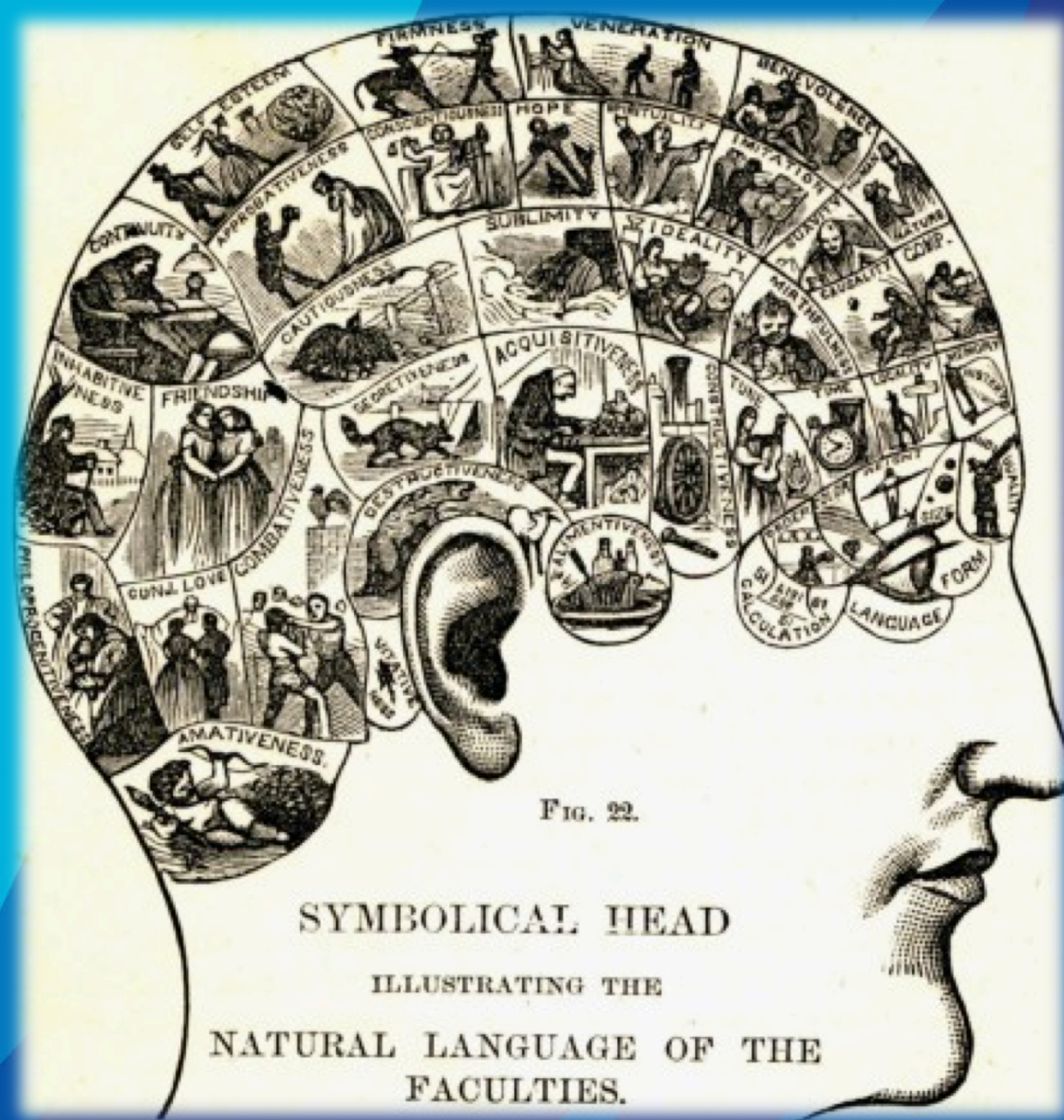# Measuring IPv6 Users

George Michaelson,

Geoff Huston

APNIC

How to measure the end user

How to measure the end user

How to measure a million end users

How to measure a million end users

- be   www.google.net

How to measure a million end users

- be   www.google.net

or

How to measure a million end users

- be   www.google.net

or

- Get your code run on millions of machines

Approaches to Measurement

A case study: APNIC's approach

- we wanted to measure IPv6 deployment as seen by end users

- We wanted to say something about ALL users

- Our website isn't that popular

- …So we were looking at a way to sample end users in a random but statistically significant fashion

- We stumbled across the advertising networks...

…buy the measurement

Placement

At low CPM, the advertising network needs to present unique, new eyeballs to harvest impressions and take your money.
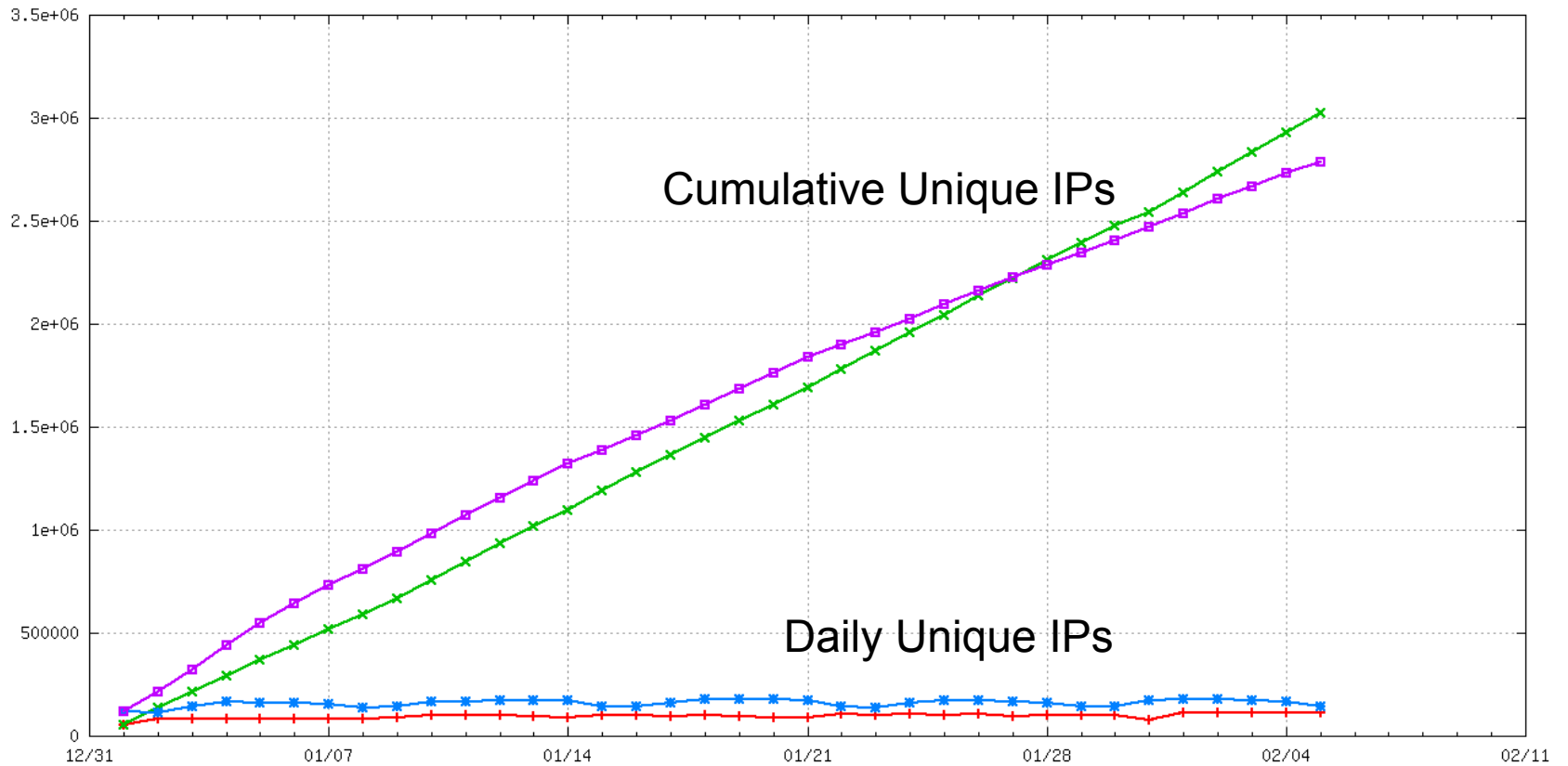
- Therefore, a 'good' advertising network provides a fresh crop of unique clients per day
- Pay for placement of ads, embed the measurement in flashcode.
- Result is lots of Unique IP addresses to measure.

APNIC

Unique IPS?

- Collect list of unique IP addresses seen
  - Per day
  - Since inception

- Plot to see behaviours of system
  - Do we see 'same eyeballs' all the time?

Lots of Unique IP'S

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What are we finding?

- http://labs.apnic.net/ipv6_measurement
  - Breakdowns by ASN, Economy, Region, Organisation

- 125+ economies provide >200 samples/ interval consistently in weeklies

- 150+ at monthlies.

- 2400 ASN provide graphable data

- Over 35,000 ASN seen during the last year.

Google visualization API

AU
flash IPv6 preferred: **0.363226**

0   0.6

APNIC

Google visualization API

TW
flash IPv6 preferred: **0.519814**

0

APNIC
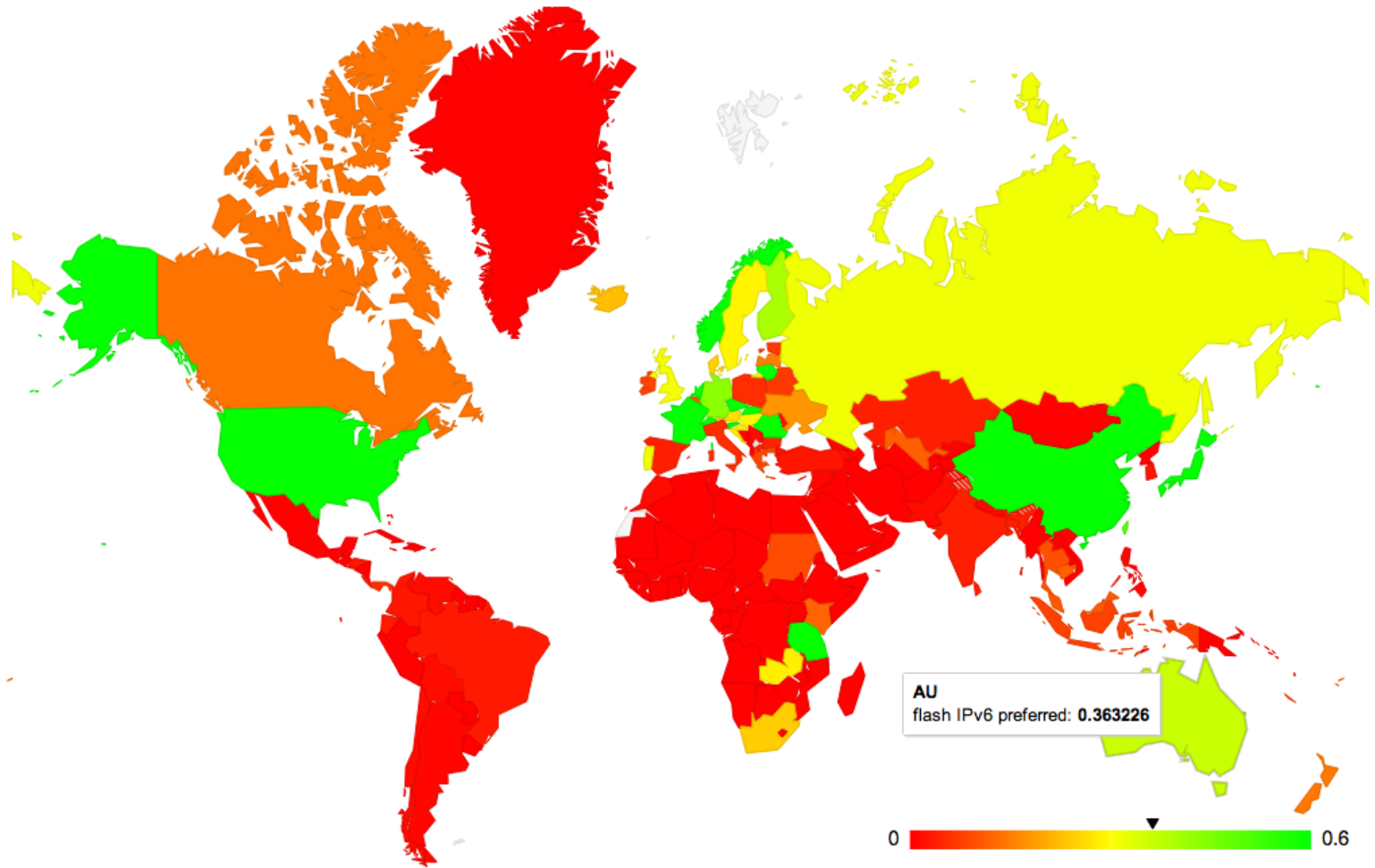
Google visualization API

Google visualization API

Draw your own graphs

http://labs.apnic.net/ipv6-measurement/datafields.html

[
  [
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    "030 Eastern Asia",
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    528930.0,
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    74917.0,
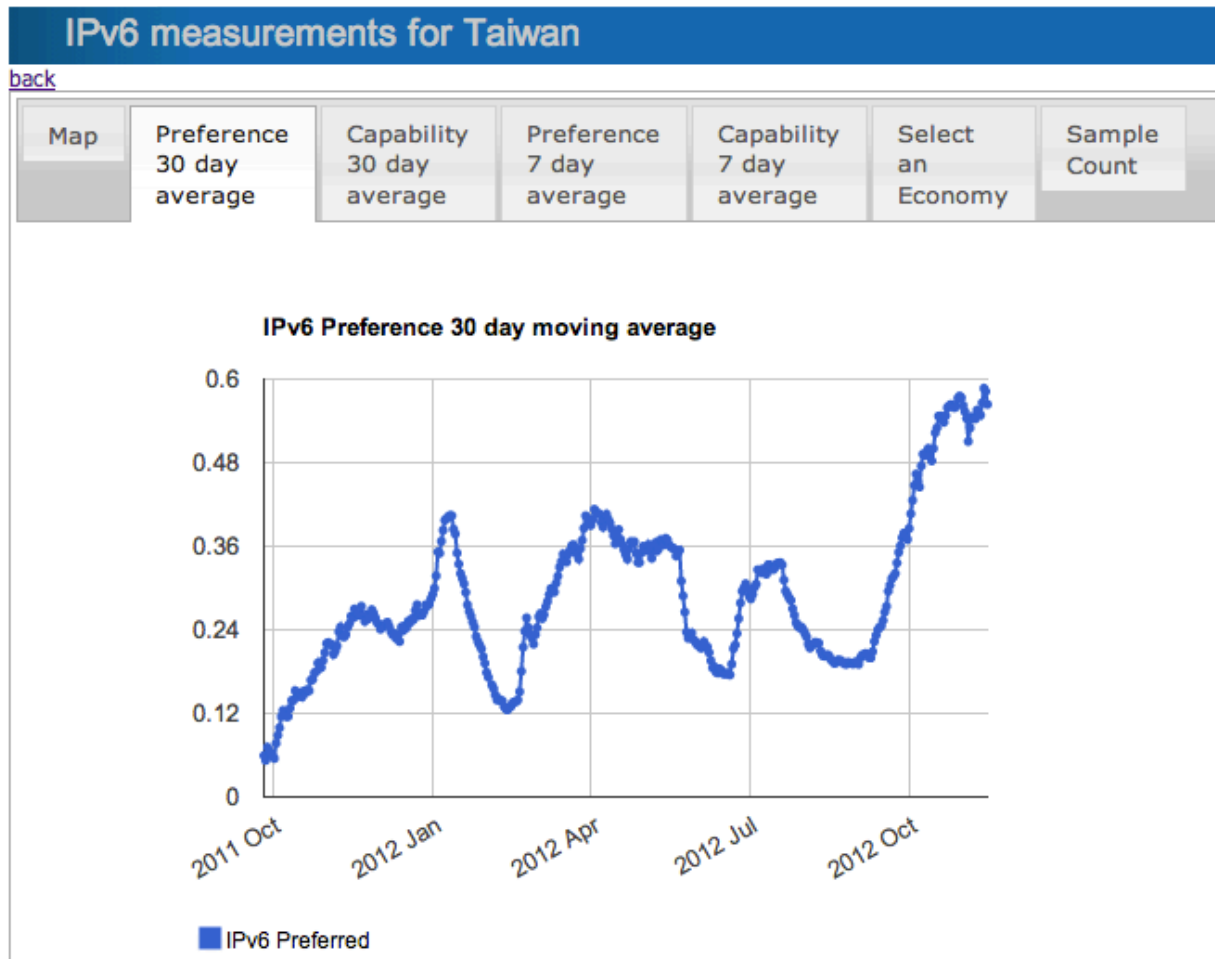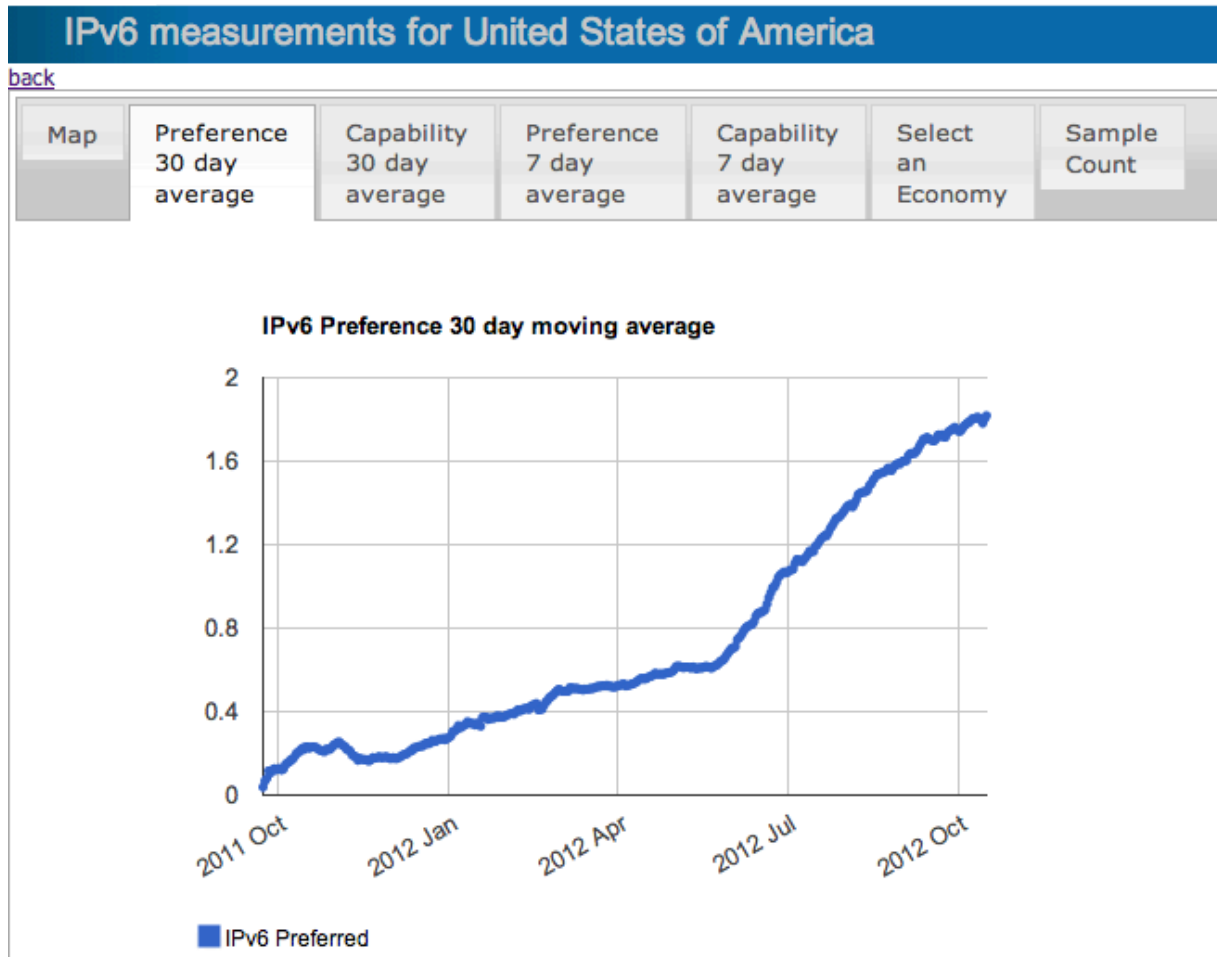   421425.0,
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    32361.0,
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2010:04,030 Eastern
Asia,58936.0,3118.0,58218.0,1331.0,62.0,30.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,3148.0,0.0,60555.0,
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2010:05,030 Eastern
Asia,51951.0,2886.0,51134.0,1127.0,797.0,404.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,2914.0,0.0,53530.
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2010:06,030 Eastern
Asia,51903.0,3005.0,50953.0,1026.0,1091.0,521.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,3024.0,0.0,53157
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0,3024.0,1082.0,0.0,4.2118525,4.2118525,1.22301675,0.0
2010:07,030 Eastern
Asia,54970.0,2949.0,54088.0,947.0,981.0,478.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,2964.0,0.0,56159.0
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964.0,985.0,0.0,3.86124625,3.86124625,1.12621675,0.0
2010:08,030 Eastern
Asia,61906.0,3534.0,61224.0,896.0,1167.0,521.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,3541.0,0.0,63224.
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,3541.0,964.0,0.0,3.95485875,3.95485875,1.04451175,0.0
2010:09,030 Eastern
Asia,49824.0,2742.0,48595.0,1279.0,1336.0,732.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,2766.0,0.0,50898
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6.0,1329.0,0.0,3.7209,3.7209,1.103643625,0.0
2010:10,030 Eastern
Asia,47752.0,2932.0,46423.0,1446.0,1407.0,828.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,2954.0,0.0,48965
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2010:11,030 Eastern
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2010:12,030 Eastern

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IPv6 Users by Country

Date: 18 Nov 2012

http://labs.apnic.net/dists/v6dcc.html

Index	ISO-3166 Code	Internet Users	V6 Use ratio	V6 Users (Est)	Population	Country
1	RO	8661904	9.59%	830676	22096694	Romania
2	FR	50077344	4.79%	2398704	64867026	France
3	LU	467323	2.56%	11963	511295	Luxembourg
4	JP	100863233	2.23%	2249250	126079042	Japan
5	EU	0	2.11%	0	0	European Union
6	US	248528598	1.61%	4001310	317405617	United States of America
7	CZ	7214045	1.05%	75747	10174959	Czech Republic
8	CH	6452594	0.93%	60009	7663414	Switzerland
9	SI	1417480	0.87%	12332	1996452	Slovenia
10	NL	15160499	0.80%	121283	16939106	Netherlands
11	CN	516739820	0.71%	3668852	1345676616	China
12	NO	4581121	0.66%	30235	4713088	Norway
13	DE	67950713	0.65%	441679	82165312	Germany
14	SK	4345906	0.63%	27379	5487256	Slovakia
15	TW	16198144	0.49%	79370	23140207	Taiwan
16	PT	5474169	0.46%	25181	10797179	Portugal
17	LT	2095386	0.44%	9219	3521658	Lithuania
18	ZA	6818030	0.37%	25226	49050580	South Africa
19	RU	61058093	0.29%	177068	137828653	Russian Federation
20	AU	19859968	0.27%	53621	22115778	Australia
21	CA	28073247	0.27%	75797	34403489	Canada
22	NG	42231693	0.26%	109802	159364883	Nigeria
23	GB	51884501	0.26%	134899	61693819	United Kingdom of Great Britain and Northern Ireland
24	MG	364777	0.25%	911	22798569	Madagascar
25	FI	4664868	0.25%	11662	5265089	Finland

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23	GB	51884501	0.26%	134899	61693819	United Kingdom of Great Britain and Northern Ireland
10	NL	15160499	0.80%	121283	16939106	Netherlands
22	NG	42231693	0.26%	109802	159364883	Nigeria
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12	NO	4581121	0.66%	30235	4713088	Norway
14	SK	4345906	0.63%	27379	5487256	Slovakia
31	UA	15168365	0.17%	25786	44744441	Ukraine
18	ZA	6818030	0.37%	25226	49050580	South Africa
16	PT	5474169	0.46%	25181	10797179	Portugal
67	IN	123592914	0.02%	24718	1211695237	India
27	SE	8461946	0.24%	20308	9108661	Sweden
68	BR	87232309	0.02%	17446	206711634	Brazil
57	ID	55851884	0.03%	16755	249338772	Indonesia
41	PL	23819066	0.07%	16673	38417849	Poland

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IPv6 measurement

- Penetration rate of IPv6 into the global AS economy is slowly rising.

- Signs Global-Unicast IPv6 will shortly overtake Teredo

- Widely distributed hop-over for IPv6 being seen.
  - due to the CPE gap ?
  - Even IPv6 enabled ISPs have customers tunnelling over the air-gap

- Much more information about IPv6, global internet behaviour is in the data

What about Taiwan?

What about Taiwan?

- Can we "drill down" inside an individual economy?
  - Get the "per AS" view of the IPv6 capability?

What about Taiwan?

- Can we "drill down" inside an individual economy?
  - Get the "per AS" view of the IPv6 capability

- You bet we can!
  - 435,000 measurements being run against Taiwanese Internet Users in the last 30 days

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Taiwan by ASN

Number of ASN in Taiwan	Number of Taiwanese ASN seen in globally routable BGP
310	98

Taiwan by ASN

Number of ASN in Taiwan	Number of Taiwanese ASN seen in globally routable BGP
310	98

Around 1/3 of the ASN allocated to Taiwanese entities (32%) are visible in the global BGP view.

Taiwan by ASN

Number of Taiwanese ASN seen in globally routable BGP	Number of Taiwanese ASN seen in this experiment
98	105 (!)

Taiwan by ASN

Number of Taiwanese ASN seen in globally routable BGP	Number of Taiwanese ASN seen in this experiment
98	105 (!)

All of BGP active ASN in Taiwan have been seen in the experiment. (and some which aren't currently active. Records go back to 2010)

Tiawan by ASN

Number of taiwanese ASN seen in this experiment	Number of Taiwanese ASN with globally routable IPv6 in BGP
105	26

24%-26% of BGP active ASN seen in Taiwan have at least one globally routable IPv6 prefix (depending on which ASN count you use)

Taiwan by ASN

Number of Taiwanese ASN with globally routable IPv6 in BGP	Number of Taiwanese ASN seen with globally routable IPv6
26	9

Taiwan by ASN

Number of Taiwanese ASN with globally routable IPv6 in BGP	Number of Taiwanese ASN seen with globally routable IPv6
26	9

Only 35% of IPv6 BGP active Taiwanese ASN seen, appear <u>end-user</u> active in IPv6, using global-unicast.

The Taiwan Leaderboard

The Taiwan Leaderboard

- The 26 IPv6 enabled ASN that are globally visible in BGP

The Taiwan Leaderboard

ASN	NetName	ASN	NetName
1659	ERX-TANET-ASN1	3462	HINET
4747	TFN-TW-TTN	4780	SEEDNET
4782	GSNET	4845	SINGTEL-TW
7482	APOL-AS	7539	TANET2-TW
9216	PUNET-AP	9264	ASNET
9311	HITRON-AS-AP	9415	ETWEBS-AS1-AP
9505	TWGATE-AP	9676	SAVECOM-TW
9831	UNIGATE-AS-AP	9919	NCIC-TW
9924	TFN-TW	10229	YAHOO-TW1
17408	ABOVE-AS-AP	17419	HINET-IPV6-TW
17709	EBT	17716	NTU-TW
18182	SONET-TW	18185	NTCU-AS-TW
18391	MRNET-AS-SG-AP	18422	ITRINET-AS-TW

The Taiwan Leaderboard

AS	AS-Name	Description from aut-num	sample count	% IPv6 preference	% IPv6 coercible
17713	NSYSU-TW	National Sun Yat-sen University	402	42.96	70.85
1659	ERX-TANET-ASN1	Tiawan Academic Network (TANet) Information Center	18169	7.89	31.99
18177	NCKU-TW	National Cheng Kung University	1544	6.79	56.82
9264	ASNET	Academic Sinica Network	387	5.84	22.14
9916	NCTU-TW	National Chiao Tung University-	1728	3.51	49.58
18420	NCU-TW	National Central University	1102	3.41	48.08
7539	TANET2-TW	TANet2- sponsored by NSC- TAIWAN	612	1.91	54.05
17712	CCU-TW	National Chung Cheng University	500	1.38	50.79
38844	NTNU-TW	National Taiwan Normal University	880	0.88	51.71
17716	NTU-TW	National Taiwan University	2212	0.49	40.12
4782	GSNET	Data Communication Business Group	846	0.47	1.64
17809	MONAD-TW-AP	Monad Digitnamic Corp.	2632	0.45	30.23
18047	NTHU-TW	National Tsing-Hua University	1133	0.44	50.92
18391	MRNET-AS-SG-AP	Mediaring Network Services Pte Ltd.	333	0.29	6.92
9919	NCIC-TW	New Century InfoComm Tech Co.- Ltd.	1920	0.21	25.82
18182	SONET-TW	Sony Network Taiwan Limited	6990	0.20	3.73
3462	HINET	Data Communication Business Group	280685	0.09	22.78
18049	TINP-TW	Taiwan Infrastructure Network Technologie	3604	0.08	28.69
24165	PHOENIX-NET-TW	PHOENIX CATV CO.-LTD	3025	0.07	24.00
9674	FET-TW	Far EastTone Telecommunication Co.- Ltd.	4165	0.05	32.69
9924	TFN-TW	Taiwan Fixed Network- Telco and Network Service Provider.	26821	0.02	23.26
24164	YJL-MEDIATV-NET	YEONG JIA LEH CABLE TV CO.- LTD.	5468	0.02	21.72
24158	TAIWANMOBILE-AS	Taiwan Mobile Co.- Ltd.	6185	0.02	31.58
9416	MULTIMEDIA-AS-AP	Hoshin Multimedia Center Inc.	18654	0.02	26.36
18185	NTCU-AS-TW	4F- No.114- Sec.1- Chung-Shiao W. Road	9	0.00	0.00
18181	NHRINET	National Health Research Institutes	21	0.00	**0.00**
17408	ABOVE-AS-AP	AboveNet Communications Taiwan	35	0.00	0.00
9918	KGTNET-TW	KG Telecommunication Co.- Ltd	5	0.00	0.00
10135	EASPNET-AS-AP	EASPNET Inc.	7	0.00	0.00
9415	ETWEBS-AS1-AP	ETWebs Taiwan Co. Ltd.	1277	0.00	23.36

The Taiwan Leaderboard

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17713	NSYSU-TW	National Sun Yat-sen University	402	42.96	70.85
1659	ERX-TANET-ASN1	Tiawan Academic Network (TANet) Information Center	18169	7.89	31.99
18177	NCKU-TW		1544	6.79	56.82
9264	ASNET		387	5.84	22.14
9916	NCTU-TW		1728	3.51	49.58
18420	NCU-TW		1102	3.41	48.08
7539	TANET2-TW		612	1.91	54.05
17712	CCU-TW		500	1.38	50.79
38844	NTNU-TW		880	0.88	51.71
17716	NTU-TW		2212	0.49	40.12
4782	GSNET		846	0.47	1.64
17809	MONAD-TW-AP		2632	0.45	30.23
18047	NTHU-TW		1133	0.44	50.92
18391	MRNET-AS-SG-A		333	0.29	6.92
9919	NCIC-TW		1920	0.21	25.82
18182	SONET-TW		6990	0.20	3.73
3462	HINET		280685	0.09	22.78
18049	TINP-TW		3604	0.08	28.69
24165	PHOENIX-NET-T		3025	0.07	24.00
9674	FET-TW		4165	0.05	32.69
9924	TFN-TW		26821	0.02	23.26
24164	YJL-MEDIATV-NE		5468	0.02	21.72
24158	TAIWANMOBILE		6185	0.02	31.58
9416	MULTIMEDIA-AS		18654	0.02	26.36
18185	NTCU-AS-TW		9	0.00	0.00
18181	NHRINET		21	0.00	**0.00**
17408	ABOVE-AS-AP		35	0.00	0.00
9918	KGTNET-TW	KG Telecommunication Co.- Ltd	5	0.00	0.00
10135	EASPNET-AS-AP	EASPNET Inc.	7	0.00	0.00
9415	ETWEBS-AS1-AP	ETWebs Taiwan Co. Ltd.	1277	0.00	23.36

Only 25 ASN in Taiwan show end user IPv6 preference.

This is predominantly the Academic/Reseach sector.

What about that potential market?

AS	AS-Name	Description from aut-num	sample count	% IPv6 preference	% IPv6 coercible
17713	NSYSU-TW	National Sun Yat-sen University	402	42.96	70.85
18177	NCKU-TW	National Cheng Kung University	1,544	6.79	56.82
131146	CGU-AS-TW	Chang Gung University	692	0.00	55.49
38847	NCHU-AS-TW	National Chung Hsing University	603	0.00	54.70
7539	TANET2-TW	TANet2- sponsored by NSC- TAIWAN	612	1.91	54.05
38844	NTNU-TW	National Taiwan Normal University	880	0.88	51.71
18047	NTHU-TW	National Tsing-Hua University	1,133	0.44	50.92
17712	CCU-TW	National Chung Cheng University	500	1.38	50.79
9916	NCTU-TW	National Chiao Tung University-	1,728	3.51	49.58
18420	NCU-TW	National Central University	1,102	3.41	48.08
17716	NTU-TW	National Taiwan University	2,212	0.49	40.12
17421	EMOME-TW	Long Distance & Mobile Business Group-	4,169	0.00	36.20
9674	FET-TW	Far EastTone Telecommunication Co.- Ltd.	4,165	0.05	32.69
1659	ERX-TANET-ASN1	Tiawan Academic Network (TANet) Information Center	18,169	7.89	31.99
24158	TAIWANMOBILE-AS	Taiwan Mobile Co.- Ltd.	6,185	0.02	31.58
17809	MONAD-TW-AP	Monad Digitnamic Corp.	2,632	0.45	30.23
18049	TINP-TW	Taiwan Infrastructure Network Technologie	3,604	0.08	28.69
24157	VIBO-NET-AS	Vibo Telecom Inc.	946	0.00	28.54
7482	APOL-AS	Asia Pacific On-line Service Inc.	2,392	0.00	27.81
9416	MULTIMEDIA-AS-AP	Hoshin Multimedia Center Inc.	18,654	0.02	26.36
9919	NCIC-TW	New Century InfoComm Tech Co.- Ltd.	1,920	0.21	25.82
4780	SEEDNET	Digital United Inc.	28,902	0.00	25.35
24165	PHOENIX-NET-TW	PHOENIX CATV CO.-LTD	3,025	0.07	24.00
9415	ETWEBS-AS1-AP	ETWebs Taiwan Co. Ltd.	1,277	0.00	23.36
9924	TFN-TW	Taiwan Fixed Network- Telco and Network Service Provider.	26,821	0.02	23.26
4662	QTCN-ASN1	GCNet (Reach & Range Inc.)	1,934	0.00	23.22
3462	HINET	Data Communication Business Group	280,685	0.09	22.78
9264	ASNET	Academic Sinica Network	387	5.84	22.14
38842	GMC-AS-TW	Global Mobile Corp.	342	0.00	21.93
24164	YJL-MEDIATV-NET	YEONG JIA LEH CABLE TV CO.- LTD.	5,468	0.02	21.72

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17713	NSYSU-TW	National Sun Yat-sen University	402	42.96	70.85
18177	NCKU-TW	National Cheng Kung University	1,544	6.79	56.82
131146	CGU-AS-TW		692	0.00	55.49
38847	NCHU-AS-TW		603	0.00	54.70
7539	TANET2-TW		612	1.91	54.05
38844	NTNU-TW		880	0.88	51.71
18047	NTHU-TW		133	0.44	50.92
17712	CCU-TW		500	1.38	50.79
9916	NCTU-TW		728	3.51	49.58
18420	NCU-TW		102	3.41	48.08
17716	NTU-TW		212	0.49	40.12
17421	EMOME-TW		169	0.00	36.20
9674	FET-TW		165	0.05	32.69
1659	ERX-TANET-A		169	7.89	31.99
24158	TAIWANMO		185	0.02	31.58
17809	MONAD-TW		632	0.45	30.23
18049	TINP-TW		604	0.08	28.69
24157	VIBO-NET-AS		946	0.00	28.54
7482	APOL-AS		392	0.00	27.81
9416	MULTIMEDI		654	0.02	26.36
9919	NCIC-TW		920	0.21	25.82
4780	SEEDNET		902	0.00	25.35
24165	PHOENIX-NE		025	0.07	24.00
9415	ETWEBS-AS1		,277	0.00	23.36
9924	TFN-TW		26,821	0.02	23.26
4662	QTCN-ASN1		1,934	0.00	23.22
3462	HINET	Data Communication Business Group	280,685	0.09	22.78
9264	ASNET	Academic Sinica Network	387	5.84	22.14
38842	GMC-AS-TW	Global Mobile Corp.	342	0.00	21.93
24164	YJL-MEDIATV-NET	YEONG JIA LEH CABLE TV CO.- LTD.	5,468	0.02	21.72

32 ASN have significant IPv6 capability latent in the userbase.

This includes non-Academic/Research networks with over 20% of the current customer base ready, right now…

APNIC

Error bars

- We can't directly measure iOS in the google flash mechanism (because flash isn't being run on iOS devices)

- We can't directly measure anyone with adblock enabled in the flash measurement (because .. Its an _advert_!)

- We can't directly measure end users who have ACLs blocking youtube (the predominant ad placement website) in the flash measurement.
  - These are 'low side' effects: we undercount in flash

- The javascript measurement is prone to distortions from repeat visits. We try to account for this.
  - This is a 'high side' effect: we can over count in javascript

Observations

- Most Research/Academic networks have good levels of IPv6 capability.
  - Some Universities appear to have deployed an IPv6 enabled SOE
  - Others appear less active (many Universities fold into TANET)

- Transit networks, providers clearly have IPv6 capability in their core.

- End user deployment was always going to be hard
  CPE upgrade costs, customer-provisioning costs

- Other economies appear to be facing similar problems
  - But some ISPs are also biting the bullet.
  - Free/Internode/RCS/Comcast

Conclusions

- We have a long way to go

- APNIC believes it can reliably measure end-user IPv6 capability independently of the ISP, both within an economy, and inter-economy

- We're committed to a long-term measurement and will continue to present data, results

- http://labs.apnic.net/ipv6-measurement

IPv6 measurement

If you see the advert

IPv6 measurement

If you see the advert

PLEASE DON'T CLICK ON IT

(it costs us more)

A word for our sponsors

- Thanks to
  - the Internet Society
  - Google
  - ISC
  - RIPE NCC

- For funding, platform support, collaboration

APNIC Research & Development