

GOVERNMENTS ENABLED WITH IPv6

IPv6 use monitoring at academic clients

Methods and results

*Brussels, Belgium
21 May 2015*



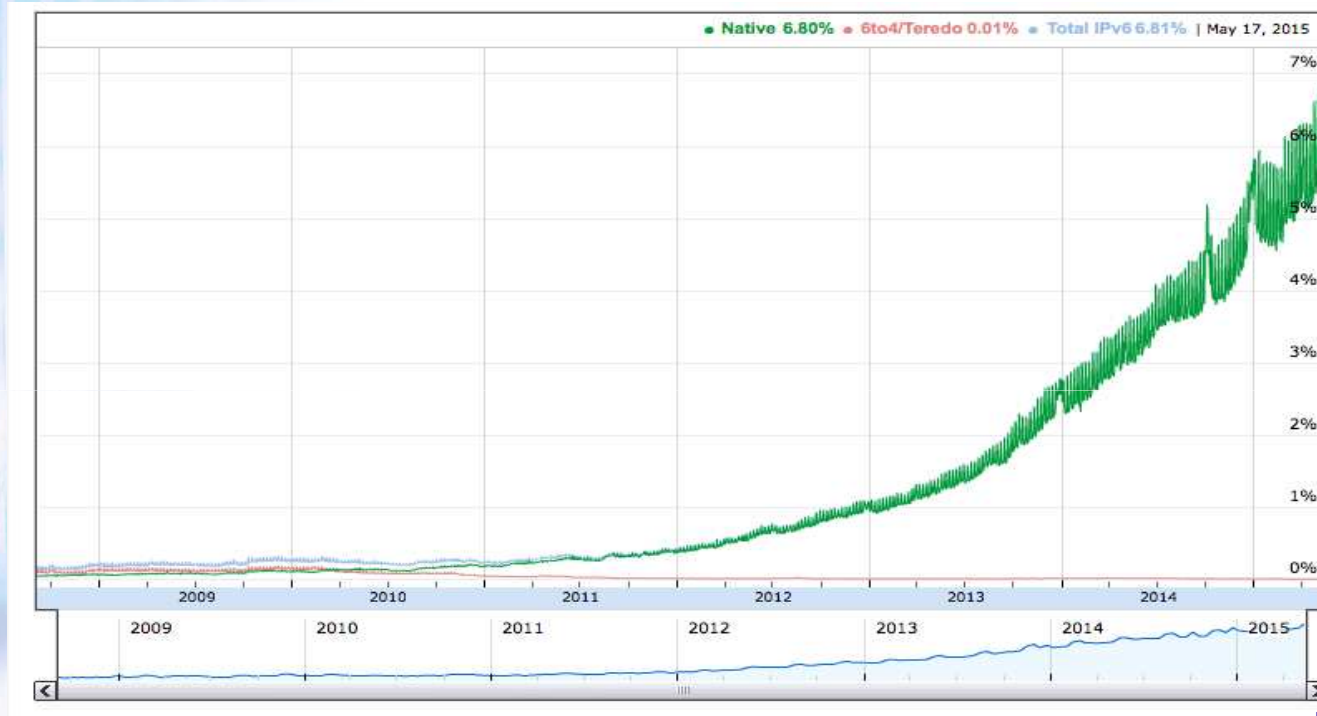
Academic Pilot: Main goals

- Collect and propagate good practices for IPv6 deployment in Academia
 - IPv6 deployment procedures in academic networks
 - Best practices and recommendations for IPv6 in Academia
- Monitoring
 - Identify and recommend tools for monitoring and characterizing IPv6 traffic in academic institutions
 - Monitor the take-up of IPv6 by Academia across Europe, and provide updated figures for the IPv6 indicator in the Digital Agenda Scoreboard.

Monitoring IPv6 adoption in Academia



Global IPv6 adoption



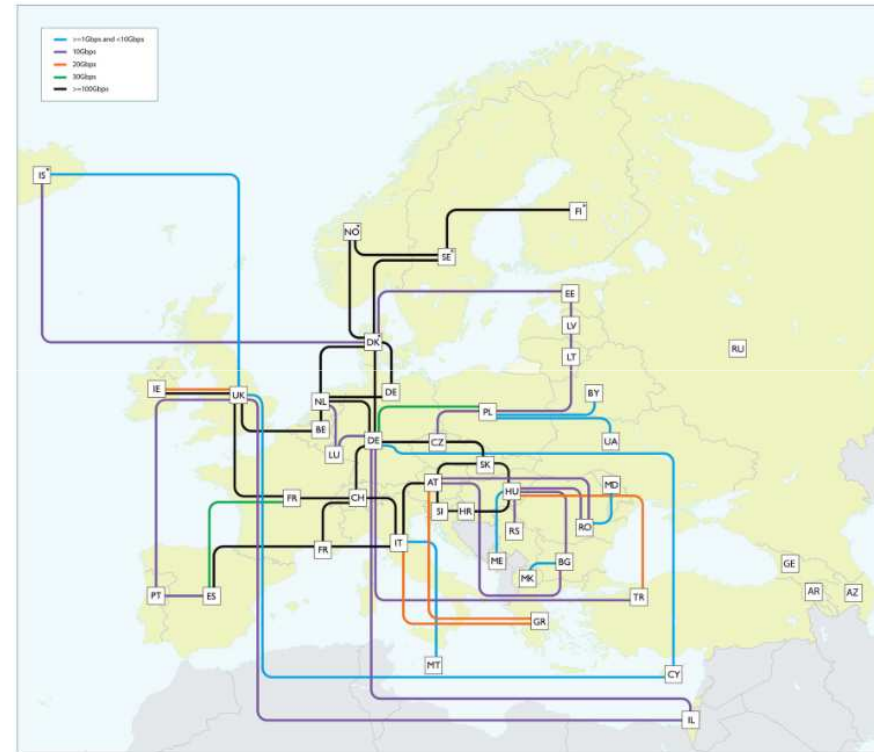
source: google

- Akamai reports similar figures
- How is Academia performing?



GÉANT

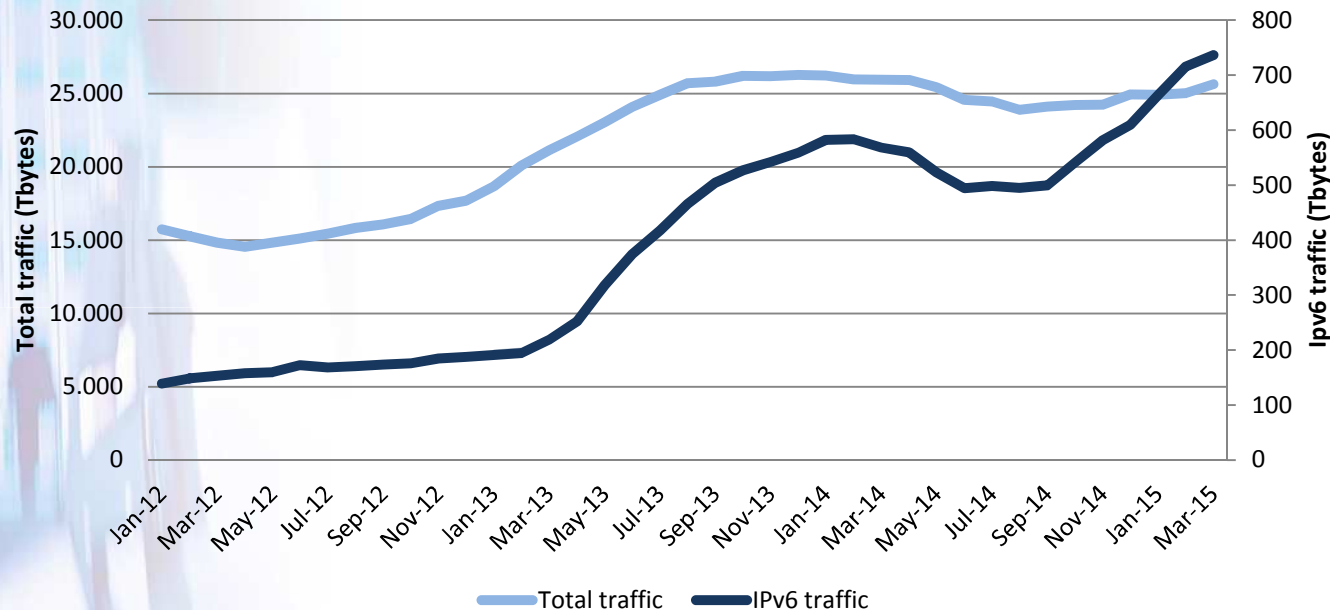
- Pan European Research and Education Network
 - 10,000 institutions
 - 50 million users
 - Interconnects National Research & Education Networks (NRENs)
- Early IPv6 adopter
 - Backbone supports native IPv6 since 2002
 - Many NRENs are also early IPv6 adopters





IPv6 traffic evolution in GÉANT (in+out)

GEANT total traffic
12 month moving average



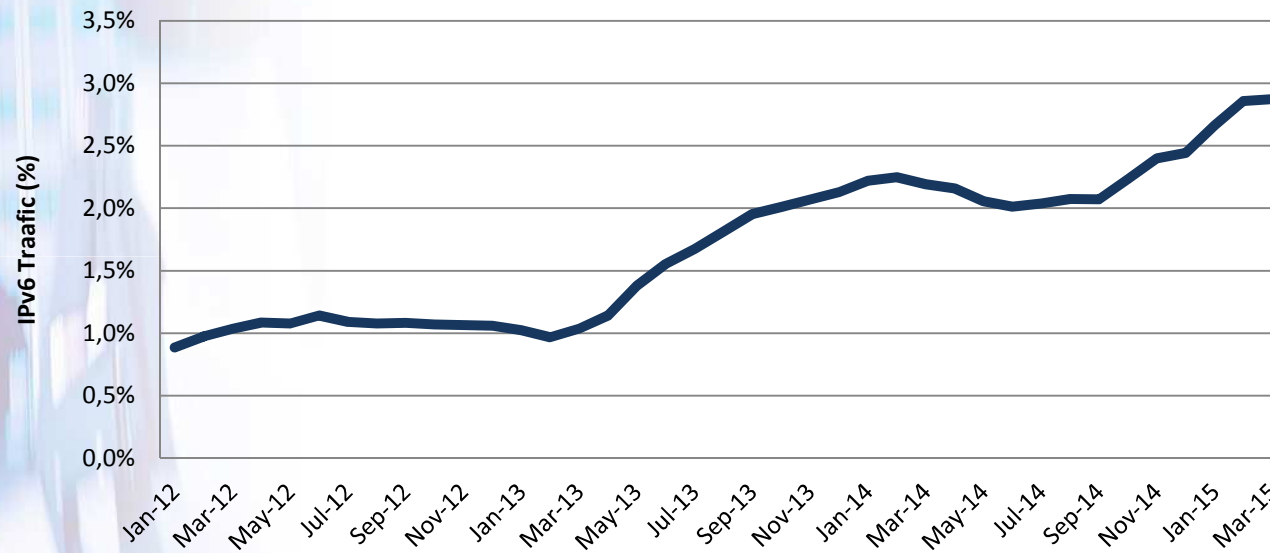
Traffic growth in last 40 months (moving average)

– IPv4: +60% - IPv6: +**429%**



IPv6 vs total traffic in GÉANT

Rate of IPv6 in global GEANT traffic



- Adoption rate more than tripled since 2012
- However, IPv6 traffic seems below what would be expected



GÉANT data: discussion

- GÉANT vs Google/Akamai: Different metrics
 - GÉANT data reports traffic, Google/Akamai report #requests
- Most IPv6 traffic today results from major content providers (e.g., Google, Facebook, Akamai, etc)
 - Some NRENs have direct peering with some of these content providers, subtracting such IPv6 traffic from the GÉANT backbone
- Some major data intensive research projects may not support IPv6 yet (?)
- Global GÉANT traffic may not reflect real IPv6 adoption in academia



Monitoring academic IPv6 services

- Monitoring IPv6 support in central services of main Universities across Europe
 - Checked WWW, DNS and Mail support
- Monitoring sample: 177 European Universities included in the top 400 of the Times Higher Education Ranking
- Same scripts and site used for government benchmarking developed by CZ.NIC
- Detailed results available at <https://devpub.labs.nic.cz/ipv6-smt-new/country/ uni/>



Academic IPv6 services

Results for top 15 Universities

World rank	University	WWW	NS	Mail
3	University of Oxford	IPv4 Only	Partial IPv6	IPv4 only
5	University of Cambridge	IPv4 Only	Partial IPv6	IPv4 only
9	Imperial College London	Full IPv6	Full IPv6	Full IPv6
13	Swiss Federal Institute of Technology Zürich	Full IPv6	Full IPv6	IPv4 only
22	University College London (UCL)	IPv4 Only	Partial IPv6	IPv4 only
29	Ludwig Maximilian University of Munich	Full IPv6	Partial IPv6	Full IPv6
34	École Polytechnique Fédérale de Lausanne	Full IPv6	Full IPv6	Full IPv6
34	London School of Economics and Political Science	IPv4 Only	IPv4 only	IPv4 only
36	University of Edinburgh	IPv4 Only	IPv4 only	IPv4 only
40	King's College London	IPv4 Only	Partial IPv6	IPv4 only
44	Karolinska Institute	IPv4 Only	Partial IPv6	Full IPv6
52	University of Manchester	IPv4 Only	Partial IPv6	IPv4 only
55	KU Leuven	Full IPv6	Full IPv6	IPv4 only
61	École Polytechnique	IPv4 Only	Partial IPv6	IPv4 only
63	Scuola Normale Superiore di Pisa	IPv4 Only	Partial IPv6	Full IPv6



Academic IPv6 services

Summary of 177 monitored Universities

	WWW	DNS	Mail
Full IPv6 support	18.6%	16.9%	24.9%
Partial IPv6 support	0.0%	51.4%	4.0%
IPv4 only	81.4%	31.6%	71.2%

- Apparent higher rate of IPv6 support in mail services
- Higher rate of partial support in DNS

Academic IPv6 services: analysis and discussion

- Several top ranked Universities lack IPv6 support
- No clear correlation between University ranking and IPv6 support
- Higher rate of IPv6 support in mail services
 - Analysis of several institutions without IPv6 support in web services but with IPv6 enabled mail services show that often the service is usually hosted in external entities with IPv6 support
- Higher rate of partial support in DNS
 - IPv4 institutions with secondary servers on IPv6 enabled institutions
- Estimated rate of European Universities with IPv6 support in central services: 18.0%-19.0%



Evaluating IPv6 penetration

- IPv6 support in central services or in the University backbone does not provide an effective estimate of IPv6 deployment in access networks
- Monitoring methodology to access IPv6 availability by end users
 - Installation of active IPv6 probes in highly accessed web pages by the Academic community
 - Each visit triggers a short and unnoticeable test between the end user device and the GEN 6 IPv6 monitoring servers
 - Log data is collected at test servers and periodically processed
 - If the source IP belongs to a monitored institution, IPv6 connectivity is evaluated and the statistics updated

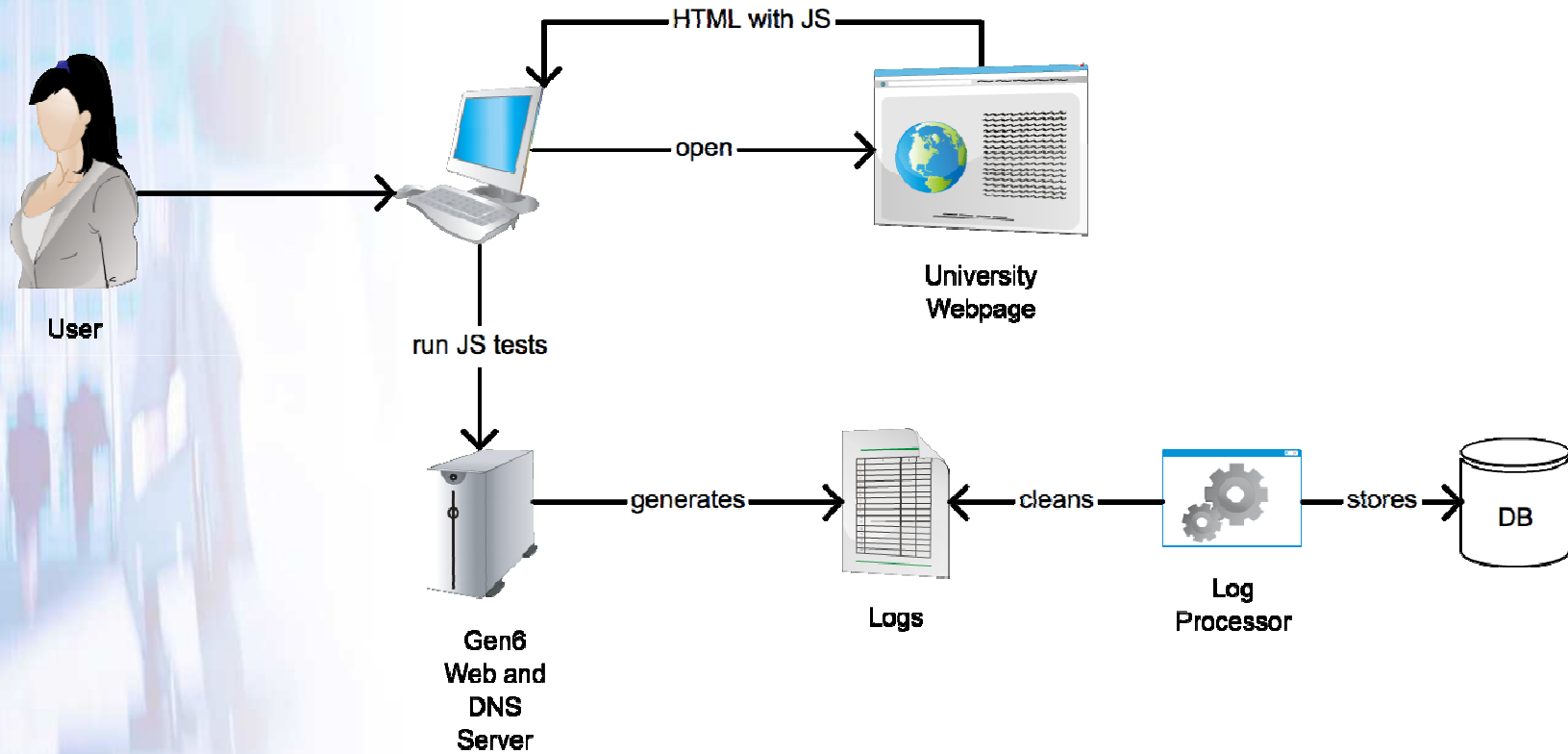


IPv6 probe

- Baseline code
 - JS script used in the scope of the IPv6 Observatory
- Adjustments
 - Include code to check IPv6 support of DNS resolvers
 - Generation of different, random IPv6 hostnames in a specific gen6 test domain in order to enable pairing between users and DNS resolver requests when processing the logs.
 - The random IPv6 host is matched by a wildcard entry on the DNS database.
 - Avoids the caching problem
- Major development effort on the server side software to process log data
 - Development from scratch for the academic monitoring activity



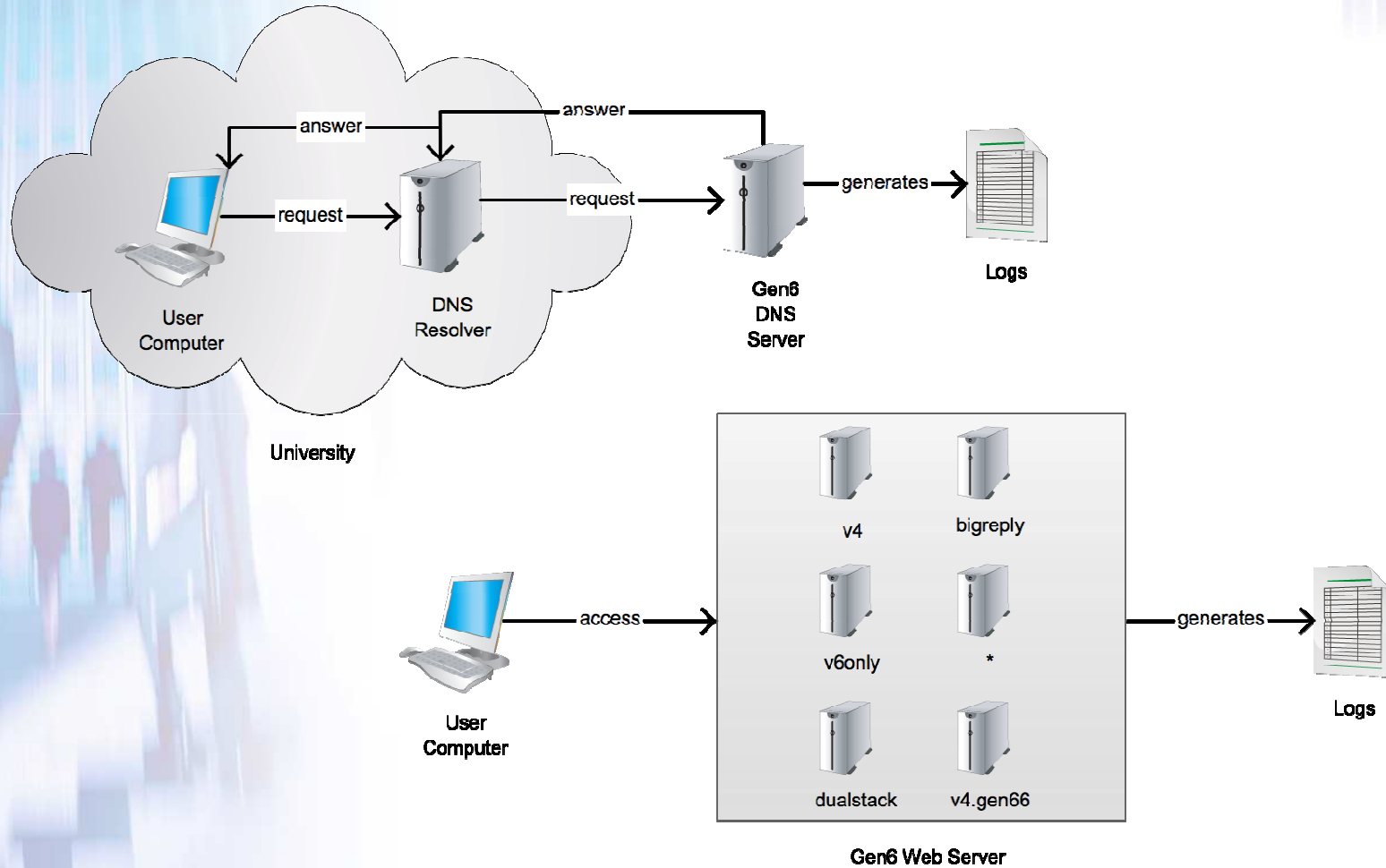
Architectural model



Gen6 academic probe model



Tests overview





Challenges

- Identify IPv4 and IPv6 blocks owned by a university
- Determine from RIPE databases if the user is inside a university network
 - Unstructured ownership data does not help
 - Unidentified IP blocks
 - One university, different names (faculties, merge, splits...)
- Bridge IPv4 and IPv6 blocks
 - Often difficult to assess given different text descriptions
- Reach the maximum number of university users
 - Install gen6 probes on academic portals and public sites with a high number of academic accesses



Results

- Collected raw data is processed daily and the statistics updated
- Monitoring results available on line at <https://gen6.tecnico.ulisboa.pt>
- Published data
 - Estimated IPv6 adoption rate in 177 European Universities included in the top 400 of the Times Higher Education Ranking
 - Detailed data available for each University



Academic monitoring website

Overview page

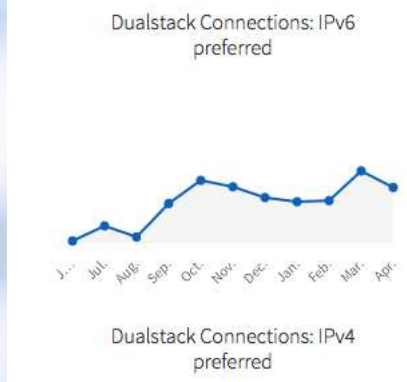
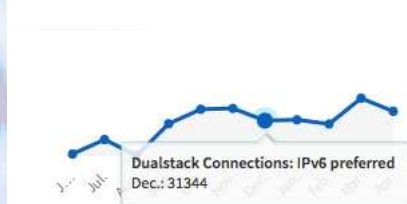
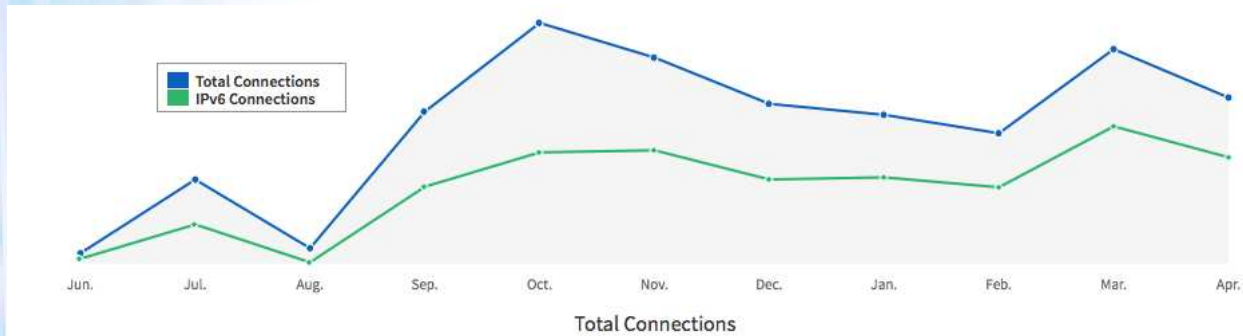
Search Show Rows: 20

University	Ranking	IPv6	IPv6 Adoption
University of Oxford	3		
Swiss Federal Institute of Technology Zürich	13	✓	14%
University College London (UCL)	22	✓	1%
Ludwig Maximilian University of Munich	29	✓	33%
École Polytechnique Fédérale de Lausanne	34		
University of Edinburgh	36		
University of Manchester	52		
KU Leuven	55	✓	17%
École Polytechnique	61		
Leiden University	64		
Heidelberg University	70	✓	1%
Delft University of Technology	71	✓	4%

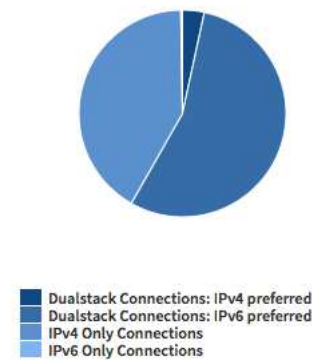


Academic monitoring website

Detail by University



Accumulated IPv4/IPv6 connections distribution





Preliminary results

- Preliminary monitoring results are still limited in statistical significance, due to few sensors deployed
 - More probe installation sites required
 - Participate!
- Current results provide:
 - A first estimate of IPv6 deployment in Academic institutions across Europe
 - Main trends concerning IPv6 penetration in Academia



Preliminary results

Top 15 monitored universities

University	European rank	World rank	Estimated adoption rate	#hits	IPv6 support		
					WWW	DNS	Mail
University of Oxford	1	3	0.0%	310	--	Partial	--
Swiss Federal Institute of Technology Zürich	4	13	14.5%	76	IPv6	IPv6	--
University College London (UCL)	5	22	0.5%	394	--	Partial	--
Ludwig Maximilian University of Munich	6	29	33.3%	297	IPv6	Partial	IPv6
École Polytechnique Fédérale de Lausanne	7	34	0.1%	715	IPv6	IPv6	IPv6
University of Edinburgh	9	36	0.0%	67	--	--	--
University of Manchester	12	52	0.0%	438	--	Partial	--
KU Leuven	13	55	17.1%	525	IPv6	IPv6	--
École Polytechnique	14	61	0.0%	99	--	Partial	--
Leiden University	16	64	0.0%	50	--	Partial	IPv6
Heidelberg University	18	70	1.4%	146	--	Partial	--
Delft University of Technology	19	71	4.0%	749	IPv6	Partial	Partial
Erasmus University Rotterdam	20	72	0.0%	19	--	--	--
Wageningen University and Research Center	21	73	0.8%	131	--	--	--
University of Bristol	22	74	9.1%	11	--	Partial	IPv6



Preliminary conclusions

- Results still limited in statistical significance
- Several top ranked Universities miss IPv6 support
- While no deterministic relation exists, adoption rates is usually higher in Universities where IPv6 is supported in central services (web/DNS/Mail)
- High variability between institutions



Preliminary conclusions (2)

- IPv6 only connections are residual
 - Detected cases result possibly from transient situations where IPv4 tests fail.
- About 5.8% of dualstack connections are IPv4 preferred
 - Higher rate than expected
 - Possibly due to drivers that switch from IPv6 preferred to IPv4 preferred when an higher IPv6 latency is detected
- Overall estimated adoption rate in European Academia: about ~13%
 - Based on a limited sample of ~18,000 connections
 - Excluding the University of Lisbon



On going improvements

- Intensify probe dissemination and deployment
- Include visual feedback of statistical significance for each University
- Improve log software to reduce the need of manual processing of unstructured RIPE information
- Upgrade and distribute test servers in order to improve scalability



Thank you

Q & A