# *Measuring Web Similarity from Dual-Stacked Hosts*

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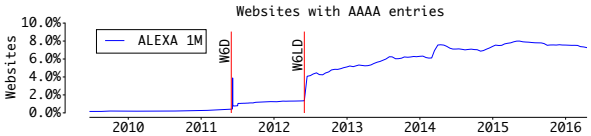
# Introduction | Research Questions

Recent work [1], [2], [3] has compared performance of dual-stacked websites over IPv4 and IPv6.

No study comparing web similarity over IPv4 / IPv6.




*http://www.employees.org/~dwing/aaaa-stats*

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We want to know:

- *How similar are webpages accessed over IPv6 to their IPv4 counterparts?*
- *What factors contribute to the dissimilarity over IPv4 and IPv6?*

# Introduction | Research Contributions

We measure against ALEXA top 100 dual-stacked websites.

1. `simweb` : A tool for measuring web similarity over IPv4 and IPv6.
2. Websites (27%) have some fraction of webpage elements failing over IPv6.
3. Failure rates over IPv6 are largely due to DNS resolution error on images, js and CSS.
4. Both same-origin and cross-origin sources contribute to the failure rates over IPv6.

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*To the best of our knowledge, this is the first study to:*

- *Measure webpage similarity over IPv4 and IPv6.*
- *Investigate IPv6 adoption that goes beyond the root page of a dual-stacked website.*

# *Methodology*

# Methodology | Metrics

We use 2 well-known webpage complexity metrics from literature [4, 5]:

1. Content Complexity
   *The number & size of fetched webpage elements.*

2. Service Complexity
   *The number of same-origin & cross-origin sources.*

# Methodology | Selection of Websites

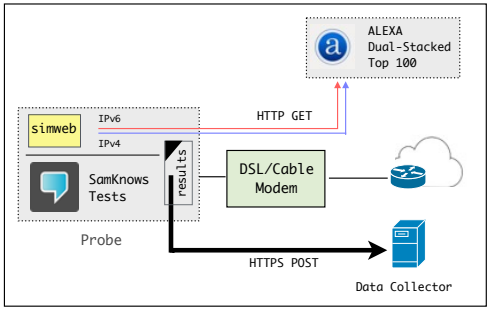
- We use the ALEXA top 100 dual-stacked websites as measurement targets [1].

1. www.google.com
2. www.facebook.com
3. www.youtube.com
4. www.yahoo.com
5. www.wikipedia.org
6. www.qq.com
7. www.blogspot.com
8. ...

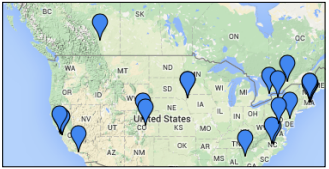
# Methodology | Measurement Setup

The `simweb` test:

- runs twice (once for each AF).
- repeats every hour.
- uses user-agent string: `Mozilla/4.0`



# Methodology | Measurement Trial





| NETWORK TYPE | # |
|---|---|
| RESIDENTIAL | 55 |
| NREN / RESEARCH | 11 |
| BUSINESS / DATACENTER | 09 |
| OPERATOR LAB | 04 |
| IXP | 01 |

| RIR | # |
|---|---|
| RIPE | 42 |
| ARIN | 29 |
| APNIC | 07 |
| AFRINIC | 01 |
| LACNIC | 01 |

We measure from 80 dual-stacked SamKnows probes.

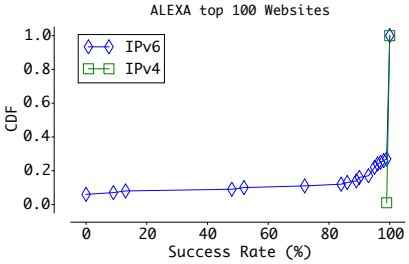
# *Data Analysis*[1]

[1] *Measurements conducted for 65 days between April 2015 and June 2015.*

# Results | Success Rates

*Can we fetch all webpage elements over IPv6?*

- 27% of websites show some rate of failure over IPv6.
- 9% exhibit more than 50% failures over IPv6.
- 6% show complete failure (0% success) over IPv6.




| # | Webpage | Success Rate (%) IPv6(↓) | Success Rate (%) IPv4 | W6LD |
|---|---|---|---|---|
| 01 | www.bing.com | 0 | 100 | ✓ |
| 02 | www.detik.com | 0 | 100 | ✓ |
| 03 | www.engadget.com | 0 | 100 | ✓ |
| 04 | www.nifty.com | 0 | 100 | |
| 05 | www.qq.com | 0 | 100 | |
| 06 | www.sakura.ne.jp | 0 | 100 | |
| 07 | www.flipkart.com | 09 | 99 | ✓ |
| 08 | www.folha.uol.com.br | 13 | 100 | |
| 09 | www.aol.com | 48 | 100 | ✓ |
| 10 | www.comcast.net | 52 | 100 | ✓ |
| 11 | www.yahoo.com | 72 | 100 | ✓ |
| 12 | www.mozilla.org | 84 | 100 | ✓ |
| 13 | www.orange.fr | 86 | 100 | ✓ |
| 14 | www.seznam.cz | 89 | 100 | ✓ |
| 15 | www.mobile.de | 90 | 100 | ✓ |
| 16 | www.wikimedia.org | 90 | 100 | |
| 17 | www.t-online.de | 93 | 100 | ✓ |
| 18 | www.free.fr | 95 | 100 | |
| 19 | www.usps.com | 95 | 100 | |
| 20 | www.vk.com | 95 | 100 | ✓ |
| 21 | www.wikipedia.org | 95 | 100 | ✓ |
| 22 | www.wiktionary.org | 95 | 100 | |
| 23 | www.elmundo.es | 96 | 100 | ✓ |
| 24 | www.uol.com.br | 96 | 100 | ✓ |
| 25 | www.marca.com | 97 | 100 | ✓ |
| 26 | www.terra.com.br | 98 | 100 | ✓ |
| 27 | www.youm7.com | 99 | 100 | |

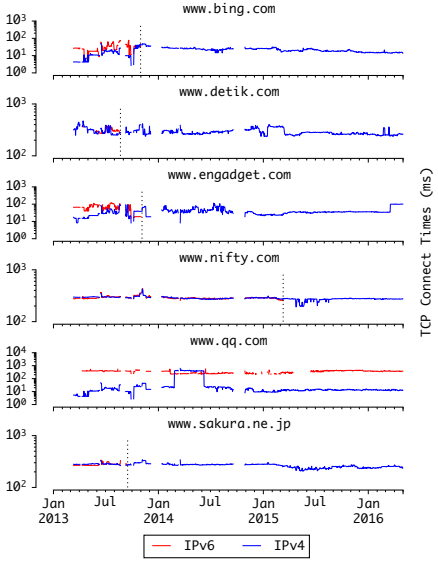
# Web Similarity | Success Rates

ALEXA top 100 dual-stacked websites:

- 6% show complete failure over IPv6.

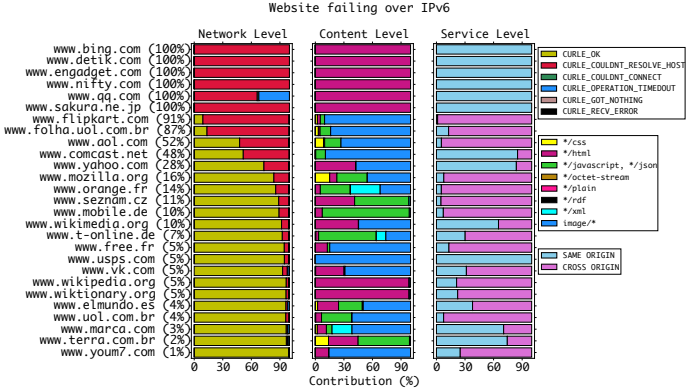
| # | Webpage | Success Rate (%) IPv6(↓) | IPv4 | W6LD |
|---|---|---|---|---|
| 01 | www.bing.com | 0 | 100 | ✓ |
| 02 | www.detik.com | 0 | 100 | ✓ |
| 03 | www.engadget.com | 0 | 100 | ✓ |
| 04 | www.nifty.com | 0 | 100 | |
| 05 | www.qq.com | 0 | 100 | |
| 06 | www.sakura.ne.jp | 0 | 100 | |

- Metrics that measure IPv6 adoption should account for *changes* in IPv6-readiness.



# Results | Causality Analysis

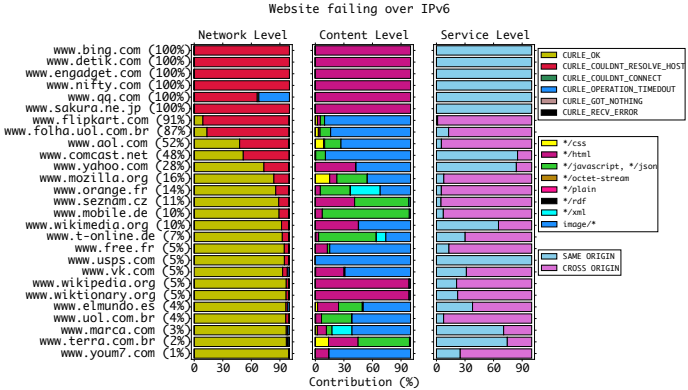
*Where in the network does the failure occur?*




- `CURLE_COULDNT_RESOLVE_HOST` is the major contributor to failure rates.
- AAAA entries missing for these webpage elements in the DNS.

# Results | Causality Analysis

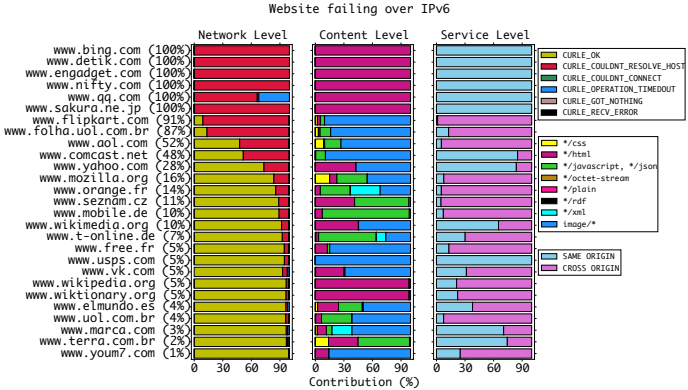
*Which type of objects fail more than others?*




- `image/*`, `*/javascript`, `*/json` and `*/css` content contribute to the majority of the failure over IPv6.

# Results | Causality Analysis

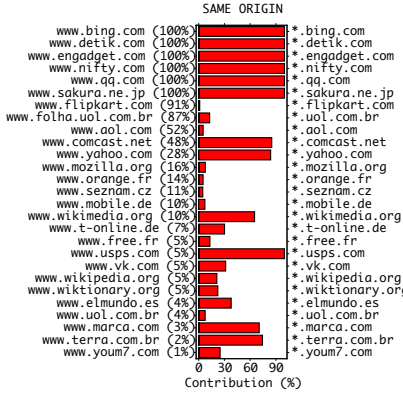
*Where do the failing objects originate from?*




- Both same and cross origin sources contribute to the failure of webpage elements over IPv6.

# Results | Causality Analysis

*What is failure contribution of same-origin sources?*

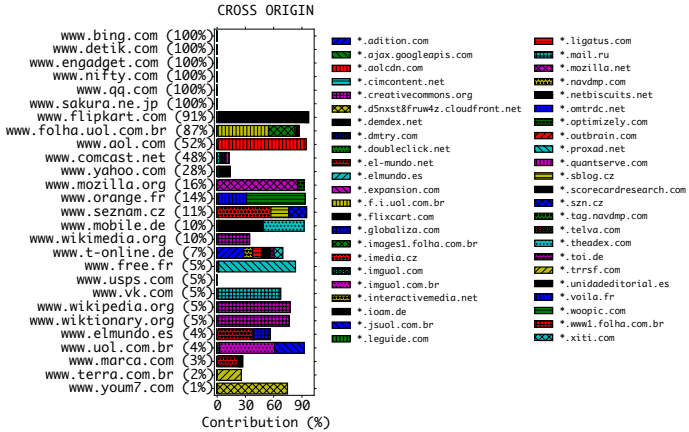



- 12% of websites have more than 50% webpage elements that belong to the same origin source and fail over IPv6.

| # | Webpage | Same Origin (↓) |
|---|---|---|
| 01 | www.bing.com | 100% |
| 02 | www.detik.com | 100% |
| 03 | www.engadget.com | 100% |
| 04 | www.nifty.com | 100% |
| 05 | www.usps.com | 100% |
| 06 | www.qq.com | 100% |
| 07 | www.sakura.ne.jp | 100% |
| 08 | www.comcast.net | 85% |
| 09 | www.yahoo.com | 83% |
| 10 | www.terra.com.br | 74% |
| 11 | www.marca.com | 70% |
| 12 | www.wikimedia.org | 65% |
| 13 | www.elmundo.es | 37% |
| 14 | www.vk.com | 31% |
| 15 | www.t-online.de | 30% |
| 16 | www.youm7.com | 24% |
| 17 | www.wiktionary.org | 22% |
| 18 | www.wikipedia.org | 22% |
| 19 | www.free.fr | 13% |
| 20 | www.folha.uol.com.br | 12% |
| 21 | www.mozilla.org | 7% |
| 22 | www.uol.com.br | 7% |
| 23 | www.mobile.de | 7% |
| 24 | www.aol.com | 5% |
| 25 | www.orange.fr | 5% |
| 26 | www.seznam.cz | 4% |
| 27 | www.flipkart.com | 1% |

# Results | Causality Analysis

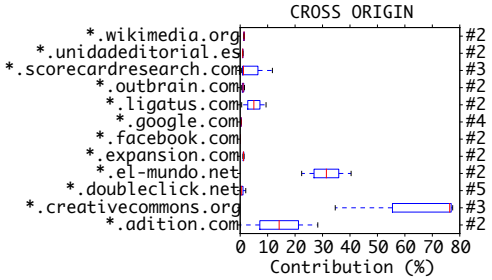
*What is failure contribution of cross-origin sources?*




- Some of the cross-origin sources contribute to the failure of multiple websites.

# Results | Causality Analysis

*Which cross-origin sources span across multiple failing websites?*




| CROSS ORIGIN | MEDIAN |
|---|---|
| *.creativecommons.org | 76.33% |
| *.el-mundo.net | 31.41% |
| *.adition.com | 14.20% |
| *.ligatus.com | 4.98% |
| *.wikimedia.org | 1.40% |
| *.expansion.com | 1.21% |
| *.scorecardresearch.com | 1.19% |
| *.outbrain.com | 1.06% |
| *.unidadeditorial.es | 0.94% |
| *.doubleclick.net | 0.54% |
| *.google.com | 0.31% |
| *.facebook.com | 0.06% |

- `doubleclick.net` spans 5 websites with a 0.54% median contribution to failure rates.
- `creativecommons.org` has 76% median contribution to the failure rate of 3 websites.

# Takeway

- Metrics that measure IPv6 adoption should account for changes in IPv6-readiness.
- Limiting to root webpage can lead to overestimation of IPv6 adoption numbers.
- Unclear whether websites with failure rates can be deemed IPv6-ready.
- Few cross-origin sources once IPv6 enabled will help large number of websites at once.

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**Graduating in 2016. Currently on the job market!**

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# *Appendix*

# Introduction | Motivation

- 4/5 RIRs have exhausted available pool of IPv4 address space [6]

| | |
|---|---|
| APNIC | Apr′11 |
| RIPE | Sep′12 |
| LACNIC | Jun′14 |
| ARIN | Sep′15 |

- Large IPv6 broadband rollouts[2] since World IPv6 Launch Day in 2012 [7].
- Increased global adoption of IPv6 to 10.5% [8] (as seen by Google, March 2016).

| | |
|---|---|
| Belgium | 40.49% |
| Switzerland | 27.38% |
| United States | 23.62% |
| Germany | 21.41% |

[2] Comcast, Deutsche Telekom AG, AT&T, Verizon Wireless, T-Mobile USA

# Methodology | SamKnows webget

SamKnows [9] probes run `webget`[3] :

- DNS lookup time.
- Time to first byte.
- HTTP request time.
- Content size.
- Download speed

as a aggregated report for a website.

```
% webget 1 www.google.com
version: WEBGETMT.2
endtime: 1427820219
status: OK
target: www.google.com
address: 2a00:1450:4008:801::1013
fetch_time: 145270
bytes_total: 194818
bytes_sec: 1848376
objects: 3
threads: 1
requests: 3
connections: 1
reused_connections: 2
lookups: 1
request_total_time: 128883
request_min_time: 12930
request_avg_time: 42961
request_max_time: 100458
...
```

[3] files.samknows.com/~gpl

# Methodology | JUB simweb

- We extend the SamKnows `webget` test to measure webpage similiarity:

`simweb` in addition also reports:

- Content Type
- Content Size
- Resource URL
- IP endpoint
- CURL response code
- HTTP status code

for each webpage element of a website.

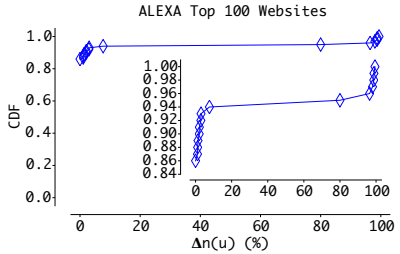
```
% SIMWEB_L=1 IPVERSION=6 webget 1 www.google.com
#: 1
version: SIMWEB.0
service: www.google.com
timestamp: 1427822156
af: 6
status: OK
curl_response_code: CURLE_OK
object_type: text/html:charset=ISO-8859-1
http_code: 200
resource_url: www.google.com
ip_endpoint: 2a00:1450:4008:801::1010;
size_bytes: 52674

#: 2
...
```

# Results | Content Similarity

*Is there a difference in the number of fetched webpage elements?*

$$\Delta n(u) = \frac{\hat{n}_4(u) - \hat{n}_6(u)}{\hat{n}_4(u)} \times 100\%$$

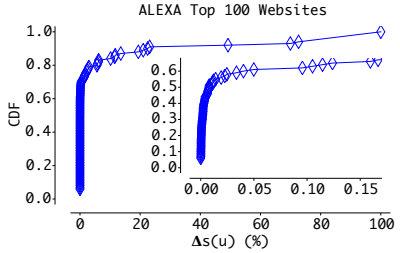
- 14% of websites exhibit dissimilarity in number.
- 6% showing more than 50% difference.




*Is there a difference in the object size of fetched webpage elements?*

$$\Delta s(u) = \frac{\hat{s}_4(u) - \hat{s}_6(u)}{\hat{s}_4(u)} \times 100\%$$

- 94% of dual-stacked websites exhibit dissimilarity in size.
- 8% showing atleast 50% difference.



# Appendix | References I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[9] V. Bajpai and J. Schonwalder, "A Survey on Internet Performance Measurement Platforms and Related Standardization Efforts," *Communications Surveys Tutorials, IEEE*, vol. 17, no. 3, pp. 1313–1341, thirdquarter 2015. [Online]. Available: http://dx.doi.org/10.1109/COMST.2015.2418435