7$	$a_7a_6a_7a_8b_8$	$a_8a_6a_7a_8b_8$	$a_8b_8a_7a_6a_7b_7$
$a_6b_6a_8b_8$	$a_7a_6b_6a_8b_8$	$a_8a_6a_8a_7b_7$	$a_8b_8a_7b_7a_6b_6$
$a_6a_7b_7a_8b_8$	$a_7a_8a_6a_8b_8$	$a_8a_6b_6a_7b_7$	
$a_6a_8a_7a_8b_8$	$a_7a_8b_8a_6b_6$	$a_8a_7a_6a_7b_7$	
$a_6a_8b_8a_7b_7$	$a_7b_7a_6a_8b_8$	$a_8a_7a_6a_8b_8$	
$a_6b_6a_7a_8b_8$	$a_7b_7a_8a_6b_6$	$a_8a_7a_8a_6b_6$	
$a_6b_6a_8a_7b_7$	$a_7a_6a_7b_7a_8b_8$	$a_8a_7b_7a_6b_6$	
$a_6b_6a_7b_7a_8b_8$	$a_7b_7a_6b_6a_8b_8$	$a_8b_8a_6a_7b_7$	
$a_6b_6a_8a_7a_8b_8$	$a_7b_7a_8a_6a_8b_8$	$a_8b_8a_7a_6b_6$	
$a_6b_6a_8b_8a_7b_7$	$a_7b_7a_8b_8a_6b_6$	$a_8a_6a_8a_7a_8b_8$	

Typical “clean” BGP noise (Beacon 1)

- PEER 267:204.42.253.253
  - (events = 602)
- ROUTES:
  - R1 ===> 267 2914 3130 3927
  - R2 ===> 267 2914 1 3130 3927

Announcement noise

- 129 : R1 (min duration: 0, max duration: 0)
- 99 : R1 R1 (min duration: 0, max duration: 839)
- 41 : R2 R1 (min duration: 2, max duration: 61)
- 24 : R2 R1 R1 (min duration: 28, max duration: 65)
- 6 : R2 R2 R1 (min duration: 52, max duration: 83)
- 2 : R1 R1 R1 (min duration: 109, max duration: 413)
- 1 : R1 R0 R1 R1 (min duration: 800, max duration: 800)
- 1 : R0 R1 (min duration: 23, max duration: 23)
- 1 : R2 R2 R1 R1 (min duration: 62, max duration: 62)

- Signal count: 304
- Average Expansion: 1.69

Withdrawal noise

- 285 : R0 (min duration: 0, max duration: 0)
- 10 : R2 R0 (min duration: 1, max duration: 54)
- 2 : R1 R0 (min duration: 510, max duration: 540)
- 1 : R0 R1 R1 R0 (min duration: 170, max duration: 170)

- Signal count: 298
- Average Expansion: 1.05

Typical highly distorted BGP noise (Beacon 1)

- Routes (total: 75)

R1 ===> 3257 2914 3130|IGP|213.200.87.254|0|90||NAG
R2 ===> 3257 2914 3130|IGP|213.200.87.254|0|290||NAG
R3 ===> 3257 1299 2914 3130|IGP|213.200.87.254|0|90||NAG
R4 ===> 3257 1239 2914 3130|IGP|213.200.87.254|0|190||NAG
R5 ===> 3257 1299 4200 2914 3130|IGP|213.200.87.254|0|90||NAG
R6 ===> 3257 1299 701 2914 3130|IGP|213.200.87.254|0|90||NAG
R7 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|190||NAG
R8 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|90||NAG
R9 ===> 3257 1299 2914 3130 3927|IGP|213.200.87.254|0|90||NAG
R10 ===> 3257 1299 4200 2914 3130 3927|IGP|213.200.87.254|0|90||NAG
R11 ===> 3257 1299 701 2914 3130 3927|IGP|213.200.87.254|0|90||NAG
R12 ===> 3257 1239 2914 3130 3927|IGP|213.200.87.254|0|190||NAG
R13 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|180||NAG
R14 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|200||NAG
R15 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|320||NAG
R16 ===> 3257 1299 2914 3130 3927|IGP|213.200.87.254|0|320||NAG
R17 ===> 3257 1299 4200 2914 3130 3927|IGP|213.200.87.254|0|320||NAG
R18 ===> 3257 1299 701 2914 3130 3927|IGP|213.200.87.254|0|320||NAG
R19 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|290||NAG
R20 ===> 3257 1299 2914 3130 3927|IGP|213.200.87.254|0|290||NAG
R21 ===> 3257 1299 701 2914 3130 3927|IGP|213.200.87.254|0|290||NAG
R22 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|280||NAG
R23 ===> 3257 1239 2914 3130 3927|IGP|213.200.87.254|0|90||NAG
R24 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|100||NAG
R25 ===> 3257 1299 2914 3130 3927|IGP|213.200.87.254|0|100||NAG
R26 ===> 3257 1299 4200 2914 3130 3927|IGP|213.200.87.254|0|100||NAG
R27 ===> 3257 1299 701 2914 3130 3927|IGP|213.200.87.254|0|100||NAG
R28 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|170||NAG
R29 ===> 3257 1239 2914 3130 3927|IGP|213.200.87.254|0|100||NAG
R30 ===> 3257 1239 2914 3130 3927|IGP|213.200.87.254|0|170||NAG
R31 ===> 3257 1299 4200 2914 3130 3927|IGP|213.200.87.254|0|270||NAG
R32 ===> 3257 1299 701 2914 3130 3927|IGP|213.200.87.254|0|270||NAG
R33 ===> 3257 3561 2914 3130 3927|IGP|213.200.87.254|0|860||NAG
R34 ===> 3257 3561 2914 3130 3927|IGP|213.200.87.254|0|170||NAG
R35 ===> 3257 701 2914 3130 3927|IGP|213.200.87.254|0|100||NAG
R36 ===> 3257 701 2914 3130 3927|IGP|213.200.87.254|0|870||NAG
R37 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|930||NAG
R38 ===> 3257 701 2914 3130 3927|IGP|213.200.87.254|0|170||NAG
R39 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|860||NAG
R40 ===> 3257 701 2914 3130 3927|IGP|213.200.87.254|0|860||NAG
R41 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|80||NAG
R42 ===> 3257 1239 2914 3130 3927|IGP|213.200.87.254|0|180||NAG
R43 ===> 3257 701 2914 3130 3927|IGP|213.200.87.254|0|80||NAG
R44 ===> 3257 701 2914 3130 3927|IGP|213.200.87.254|0|180||NAG
R45 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|1080||NAG
R46 ===> 3257 3561 2914 3130 3927|IGP|213.200.87.254|0|80||NAG
R47 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|1560||NAG
R48 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|870||NAG
R49 ===> 3257 1 3130 3927|IGP|213.200.87.254|0|180||NAG
R50 ===> 3257 3561 1 3130 3927|IGP|213.200.87.254|0|860||NAG
R51 ===> 3257 1 3130 3927|IGP|213.200.87.254|0|1080||NAG
R52 ===> 3257 1 3130 3927|IGP|213.200.87.254|0|860||NAG
R53 ===> 3257 3561 2914 3130 3927|IGP|213.200.87.254|0|180||NAG
R54 ===> 3257 1239 1 3130 3927|IGP|213.200.87.254|0|180||NAG
R55 ===> 3257 3561 1 3130 3927|IGP|213.200.87.254|0|180||NAG
R56 ===> 3257 1 3130 3927|IGP|213.200.87.254|0|1310||NAG
R57 ===> 3257 1 3130 3927|IGP|213.200.87.254|0|190||NAG
R58 ===> 3257 1 3130 3927|IGP|213.200.87.254|0|1560||NAG
R59 ===> 3257 1 3130 3927|IGP|213.200.87.254|0|80||NAG
R60 ===> 3257 701 1 3130 3927|IGP|213.200.87.254|0|870||NAG
R61 ===> 3257 1239 2914 3130 3927|IGP|213.200.87.254|0|80||NAG
R62 ===> 3257 3561 1 3130 3927|IGP|213.200.87.254|0|70||NAG
R63 ===> 3257 1239 1 3130 3927|IGP|213.200.87.254|0|70||NAG
R64 ===> 3257 1 3130 3927|IGP|213.200.87.254|0|70||NAG

Routes enumeration (cont'd)

- R65 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|70||NAG
- R66 ===> 3257 3561 2914 3130 3927|IGP|213.200.87.254|0|70||NAG
- R67 ===> 3257 701 2914 3130 3927|IGP|213.200.87.254|0|70||NAG
- R68 ===> 3257 1239 2914 3130 3927|IGP|213.200.87.254|0|70||NAG
- R69 ===> 3257 701 1 3130 3927|IGP|213.200.87.254|0|70||NAG
- R70 ===> 3257 1 3130 3927|IGP|213.200.87.254|0|930||NAG
- R71 ===> 3257 1 3130 3927|IGP|213.200.87.254|0|170||NAG
- R72 ===> 3257 701 1 3130 3927|IGP|213.200.87.254|0|180||NAG
- R73 ===> 3257 701 2914 3130 3927|IGP|213.200.87.254|0|920||NAG
- R74 ===> 3257 1 3130 3927|IGP|213.200.87.254|0|1610||NAG
- R75 ===> 3257 2914 3130 3927|IGP|213.200.87.254|0|1130||NAG

Announcement noise

- 52 : R7 R8 (min duration: 0, max duration: 3)
- 46 : R62 R64 R65 (min duration: 4, max duration: 46)
- 29 : R8 (min duration: 0, max duration: 0)
- 17 : R13 R7 R8 (min duration: 0, max duration: 1)
- 14 : R13 R8 (min duration: 0, max duration: 1)
- 12 : R28 R41 (min duration: 0, max duration: 1)
- 10 : R28 R24 (min duration: 0, max duration: 0)
- 8 : R13 R41 (min duration: 0, max duration: 0)
- 6 : R41 (min duration: 0, max duration: 0)
- 6 : R7 R13 (min duration: 0, max duration: 25)
- … <omitted>
- Total: 173 combinations
- Signal count: 323
- Average Expansion: 2.88

Withdrawal noise

- 16 : R9 R10 R0 (min duration: 46, max duration: 86)
- 7 : R9 R11 R0 (min duration: 59, max duration: 89)
- 7 : R0 R42 R0 (min duration: 1, max duration: 11)
- 6 : R0 R36 R0 (min duration: 7, max duration: 46)
- 5 : R9 R8 R9 R10 R11 R0 (min duration: 81, max duration: 106)
- 5 : R9 R10 R11 R0 (min duration: 82, max duration: 104)
- 4 : R0 R42 R13 R0 R42 R0 R36 R0 (min duration: 40, max duration: 67)
- 4 : R9 R13 R8 R9 R10 R0 (min duration: 67, max duration: 99)
- … <omitted>

- Total: 206 combinations
- Signal count: 296
- Average Expansion: 6.83

Cumulative Beacon statistics

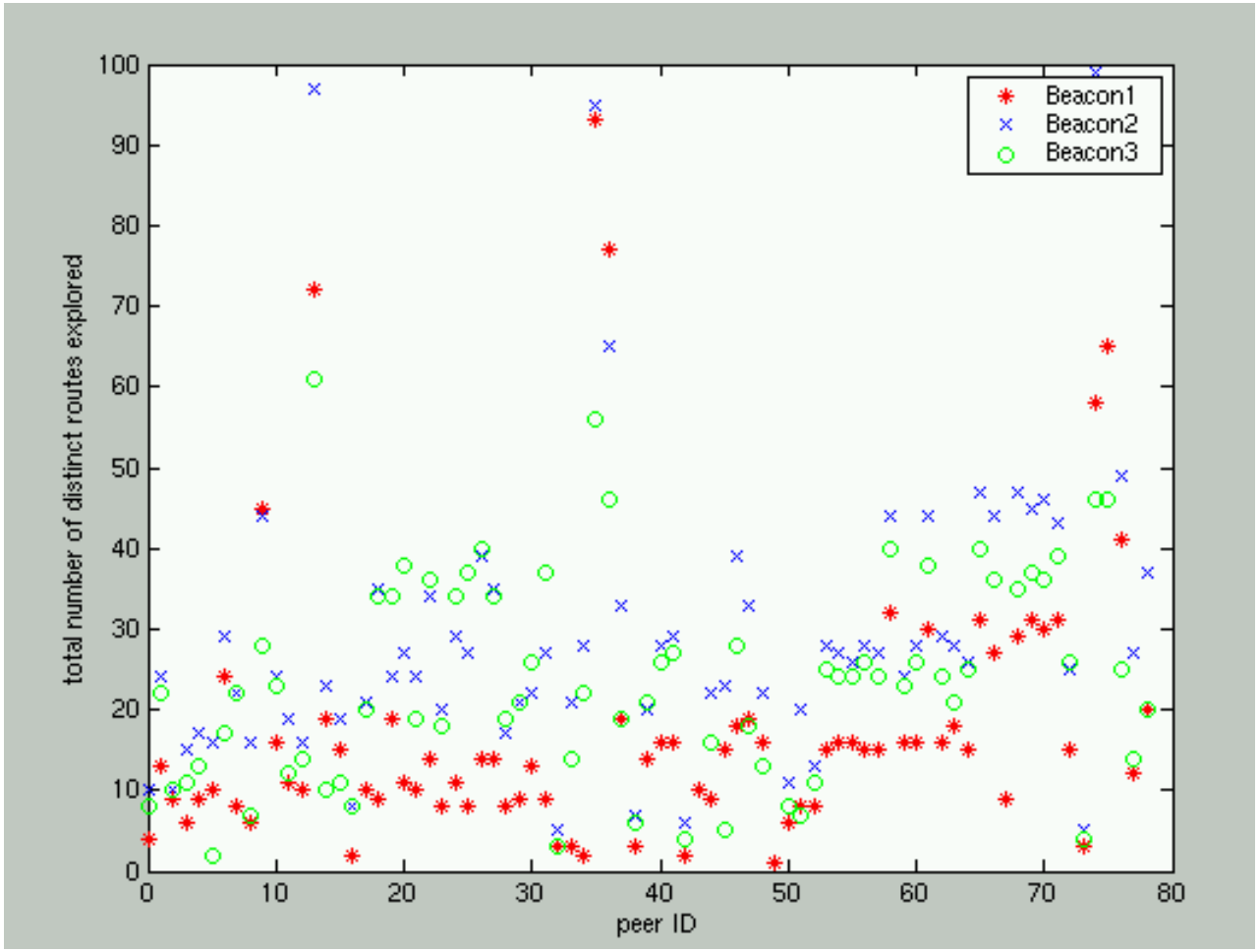
- Vantage points:
  - RIPE00, route-view, Berkeley, MIT, MIT-RON nodes, ATT-Research, AT&T, AMS-IXP, Verio

Beacon	Max no. transient routes	Max ANN-out-signal length	Max WD-out-signal length	Max ANN-avg expansion	Max WD-avg expansion
1	93	22	19	4.11	7.34
2	99	17	22	4.10	10.23
3	61	14	22	3.95	14.38

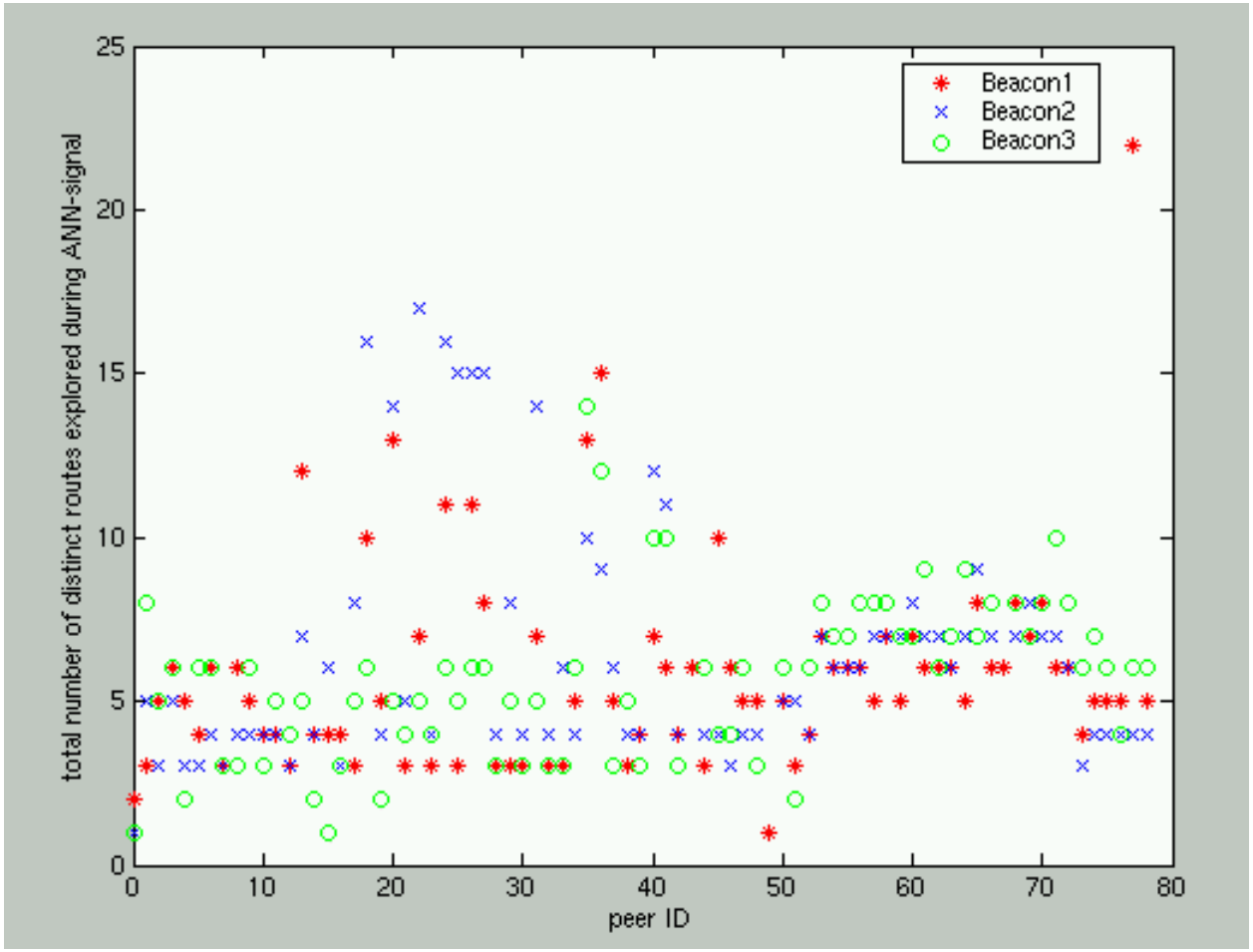
Cumulative Beacon statistics

RIPE Beacon	Max no. transient routes	Max ANN-out-signal length	Max ANN-avg expansion	Max WD-out-signal length	Max WD-avg expansion
195.80.224.0/24	49	5	2.11	18	8.75
195.80.225.0/24	11	4	2	14	5.59
195.80.226.0/24	1	2	1.28	1	1
195.80.227.0/24	95	13	6.06	24	12.24
195.80.228.0/24	8	7	1.85	4	2.25
195.80.229.0/24	58	14	6.79	27	9.71
195.80.230.0/24	--	--	--	--	--
195.80.231.0/24	--	--	--	--	--
195.80.232.0/24	4	2	1.86	4	1.86

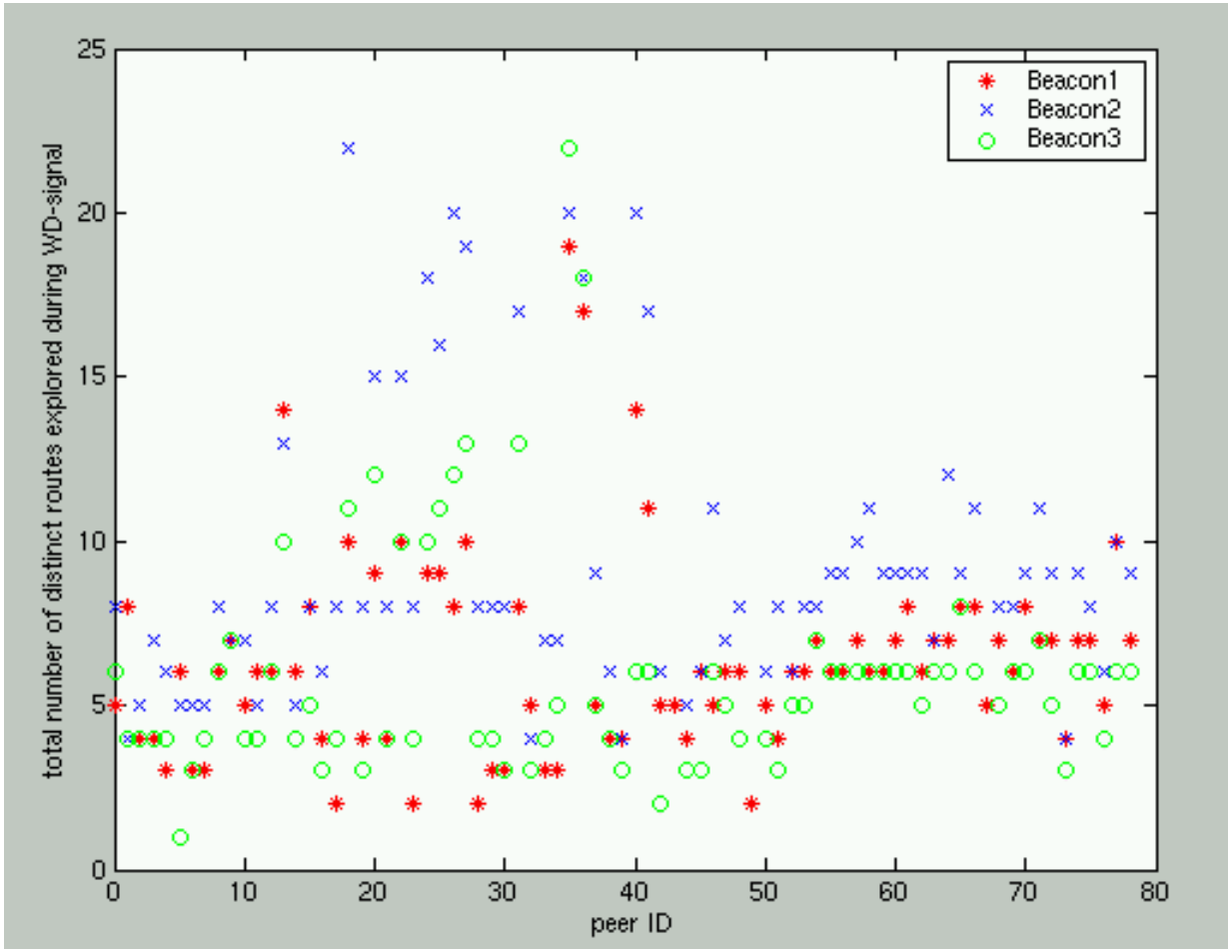
More detailed Beacon stats
Total number of routes



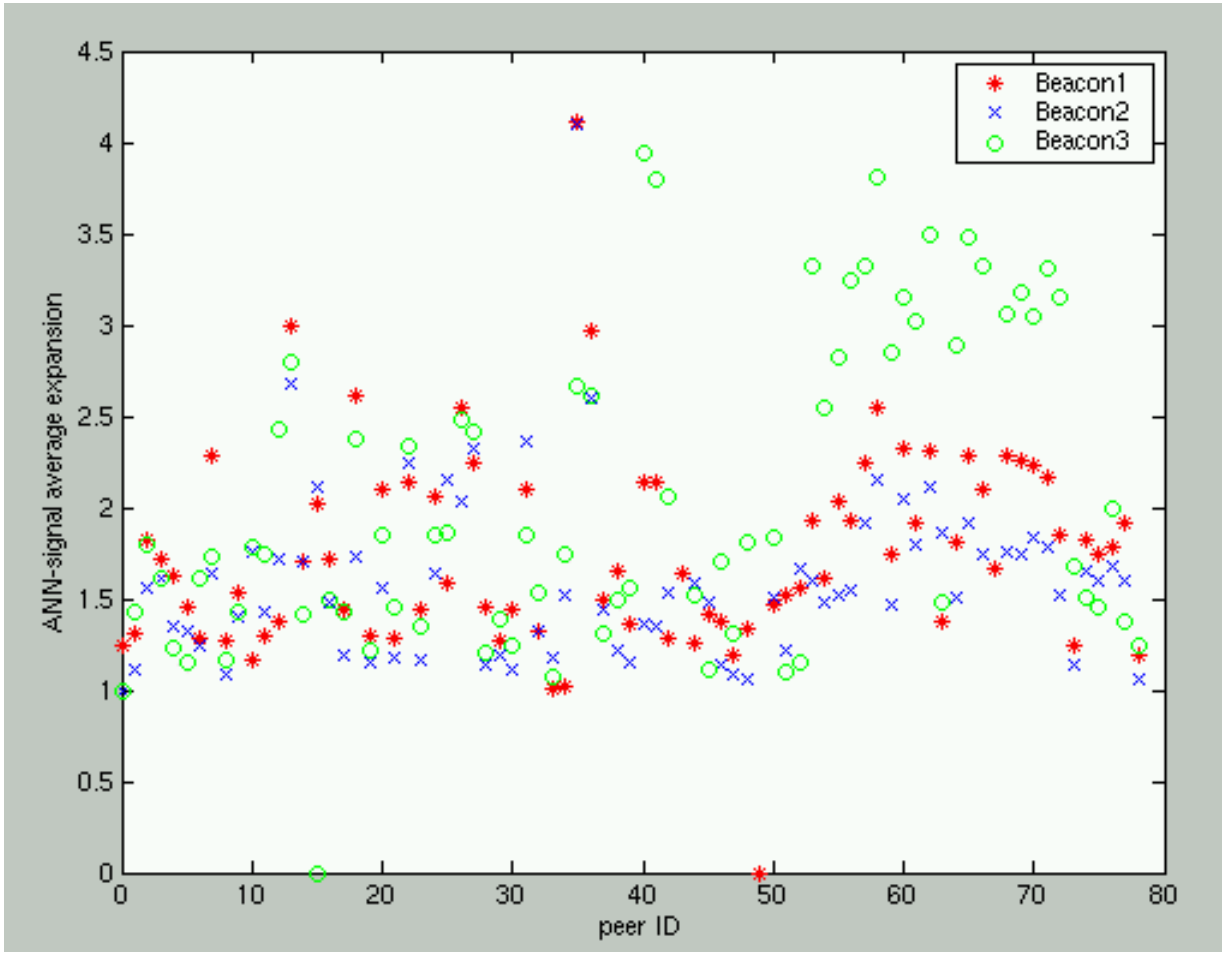
Max no. updates for ANN-signal



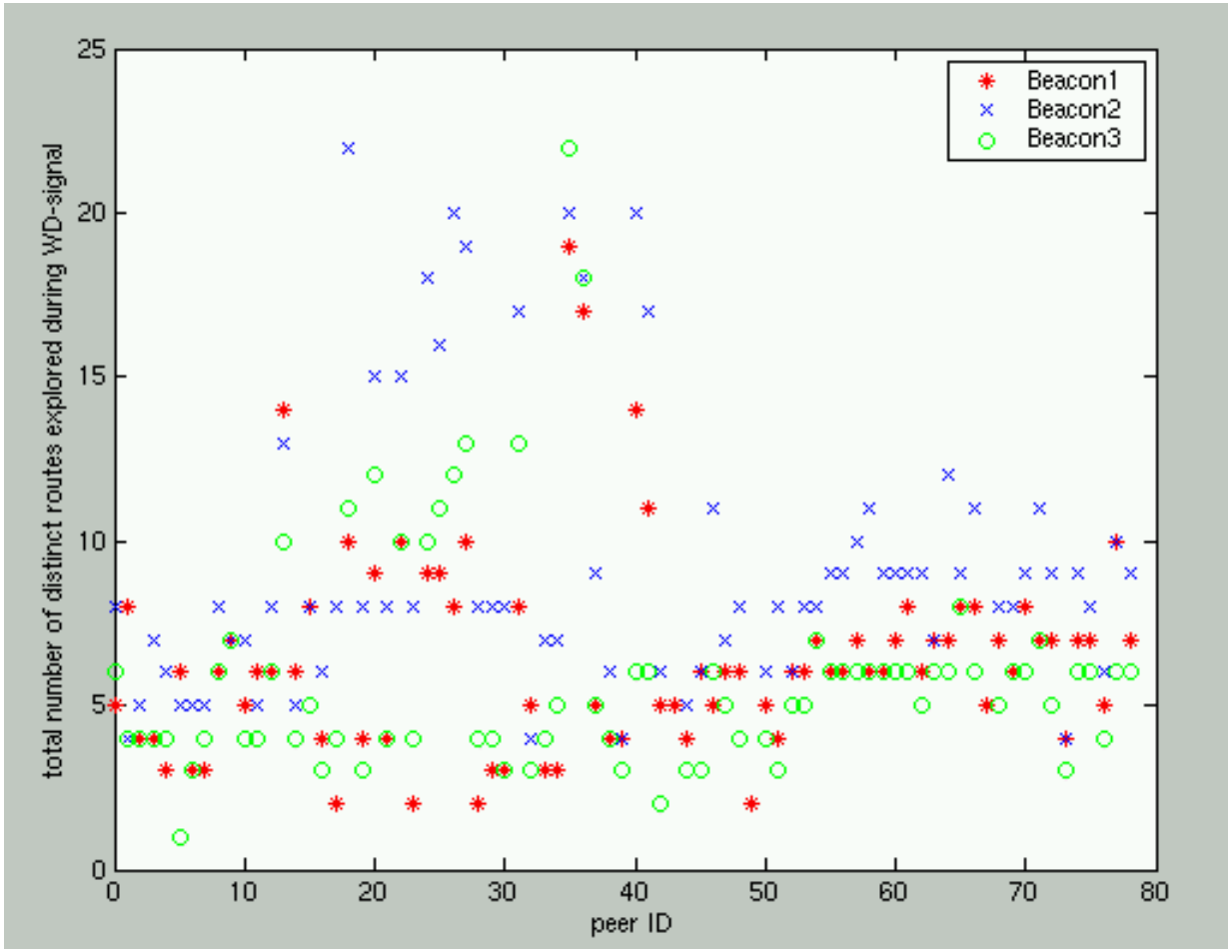
Max no. updates for WD-signal



Average expansion for ANN-signal



Average expansion for WD-signal



List of peers: (AS: IP)

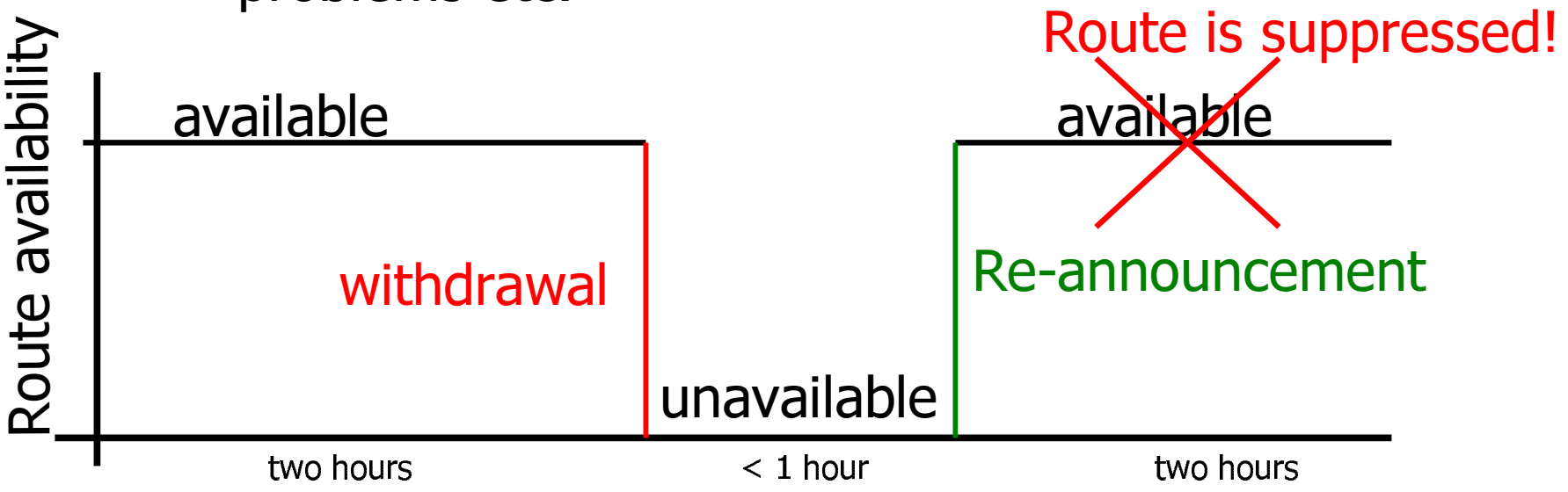
0: 10781:204.17.195.235	22: 2914:129.250.0.3	41: 3549:64.211.147.146	61: 7018
1: 10781:204.17.195.236	23: 2914:129.250.0.43	42: 3561:208.172.146.2	62: 7018
2: 1103:193.148.15.34	24: 2914:129.250.0.45	43: 3:18.168.0.18	63: 7018
3: 11085:131.149.2.1	25: 2914:129.250.0.52	44: 3:18.168.0.27	64: 7018
4: 11608:207.246.129.6	26: 2914:129.250.0.55	45: 4608:202.12.29.64	65: 7018
5: 1221:203.62.252.26	27: 2914:129.250.0.56	46: 4777:202.12.28.190	66: 7018
6: 1239:144.228.241.81	28: 2914:129.250.0.57	47: 513:192.65.184.3	67: 7018
7: 12859:193.148.15.200	29: 2914:129.250.0.6	48: 5511:193.251.128.22	68: 7018
8: 13129:212.20.151.234	30: 2914:129.250.0.69	49: 6431:135.207.27.66	69: 7018
9: 16150:217.75.96.60	31: 2914:129.250.0.84	50: 6431:192.20.225.225	70: 7018
10: 1668:66.185.128.1	32: 293:134.55.20.229	51: 6521:207.173.16.1	71: 7018
11: 1:4.0.4.90	33: 3130:147.28.255.1	52: 6539:216.18.31.102	72: 7018
12: 22208:66.198.48.194	34: 3130:147.28.255.2	53: 7018	73: 7018
13: 22208:66.198.48.195	35: 3257:193.148.15.85	54: 7018	74: 7911:64.200.199.3
14: 25:128.32.1.200	36: 3257:213.200.87.254	55: 7018	75: 7911:64.200.199.4
15: 25:128.32.1.3	37: 3333:193.0.0.56	56: 7018	76: 8121:199.74.221.1
16: 267:204.42.253.253	38: 3356:209.244.2.115	57: 7018	77: 852:66.203.205.62
17: 2914:129.250.0.10	39: 3549:195.66.224.112	58: 7018	78: 9177:212.47.190.1
18: 2914:129.250.0.101	40: 3549:208.51.113.254	59: 7018	
19: 2914:129.250.0.11		60: 7018	
20: 2914:129.250.0.18			

What is route flap damping?

- RFC2439
  - Supported by all major router vendors
  - Believed to be widely deployed
- Goals:
  - Reduce router processing load due to instability
  - Do not sacrifice convergence times for well-behaved routes

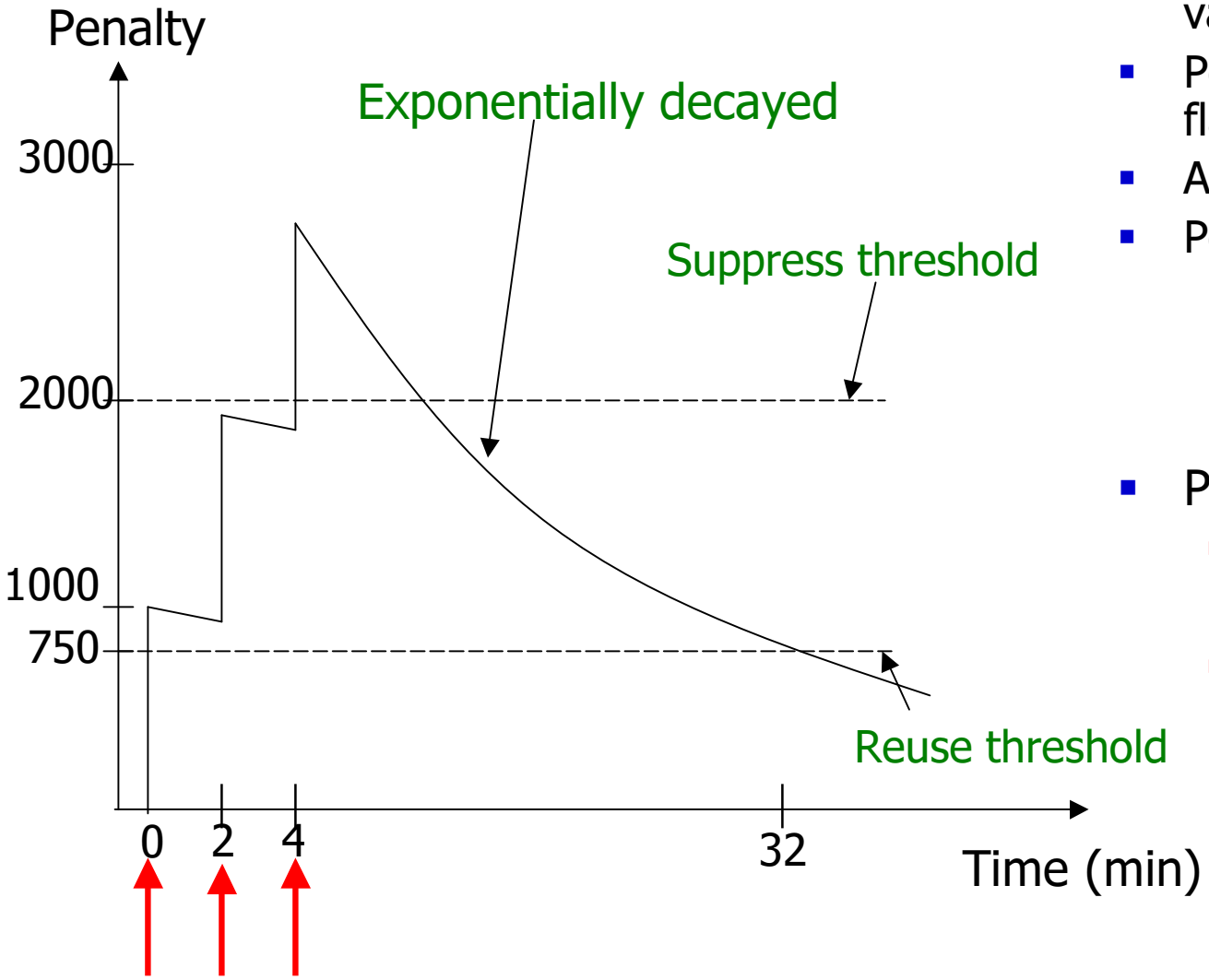
Transient instability

- Router reboot
  - Due to circuit or software upgrade, etc.
- A single link flap
  - Due to network congestion, link connectivity problems etc.



How does route flap damping work?

(using default Cisco parameters)



- For each peer, per destination, keep a penalty value
- Penalty increases for each flap
- A flap is a route change
- Penalty decays exponentially

$$P(t') = P(t)e^{-\lambda(t'-t)}$$

- Parameters:
  - Fixed:

    Penalty increment
  - Configurable:

    half-life, suppress-, reuse-threshold, max suppressed time

Route flap damping analysis

- Use RIPE-229 recommended flap damping setting for /24:
  - Cisco: half life=30min, suppress=3000
  - Juniper: half life=30min, suppress=6000

Beacon	No. suppression events by Cisco	No. suppression events by Juniper	Total event count
1	1325 (4%)	381 (1%)	32,527
2	2878 (14%)	1259 (6%)	19,930
3	581 (10%)	146 (3%)	5,555

Distinguishing btw ANN and WD

Beacon	Cisco/ANN-triggered	Juniper/ANN-triggered	Total ANN-event
1	86 (0.5%)	18 (0.0%)	16191
2	59 (0.0%)	18 (0.0%)	9858
3	26 (0.0%)	5 (0.0%)	2777

Beacon	Cisco/WD-triggered	Juniper/WD-triggered	Total WD-event
1	1239 (7.6%)	363 (2.2%)	16336
2	2819 (28%)	1241 (12%)	10072
3	555 (20%)	141 (5%)	2778

Cascaded withdrawals! (1)

- Peer: 213.200.87.254, AS=3257 from RouteViews
- In response to WD-beacon at 01:00, Aug 20th.
- Using Cisco setting + RIPE229 recommendation
  - (Note: first 2 announcements differ in community attributes)

Time 8/20	A/W	ASPath	Penalty
01:00:16	A	3257 1299 2914 3130 3927	500
01:00:47	A	3257 1299 2914 3130 3927	988
01:00:50	W		1985
01:00:50	A	3257 1299 4200 2914 3130 3927	1985
01:01:13	A	3257 1299 701 2914 3130 3927	2451
01:02:05	W		3354

Above suppress threshold

Cascaded withdrawals! (2)

- Peer: 212.47.190.1, AS=9177 from RIPE
- In response to WD-beacon at 18:00, Aug 10th.
- Using Cisco setting + RIPE229 recommendation

Time 8/10	A/W	ASPath	Penalty
18:00:15	A	9177 3320 1 2914 3130 3927	500
18:00:41	A	9177 6730 5400 2914 3130 3927	990
18:01:41	A	9177 3320 2914 3130 3927	1445
18:03:06	A	9177 3320 1239 2914 3130 3927	1853
18:03:35	W		2812
18:04:03	A	9177 6730 5400 2914 3130 3927	2752
18:04:31	W		3694

Above suppress threshold

Why does this happen?

- BGP is a path vector protocol
  - Explores alternate routes before withdrawal
  - Topology dependent
- Delay in messages due to variations in
  - MinRouteAdver timer values
  - Propagation delays
  - Router processing overhead
- Route flap damping parameter setting
  - Cisco/Juniper punishes virtually all route changes
  - Default setting and RIPE-229 recommendation are too aggressive

Current ongoing work

- Validation of Net-FST
  - Network of finite state transducers
  - Examine the output patterns
- Stochastic model
  - predict BGP update patterns
  - Validate using simulations (SSFnet)
- Infer network properties
  - Based on output BGP update patterns
- Use Beacons as a calibration tool
  - Interpret the root cause of BGP updates
- Proposed improved route flap damping algorithm

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Acknowledgements

- Beacon hosts
  - Randy Bush
  - Dave Meyer
  - Geoff Huston
- RIPE, Route-view, MIT RON projects
- Discussion with
  - Ramesh Govindan, Randy Katz, George Varghese

Back up slides

RIPE-229

- RIPE-229 recommendation:
  - Don’t damp until fourth flap
  - /24 or longer prefixes: max=min outage 60 min
  - /22, /23 prefixes:
    - max outage=45min, min outage=30min
  - Other prefixes:
  - max outage=30min, min outage=10min

Router vendor default values

Parameter	Cisco	Juniper
Withdrawal penalty	1000	1000
Re-advertisement penalty	0	1000
Attributes change penalty	500	500
Suppress threshold	2000	3000
Half-life (min)	15	15
Reuse threshold	750	750
Max suppress time (min)	60	60

- Cisco
  - Three flaps can suppress route
- Juniper
  - Minimum four flaps to suppress route
- Example:
  - Three flaps with 2 min interval
  - Cisco: suppress on the third flap for more than 28 minutes