HURRICANE ELECTRIC
INTERNET SERVICES

Hurricane Electric

IPv6 Native Backbone – Massive Peering!

Hurricane Electric's IPv6 Global Backbone and Services

Rocky Mountain v6 Task Force
IPv6 Summit 2009

Denver, Colorado – 22nd April 2009

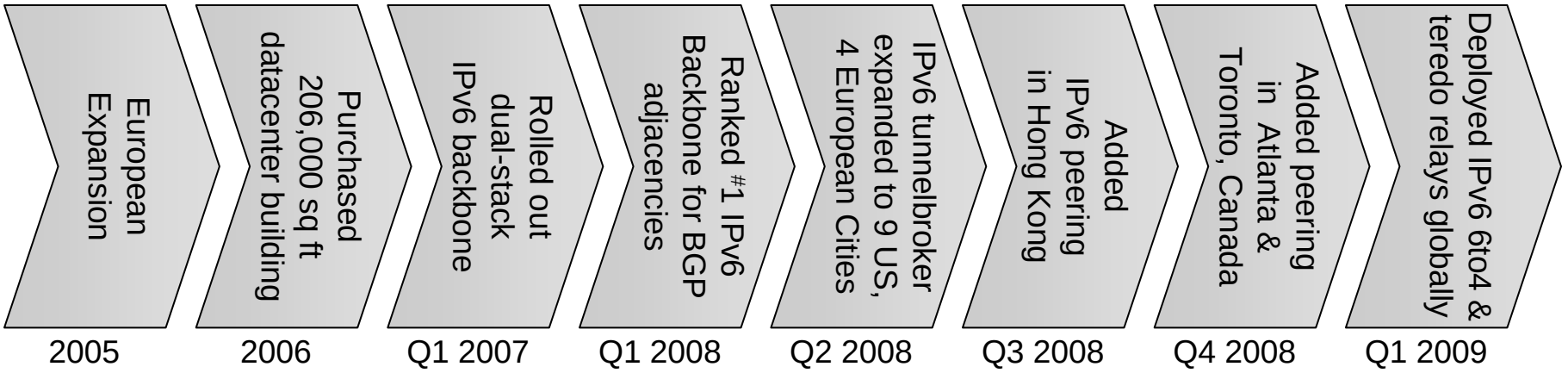
Martin J. Levy, Director IPv6 Strategy
Hurricane Electric

Hurricane Electric – Talk Outline

- An Introduction to Hurricane Electric's IPv6 Backbone
  - #1 global IPv6 backbone
- IPv6 Peering (where the IPv6 traffic flows!)
  - This is not news – there is lots of IPv6 peering
- Hurricane Electric IPv6 traffic levels
  - High-level review of IPv6 traffic volumes
- IPv6 & DNS?
  - Is there a better measure of IPv6's existence?

Hurricane Electric – Roots and History

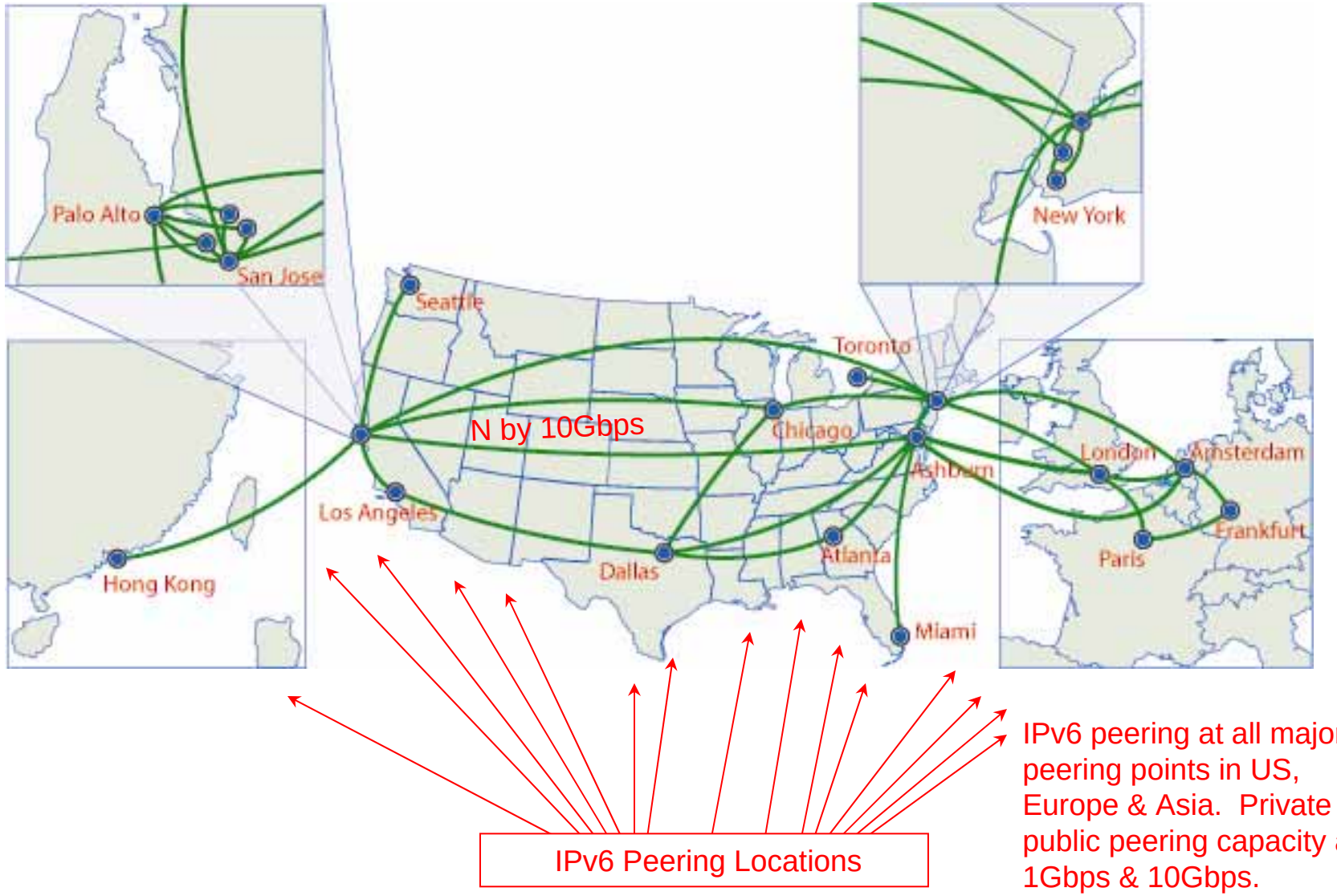
- Founded 14 years ago - ISP & datacenter operator
  - Roots within the Silicon Valley high-tech community
  - 1999 – Nationwide IPv4 network
  - 2001 – IPv6 native and tunnel connectivity (http://tunnelbroker.net)



  - Support and sponsor global open-software efforts

Hurricane Electric – IPv6 Network Reach

All Hurricane Electric POPs are full IPv6 Native routing and peering



IPv6 peering at all major peering points in US, Europe & Asia. Private and public peering capacity at 1Gbps & 10Gbps.

Hurricane Electric – IPv6 Native Services

- Three years into native IPv6 network deployment
  - Eight years of IPv6 on the network
- IPv6 native router platform across all POP's
  - All IPv6 BGP customer connections are native
  - All IPv6 datacenter customer are native
- IPv6 dual-stack & native DNS servers
- IPv6 dual-stack & native NTP servers
- IPv6 & IPv4 public looking glass & route servers
- 24/7 NOC with IPv6 expertise

Not just "Joe" on Thursdays

- MPLS capable POP to POP to POP
- IPv6 hosting services

Hurricane Electric – IPv6 Web Hosting

- True Virtual Host (http://www.yourname.com)
- Support for PHP 5
- Your Own Secure Web (SSL) Directory
- Your Own MySQL Database
- Your Own Standard Web Directory
- Your Own cgi-bin Directory
- Direct Access Via SFTP
- Direct Access Via SSH
- OC192 (10 Gbps) Backbone
- Multiple Connections For Backup And Redundancy
- Battery Backup and Emergency Generator
- High Performance Carefully Managed Web Servers
- Online Billing Information
- Webmail!
- POP3/IMAP Authenticated SMTP
- Multiple POP3/IMAP Mailboxes per Account
- Unlimited Mail Forwarding
- Unlimited Mail Autoresponders
- Detailed Daily Web Activity Reports
- Access To Raw access_log Files
- Server Side Includes
- Email Forms
- Full Shell Account
- Full Unix Development Environment
- Perl
- gcc
- crontab

Pricing Guide

Self Serve Web Space Rate Schedule

All IPv6 Enabled

	Starter Virtual Host	Enhanced Virtual Host	Professional Virtual Host	Enterprise Virtual Host
Monthly	$9.95	$24.95	$59.95	$299.95
Setup Fees	$0	$0	$0	$0
Storage Included	2 GB	150 GB	300 GB	1 TB
Additional Storage	10 cents/MB	2 cents/MB	2 cents/MB	1 cent/MB
Traffic Included	125 GB	1500 GB	3000 GB	10 TB
Additional Traffic	$2/GB	$1/GB	25 cents/GB	25 cents/GB
POP3/IMAP Mailboxes Included	1000	2500	5000	10,000
Payment Method	Credit Card	Credit Card	Credit Card, Check	Credit Card, Check

Hurricane Electric's Free IPv6 Certification Program

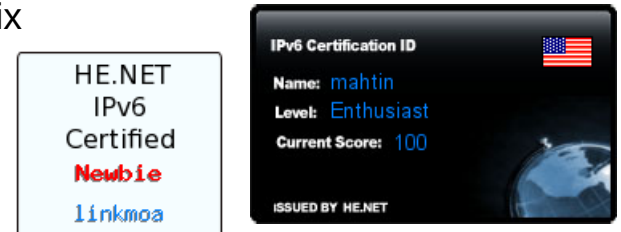
http://ipv6.he.net/certification/

IPv6 – Certification (and learning)

- Prove that you have IPv6 connectivity
- Prove that you have a working IPv6 web server
- Prove that you have a working IPv6 email address
- Prove that you have working forward IPv6 DNS
- Prove that you have working reverse IPv6 DNS for your mail server
- Prove that you have name servers with IPv6 addresses that can respond to queries via IPv6
- Prove your knowledge of IPv6 technologies through quick and easy testing

- the format of IPv6 addresses
- AAAA records
- reverse DNS for IPv6
- the IPv6 localhost address
- the IPv6 default route
- the IPv6 documentation prefix
- the IPv6 link local prefix
- the IPv6 multicast prefix
- do an IPv6 ping
- do an IPv6 traceroute
- common IPv6 prefix
- and more!

http://ipv6.he.net/certification/



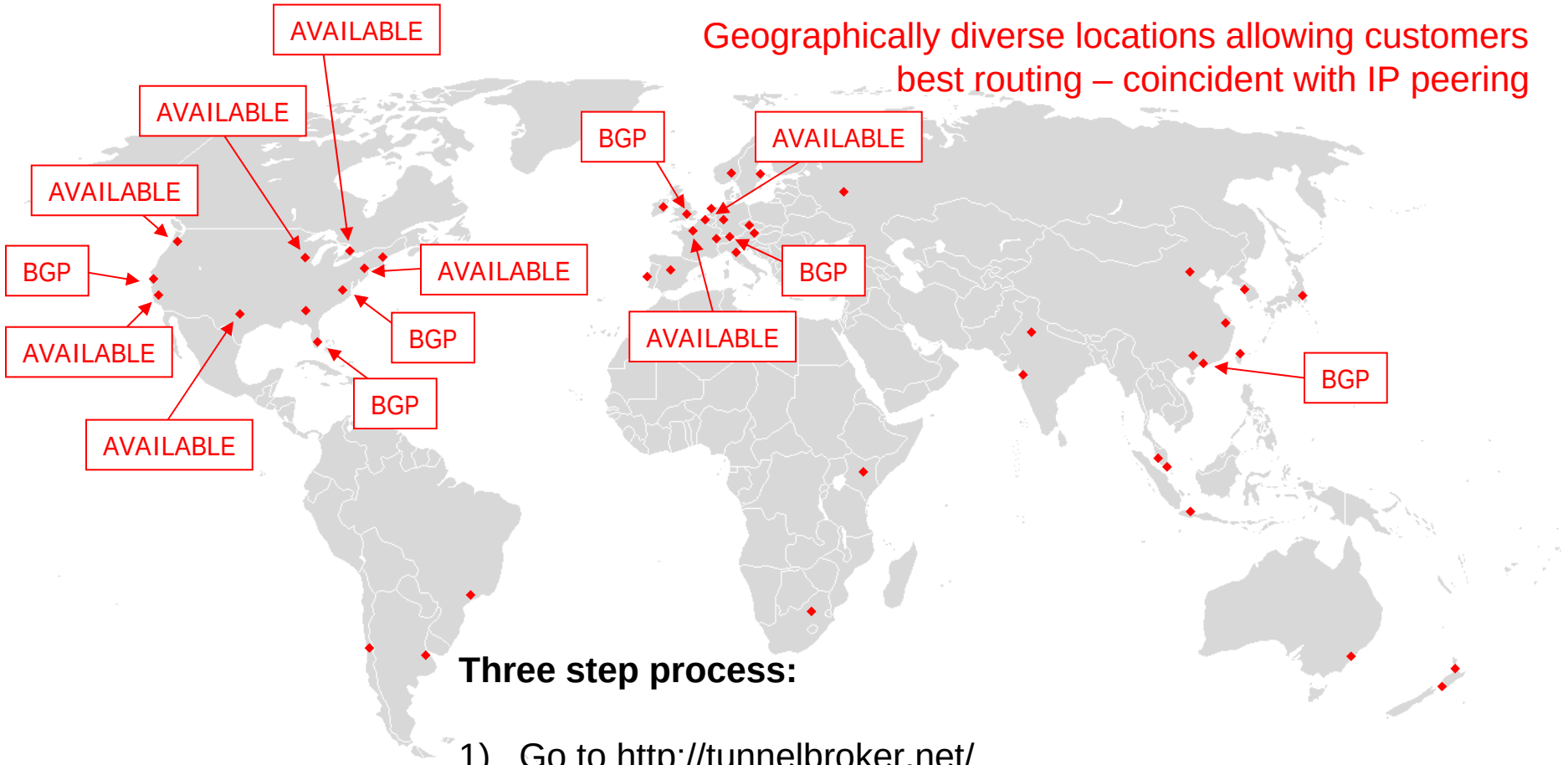
2,430++ Certifications!

Hurricane Electric's Tunnel Broker

http://tunnelbroker.net/

(IPv6 Tunnels Exist! – sometimes it's the only way)

Hurricane Electric – IPv6 Tunnel Broker locations

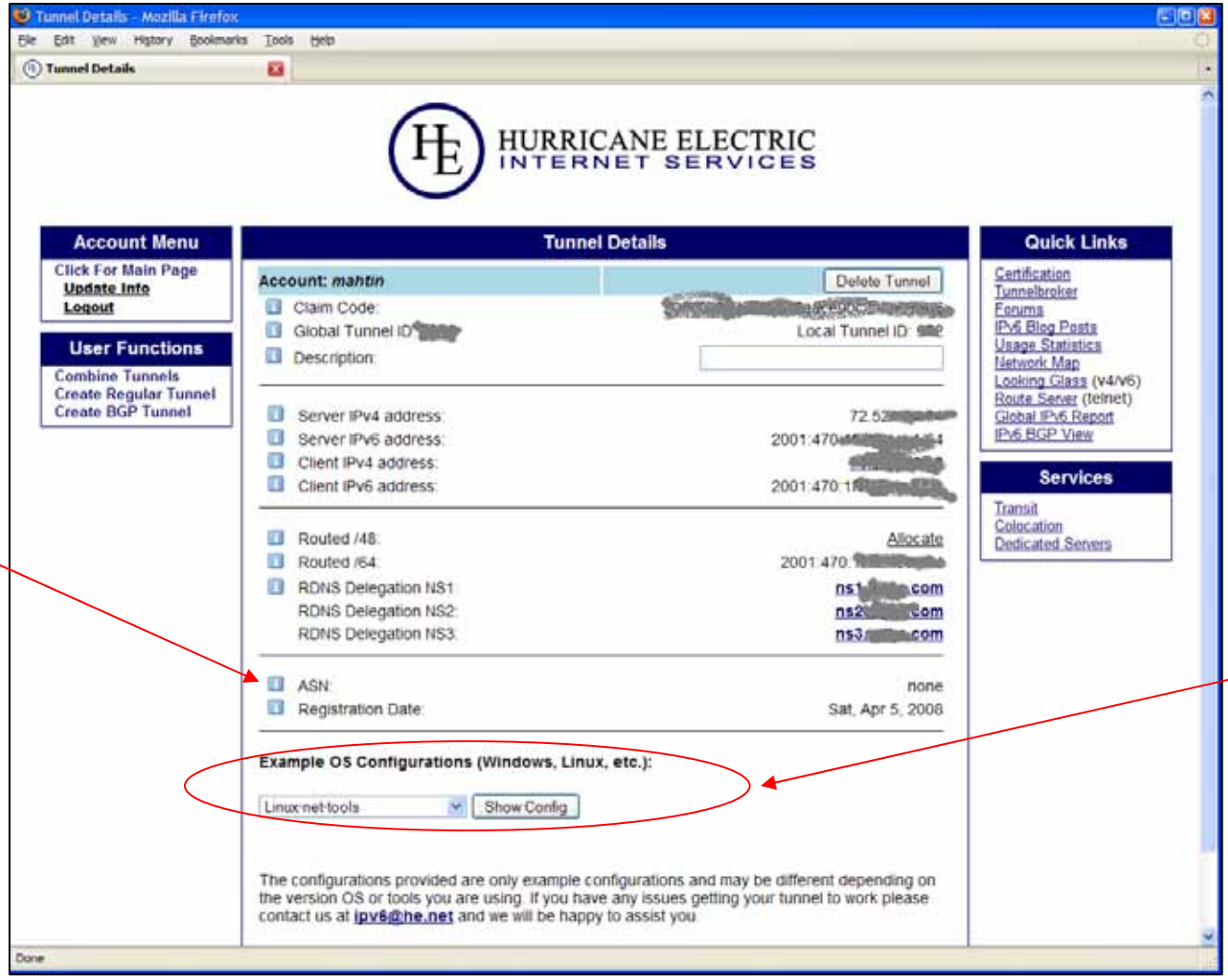


Geographically diverse locations allowing customers best routing – coincident with IP peering

Three step process:

1) Go to http://tunnelbroker.net/
2) Setup an account – choose a location
3) Setup your own host to allow tunnels

Hurricane Electric – IPv6 Tunnel Broker (web) setup



Hurricane Electric – IPv6 Tunnel Broker setup

Windows XP

```
ipv6 install
ipv6 rtu ::/0 2/::72.52.##.## pub
ipv6 adu 2/2001:470:##:##::2
```

Linux

```
modprobe ipv6
ip tunnel add he-ipv6 mode sit \
    remote 72.52.##.## local ##.##.##.## ttl 255
ip link set he-ipv6 up
ip addr add 2001:470:##:##::2/64 dev he-ipv6
ip route add ::/0 dev he-ipv6
ip -f inet6 addr
```

MacOS X

```
ifconfig gif0 tunnel ##.##.##.## 72.52.##.##
ifconfig gif0 inet6 2001:470:##:##::2 2001:470:##:##::1 prefixlen 128
route -n add -inet6 default 2001:470:##:##::1
```

Windows Vista

```
netsh interface ipv6 add v6v4tunnel IP6Tunnel ##.##.##.## 72.52.##.##
netsh interface ipv6 add address IP6Tunnel 2001:470:##:##::2
netsh interface ipv6 add route ::/0 IP6Tunnel 2001:470:##:##::1
```

Juniper JunOS

```
interfaces {
    ip-0/1/0 {
        unit 0 {
            tunnel {
                source ##.##.##.##;
                destination 72.52.##.##;
            }
            family inet6 {
                address 2001:470:##:##::2/64;
            }
        }
    }
}
routin
    rib
        s
    }
}
```

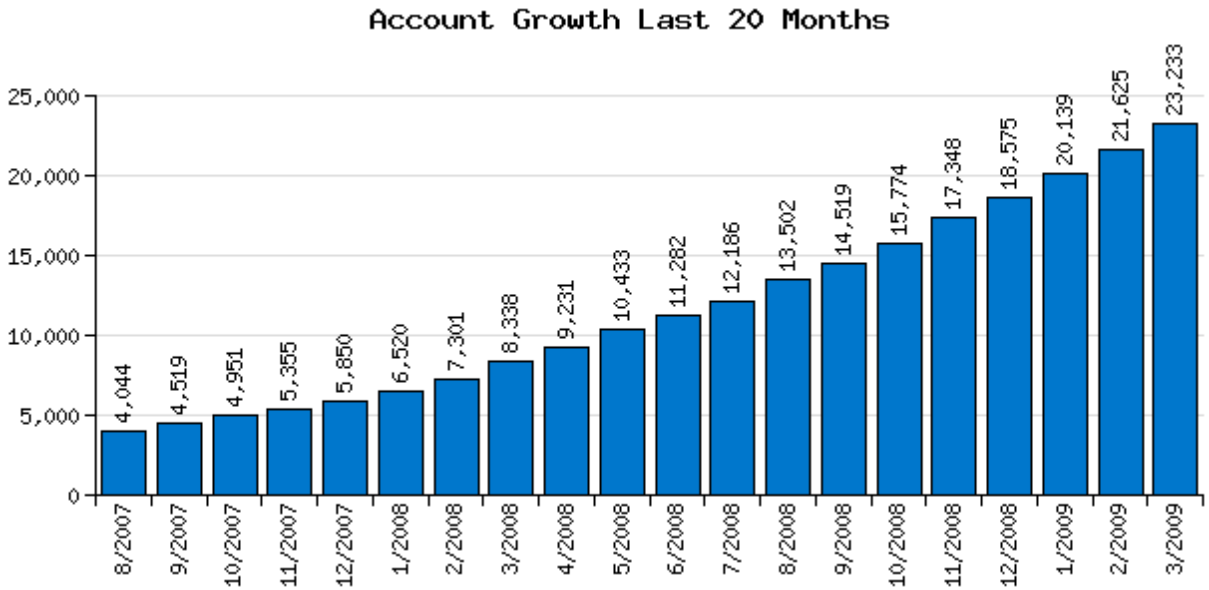
Cisco IOS

```
configure terminal
interface Tunnel0
 description Hurricane Electric IPv6 Tunnel Broker
 no ip address
 ipv6 enable
 ipv6 address 2001:470:##:##::2
 tunnel source ##.##.##.##
 tunnel destination 72.52.##.##
 tunnel mode ipv6ip
ipv6 route ::/0 Tunnel0
end
write
```

Hurricane Electric – IPv6 Tunnel Broker statistics

Stats available at: http://tunnelbroker.net/

Country	Users	%
UNITED STATES	5,375	37.51 %
NETHERLANDS	1,009	7.04 %
GERMANY	887	6.19 %
UNITED KINGDOM	664	4.63 %
POLAND	612	4.27 %
ITALY	578	4.03 %
CANADA	482	3.36 %
CZECH REPUBLIC	391	2.73 %
FRANCE	385	2.69 %
BULGARIA	285	1.99 %
NORWAY	233	1.63 %
AUSTRALIA	223	1.56 %
SWEDEN	223	1.56 %
BELGIUM	201	1.40 %
CHINA	191	1.33 %
BRAZIL	189	1.32 %
SLOVENIA	174	1.21 %
HUNGARY	153	1.07 %
INDONESIA	127	0.89 %
RUSSIAN FEDERATION	122	0.85 %
JAPAN	96	0.67 %

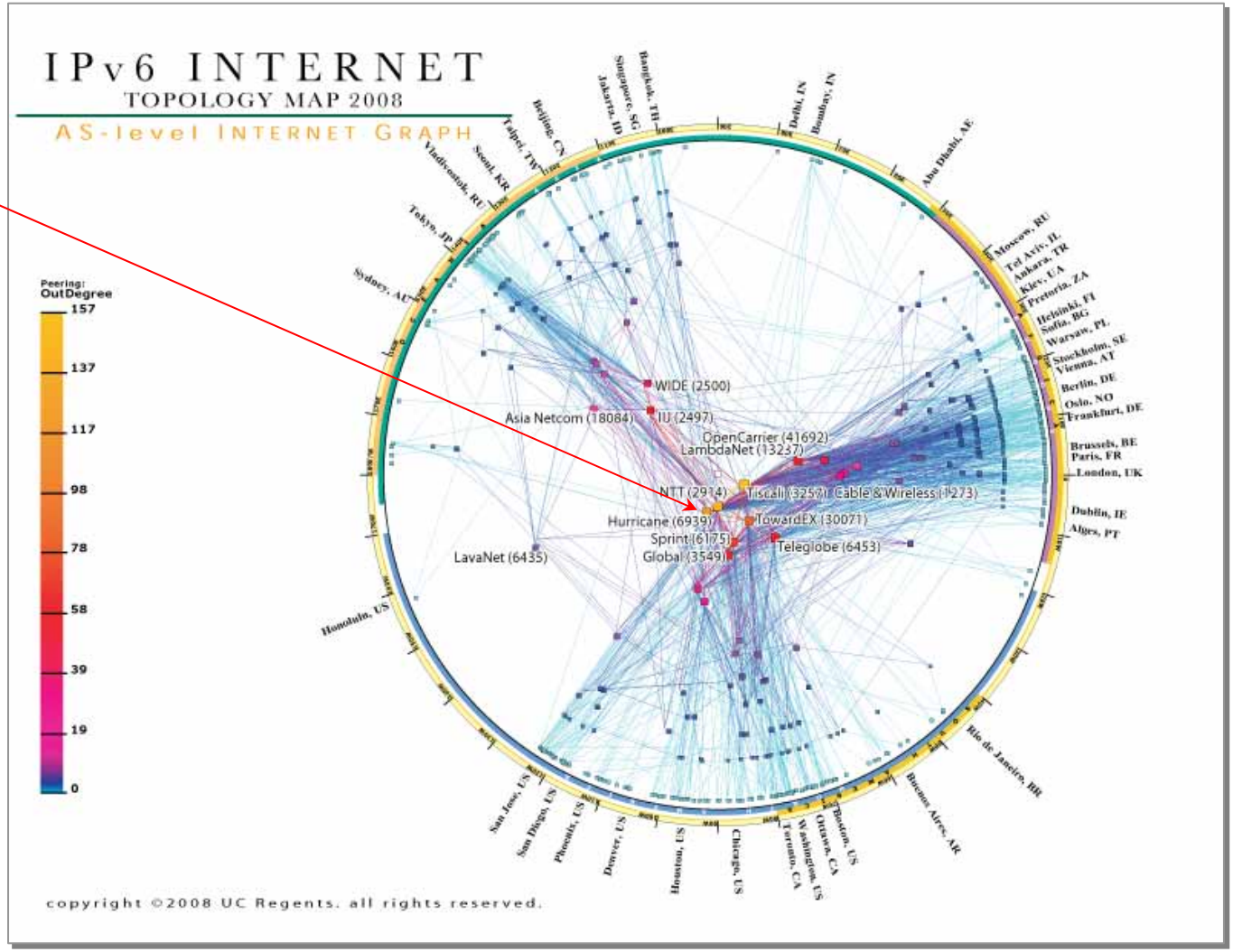


Where did all this lead us?

(or – was it worth it?)

Hurricane Electric – IPv6 Status (CAIDA) – Jan 2008

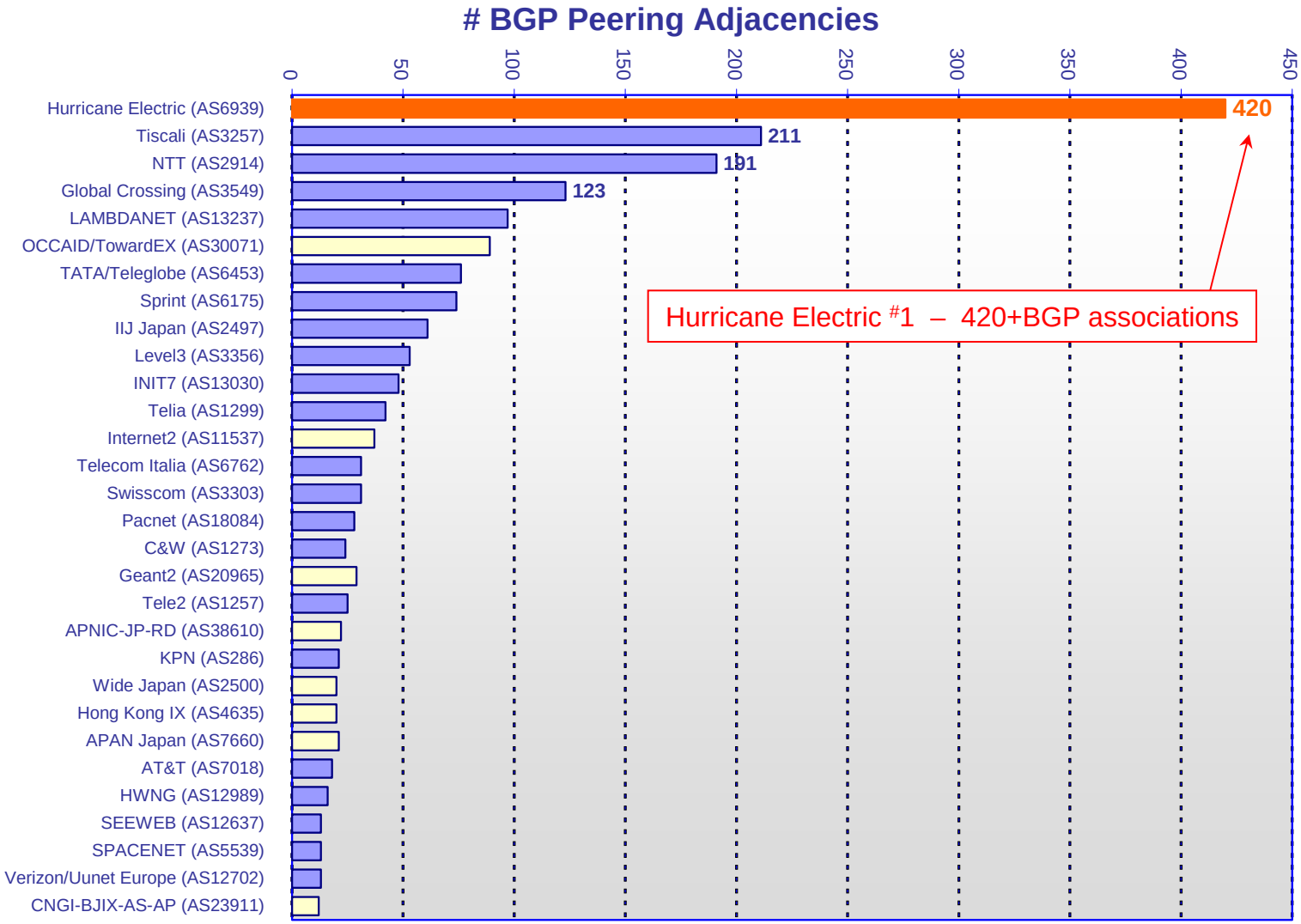
Hurricane Electric



CAIDA status as of January 2008 – Further improved since

See: http://www.caida.org/research/topology/as_core_network/ipv6.xml for full description and explanation.

Hurricane Electric – IPv6 Status (Oregon) – Apr 2009

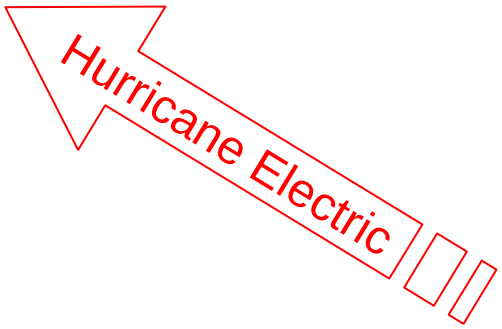


Data extracted from http://bgp.potaroo.net/v6/as6447/bgp-as-adj.txt

Hurricane Electric – also an IPv4 network

rank	AS number	AS information		customer cone			degree
		ISP's name	country	/24s	prefixes	ASes	
1	701	MCI Communications Services, Inc. d/b/a Verizon Business	US	6,865,407	260,592	27,813	2,219
2	1239	Sprint	US	6,833,469	257,243	27,338	1,529
3	3356	LEVEL3 Level 3 Communications	US	6,569,879	250,564	26,399	2,325
4	174	COGENT Cogent/PSI	US	6,366,542	245,857	26,094	2,280
5	3549	GBLX Global Crossing Ltd.	US	6,294,483	249,727	26,620	1,283
6	4323	tw telecom holdings, inc.	US	6,228,876	246,010	26,099	1,225
7	6939	Hurricane Electric, Inc.	US	6,171,515	236,553	25,294	1,151
8	2828	XO Communications	US	6,145,843	234,370	24,961	744
9	7018	AT&T WorldNet Services	US	5,998,350	223,768	22,286	2,199
10	4589	EASYNET Easynet Group Plc	EU	5,951,840	227,076	24,224	703

ranking mode: relationship based, pruning customer cone with inferred p2p links
alpha parameter: 0.00040
Whois:Nov 19, 2008 - APNIC, ARIN, LACNIC, AFRNIC, and RIPE
AS links: BGP ribs from bgp_site (rrc12)
AS links: 5 days starting on Mar 25, 2009 (1 snapshots at 8 hour intervals)
prefix-to-AS mappings: RouteViews BGP snapshot on Apr 8, 2007



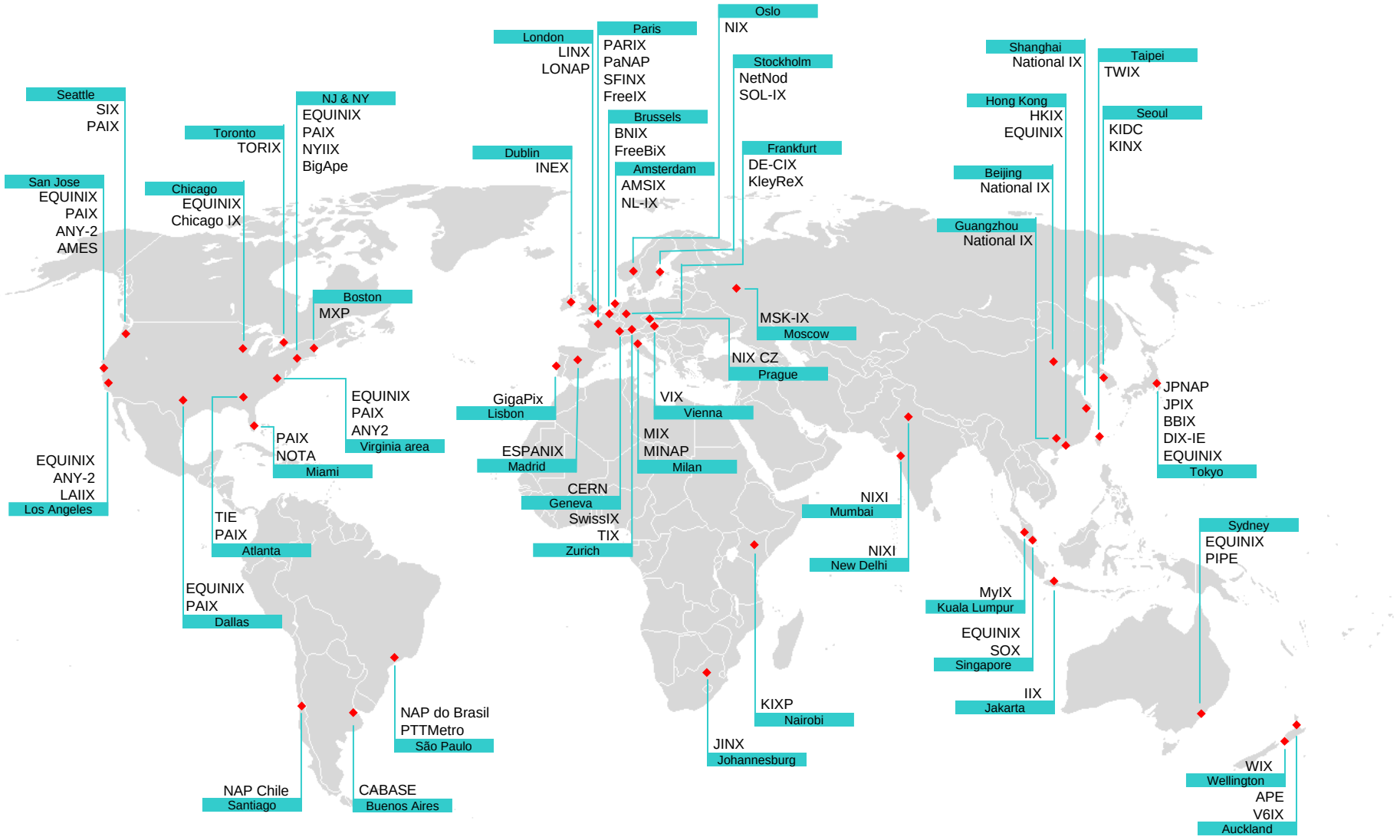
CAIDA IPv4 status – Hurricane Electric AS6939 #7 in the IPv4 world

http://as-rank.caida.org/

Hurricane Electric in the Global IPv6 Peering World

(Where do IPv6 backbones interconnect?)

IPv6 Peering Points – they're everywhere!



Hurricane Electric at major IPv6 Peering Points

Miami

Seattle

San Jose, Los Angeles

Frankfurt Germany

London, England

Amsterdam, Netherlands

San Jose, Los Angeles,
Dallas, Chicago, Ashburn

Paris, France

New York

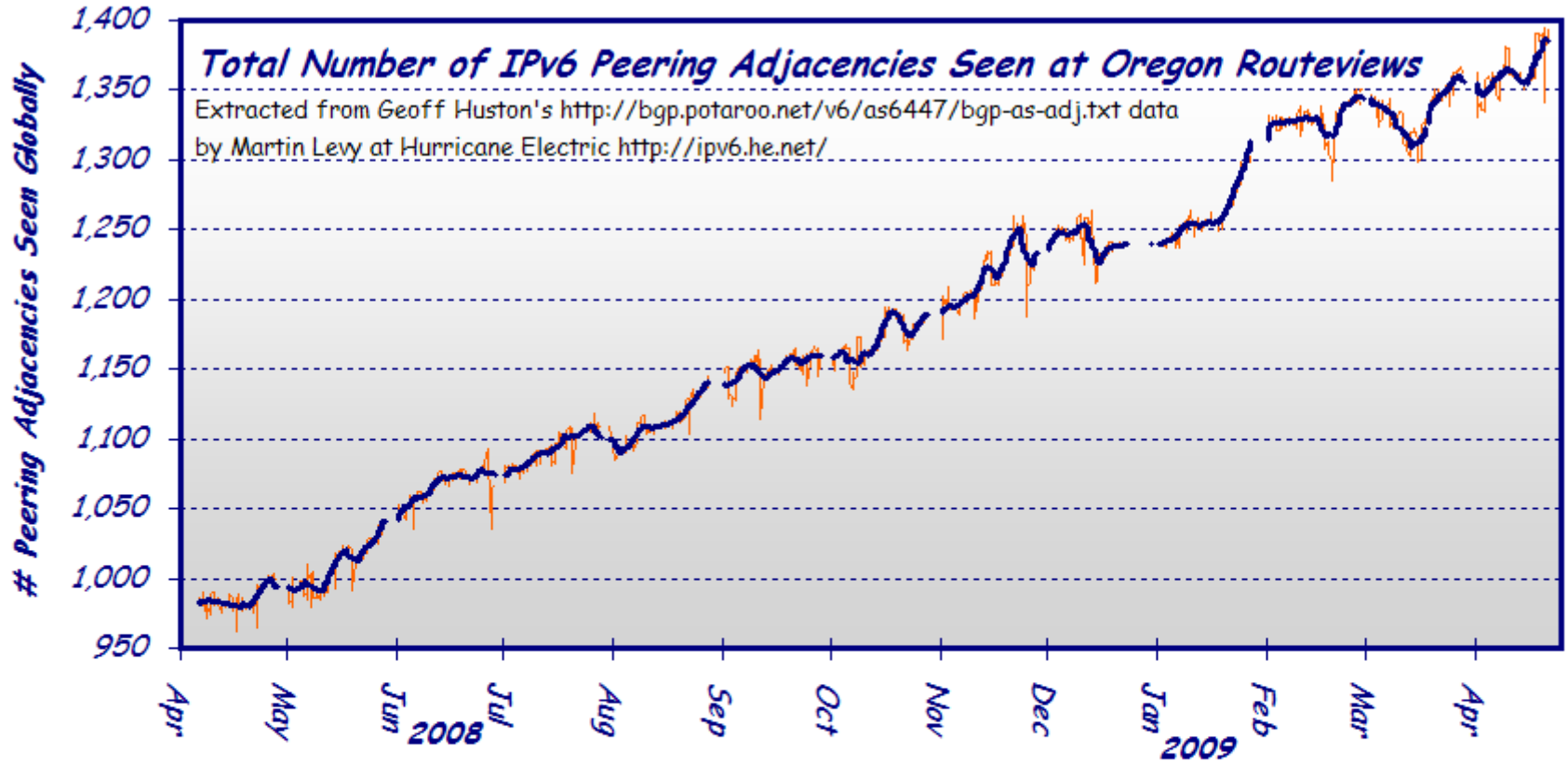
Toronto, Canada

London, England

Palo Alto, New York

Hong Kong SAR, China

IPv6 at peering exchanges

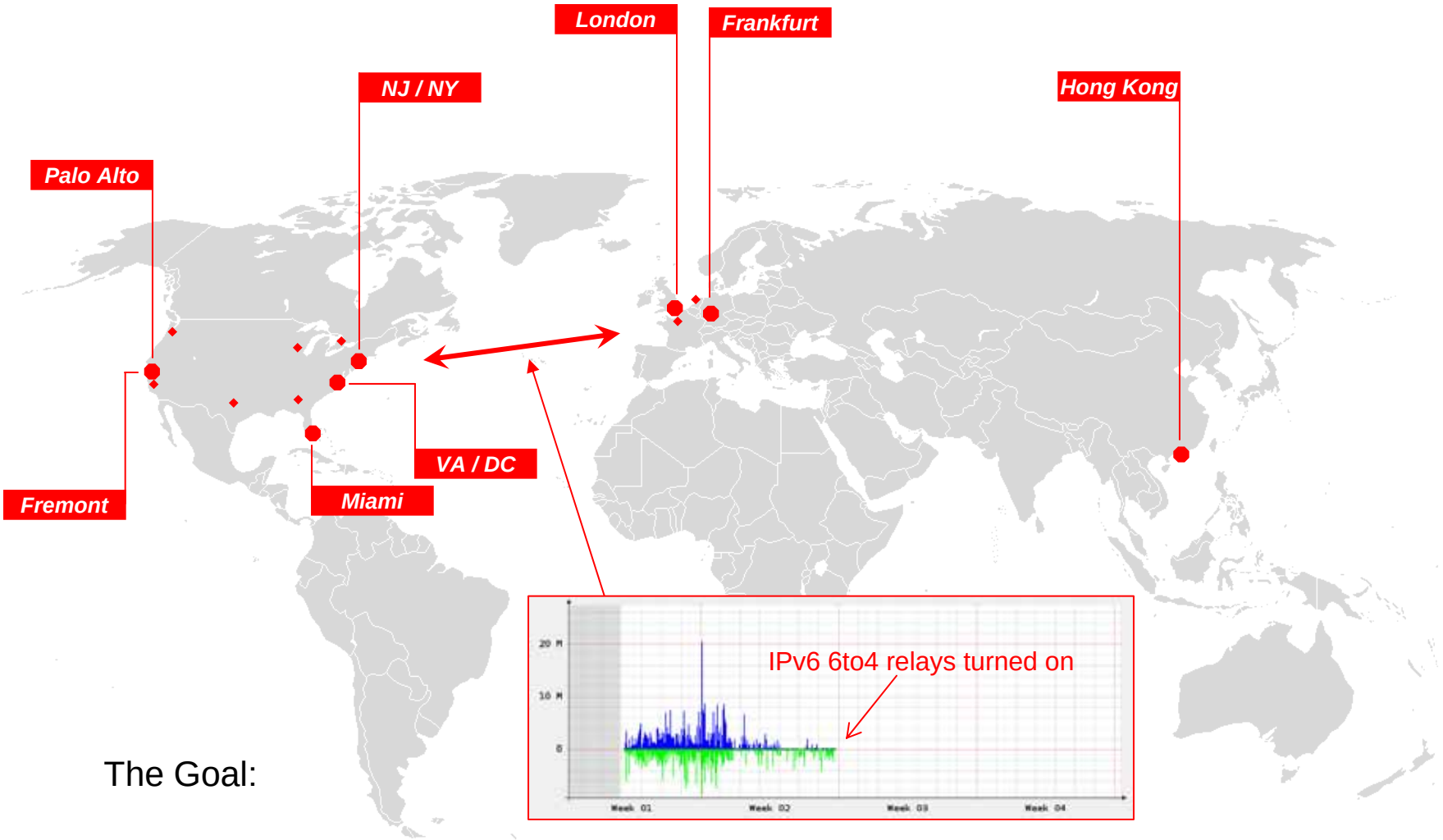


- IPv6 Peering
  - Is there any? (Hint: The answer is yes)
  - Hurricane Electric has 400+ IPv6 BGP neighbors

IPv6 services on the network

(6to4 and teredo relays)

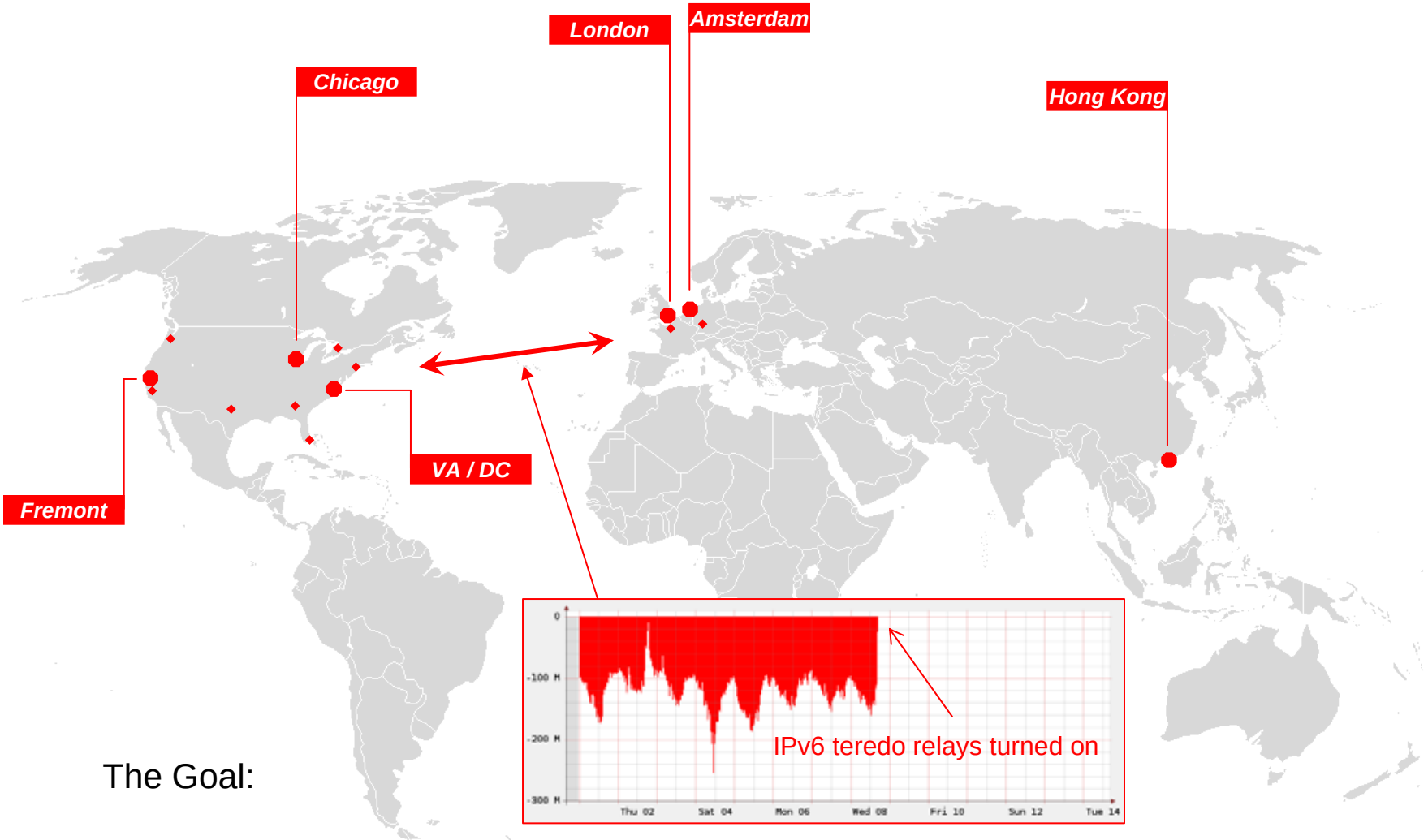
Hurricane Electric – 6to4 relay service



The Goal:

Localize 6to4 traffic (2002::/16 & 192.88.99.1/32 via anycast routing)

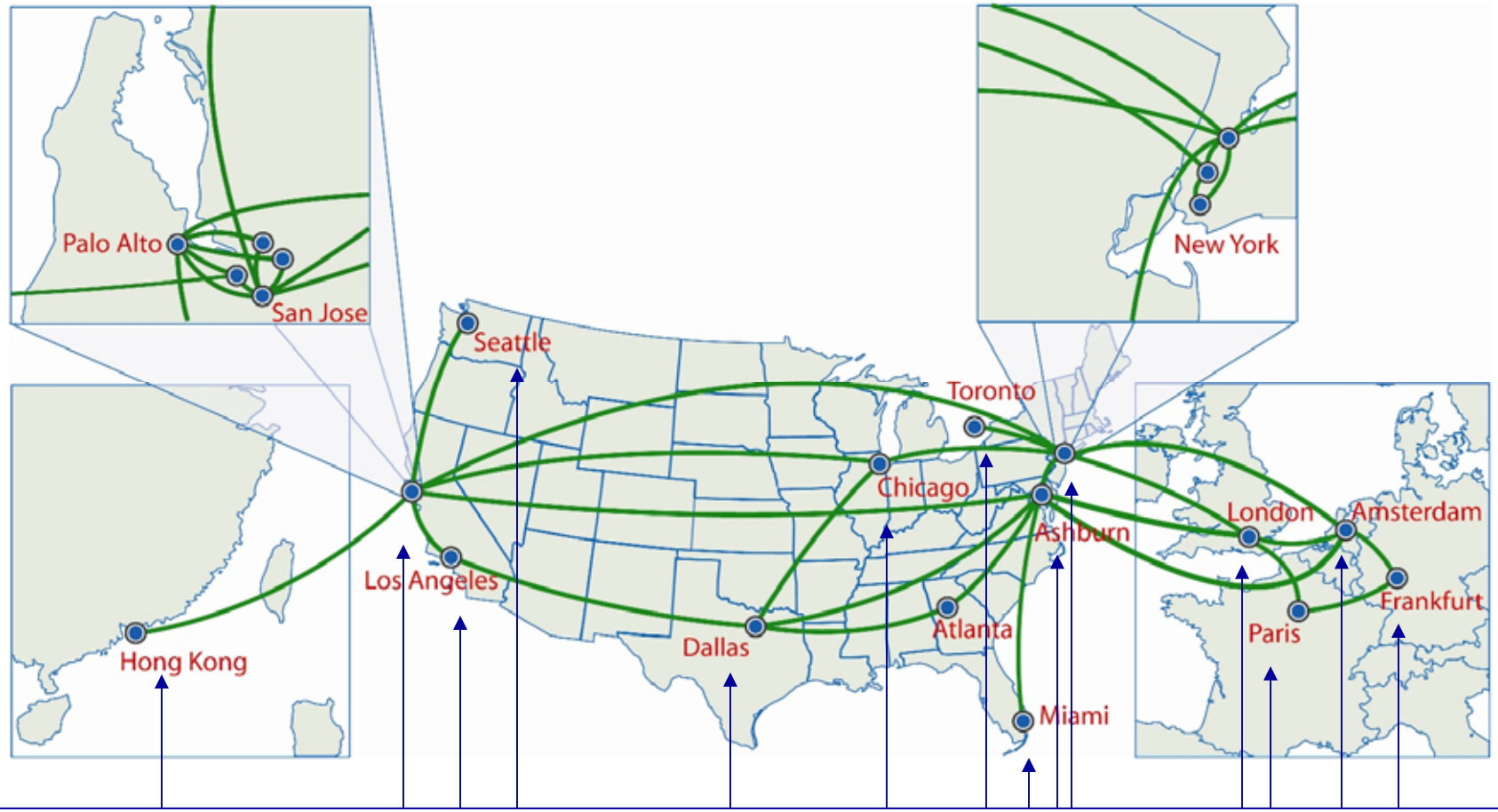
Hurricane Electric – teredo relays



The Goal:

Localize teredo (2001::/32 via anycast routing)

Hurricane Electric – 6to4 & teredo relays



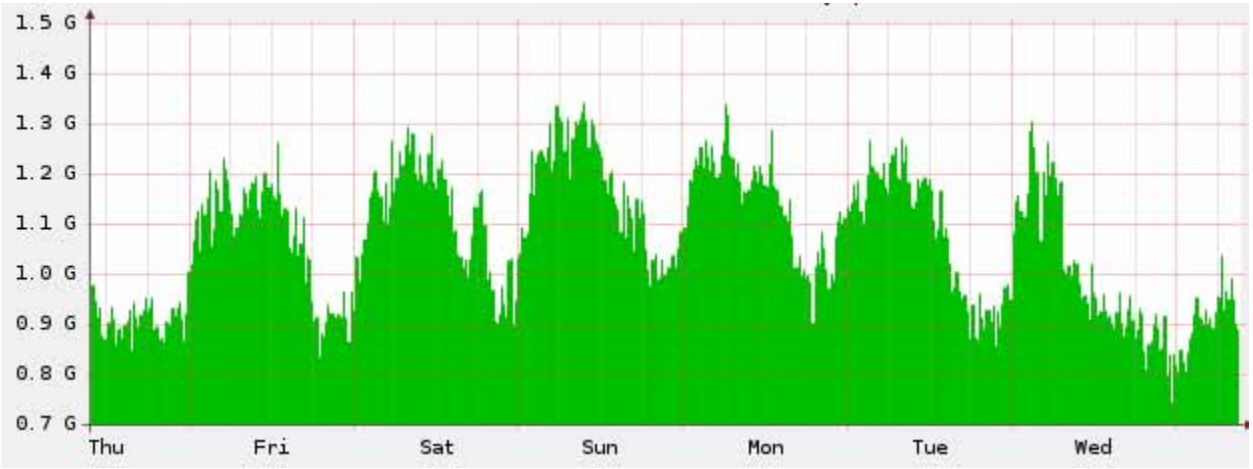
6to4 and Teredo relay deployment – fourteen relays anycast'ed servers – April 2009

Existing Hurricane Electric live sites:

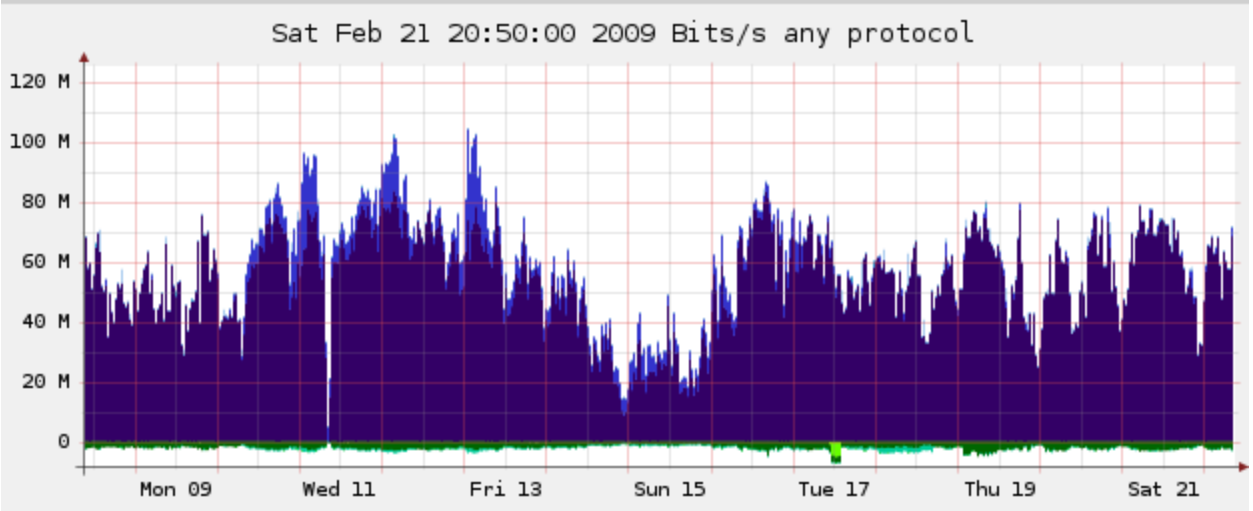
Hong Kong, Seattle, San Jose, Los Angeles, Chicago, Dallas, Toronto
New York, Ashburn, Miami, London, Amsterdam, Paris and Frankfurt.

IPv6 Global Traffic? Is there any?

Public stats – Hurricane Electric IPv6 traffic

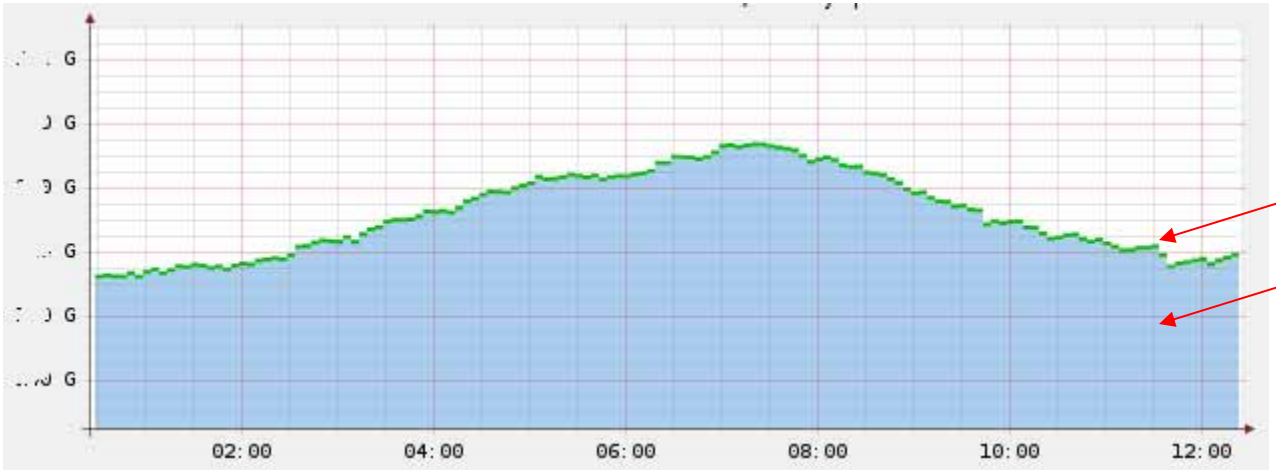


Overall IPv6 traffic



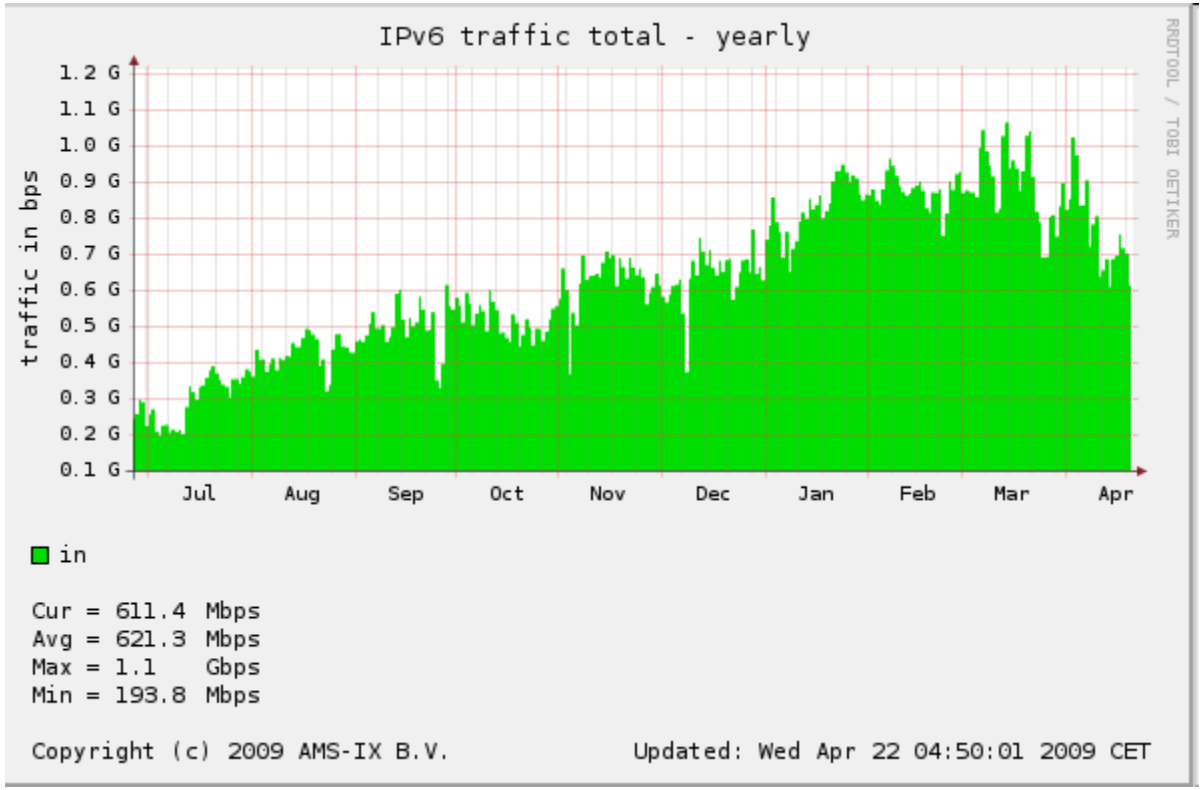
Sample IPv6 Peering Traffic
(summed globally)

Hurricane Electric stats – IPv6 vs. IPv4 traffic



- IPv6 traffic levels don't relate to IPv4 traffic levels
  - Different customer base
  - Different traffic flows
- This will change – they will converge

Public stats – AMSIX IPv6 traffic



AMS-IX sflow stats http://www.ams-ix.net/technical/stats/sflow/?type=ipv6

IPv6 Qualitative Viewpoint

are traffic levels the right measurement?

IPv6 – less quantitative and more qualitative

RFC5156 says:

2.2. IPv4-Mapped Addresses
::FFFF:0:0/96 are the IPv4-mapped addresses [RFC4291]. Addresses within this block should not appear on the public Internet.

2.3. IPv4-Compatible Addresses
::<ipv4-address>/96 are the IPv4-compatible addresses [RFC4291]. These addresses are deprecated and should not appear on the public Internet.

Address	Notes	
::ffff:0:0/96	v4-mapped	107,729
2000::/3	unicast	46,233
::	unspecified	17,038
::/96	v4-compatible	912
2002::/16	6to4	641
::1	localhost	614
invalid	invalid	111
3ffe::/16	6bone	101
fe80::/10	link-local	40
fec0::/10	site-local	1
2001::/32	teredo	-
fc00::/7	ULA	1
	Total IPv6	173,421
	Total usable IPv6	46,874

Count of IPv6 addresses within .COM domain (Queries on 78,630,991 domains to find AAAA records)

Measured on Feb 12, 2009

- IPv6 readiness on a backbone
  - Does a backbone have IPv6 enabled?
  - Are domains served by IPv6 DNS servers
  - Do the basic services operate on v4 & v6?

IPv6 – Registered domains with AAAA records

http://bgp.he.net/ipv6-progress-report.cgi

Generated by querying for A (IPv4) and AAAA (IPv6) records for all domains in the listed TLDs (top level domains).

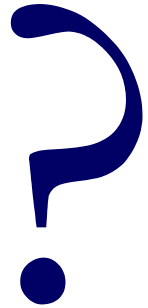
Demonstrates growing use of AAAA records for the primary domain name of websites and other Internet services.

.SK == Slovakia

TLD	domains	A	AAAA	A-glue	AAAA-glue
com	80,240,519	27,259,059	224,559	1,524,266	236
net	12,199,546	10,198,963	30,420	322,000	406
org	7,514,167	6,327,390	20,886	204,980	145
info	5,102,992	4,049,506	8,100	134,247	142
biz	2,019,764	1,576,632	4,695	20,364	
us	1,551,612	1,147,992	4,082	14,844	
ca	1,207,784	972,421	122	15,398	
no	422,532	315,916	137	1,383	3
sk	176,858	130,085	9,804	3,551	3
to	52,395	11,734	22	1,973	1
am	50,344	9,508	5	530	4
kz	38,001	23,705	2	43,847	
tc	36,756	9,046	9	518	
ma	28,671	9,343	3	29,136	
gd	28,643	2,683	2	191	
ag	13,440	9,569	21	289	
ge	12,080	8,598	9	176	1
vg	8,921	6,646	6	343	
ba	8,133	6,770	2	5,923	
gt	6,864	4,900	1	440	2
pe	6,150	3,170	1	84	
lk	5,892	3,296	1	1,395	
sc	5,610	4,577	3	194	
ug	3,110	1,913	1	72	
sn	2,337	948	5	251	1
lc	1,588	423	1	29	
mw	1,324	539	3		
cu	810	209		582	9
nf	640	441	2	12	
tn	52	5		321	2
au	20	1		27	4
Total	110,747,555	52,095,988	302,904	2,327,366	959

Summary

Q&A



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