

What to Do Today if You Want to Deploy IPv6 Tomorrow

Some Observations on IPv6 Planning & Preparation Efforts in Large Organizations

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Who I Am



- Founder and managing director of vendor independent network consulting & security assessment company ERNW.
 - 42 members of staff as of Mar 2015.
 - Mainly serving global enterprise orgs.
- Old-school network guy with some background in large scale operations.
- Involved with IPv6 since 1999 and regularly blogging at www.insinator.net.

Disclaimer



- We don't have any contractual relationship, sales partnership, whatever with \$HOST.
 - We've not even received any swag (like t-shirts or mugs) from them, ever.
- We don't get (or would have expected) money for being here today.
 - It's all about contributing to the greater good of global IPv6 deployment. Seriously.
- For the record: from our side, we've sent over an NDA for today's event.
 - Be relaxed. What happens in \$PLACE stays thr.

Agenda

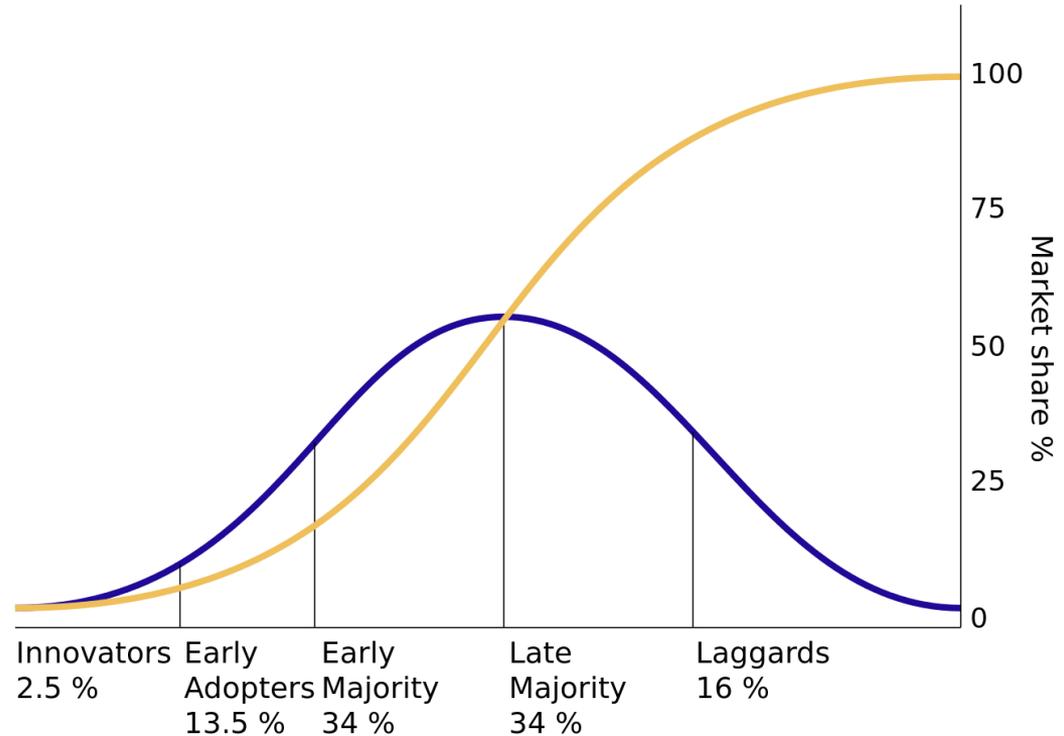
- Where do we stand, and why it's time to act.
- Typical steps of IPv6 planning & preparation efforts, and what to keep in mind/take care of.
- Conclusions



Diffusion of Innovations

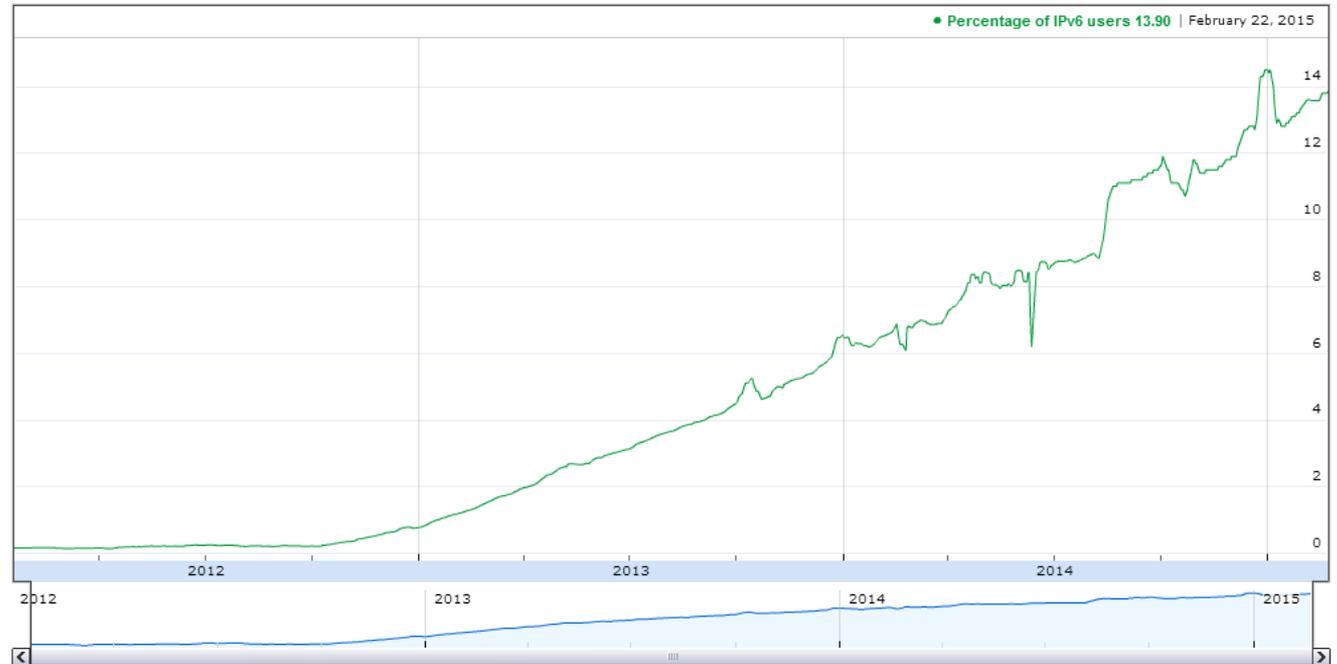
In the following please keep that 16% point in mind.

http://en.wikipedia.org/wiki/Diffusion_of_innovations



Current Stats (I)

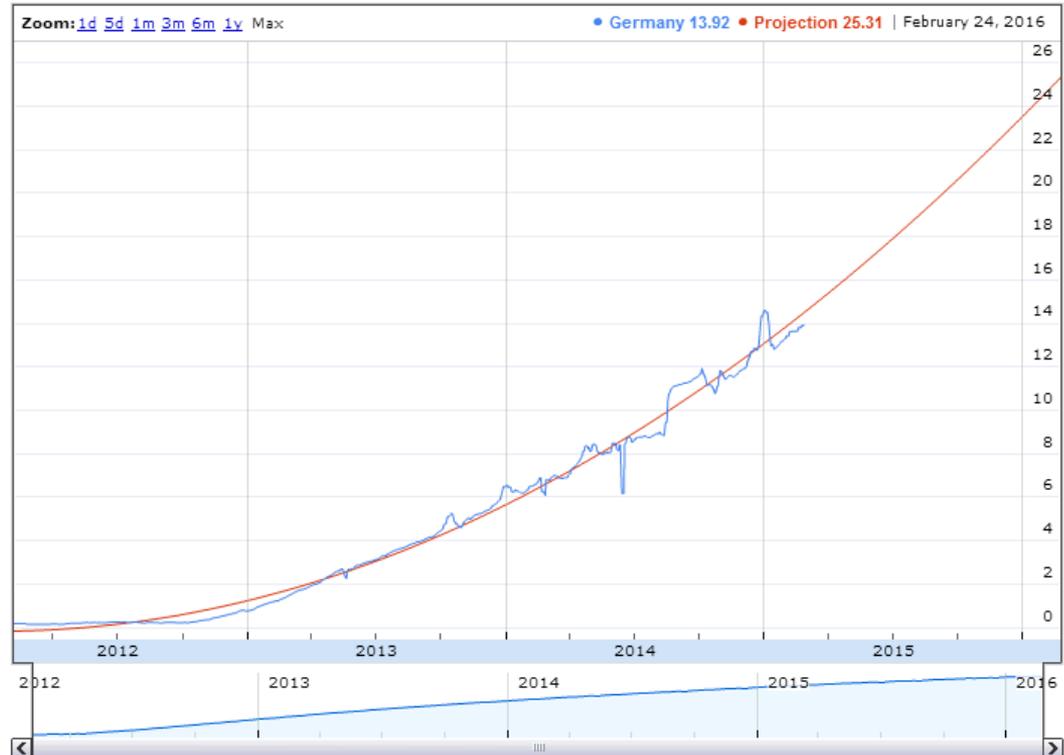
DE



<http://6lab.cisco.com/stats/>

Projection

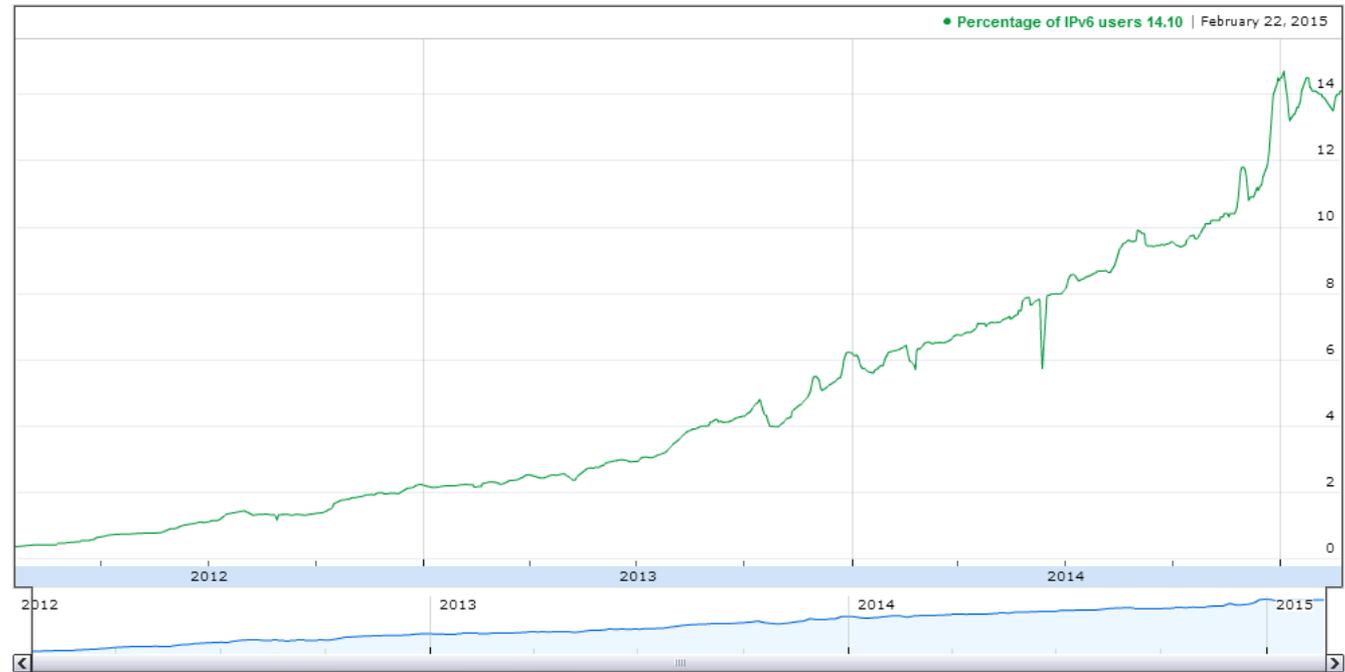
DE



<https://www.vyncke.org/ipv6status/project.php>

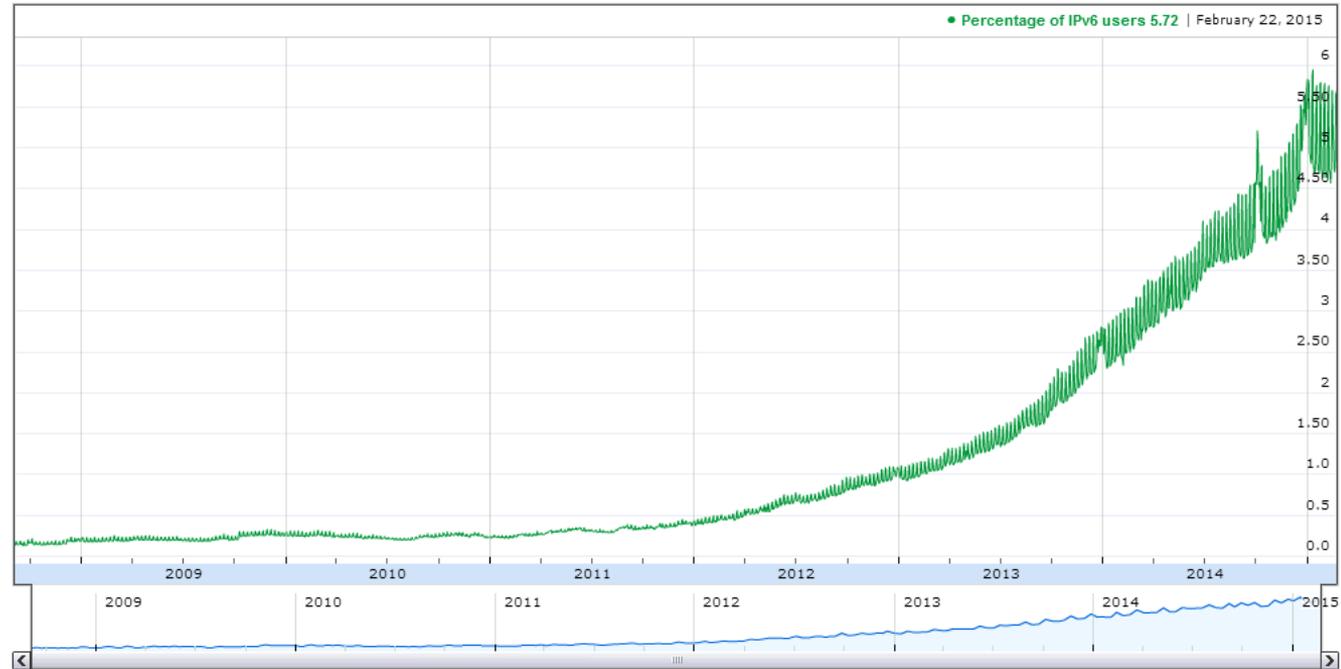
Stats (II)

US



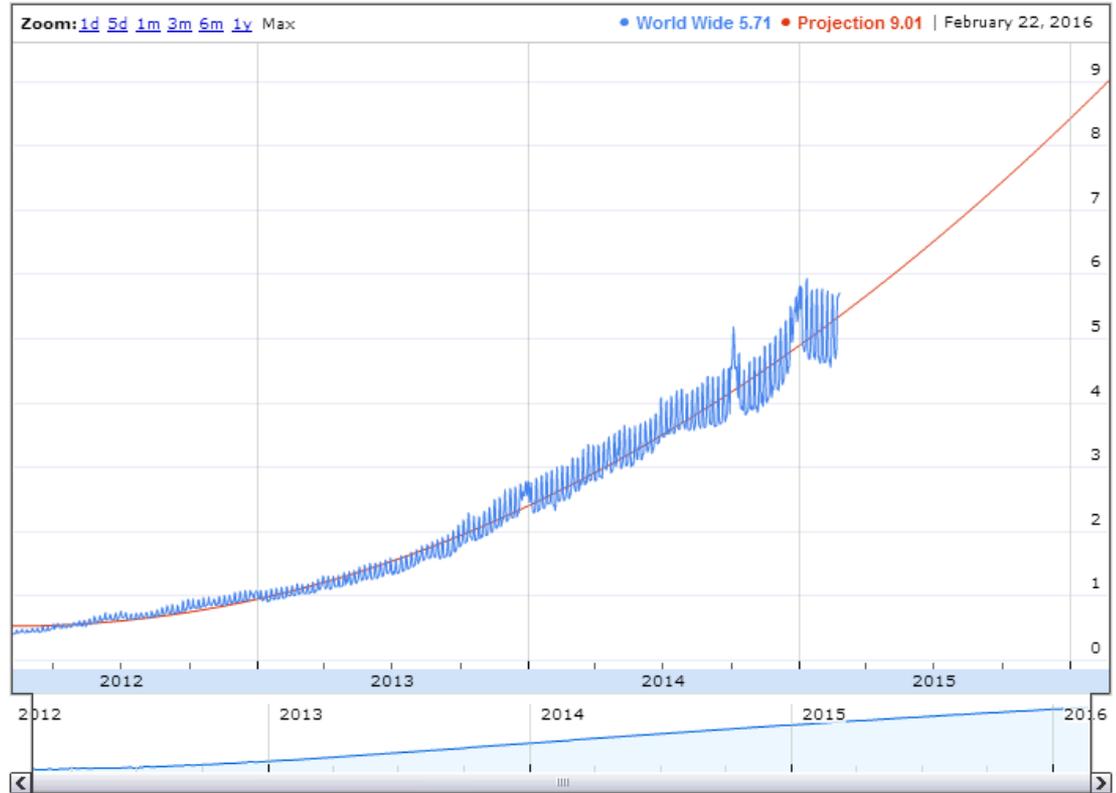
Stats (III)

Global



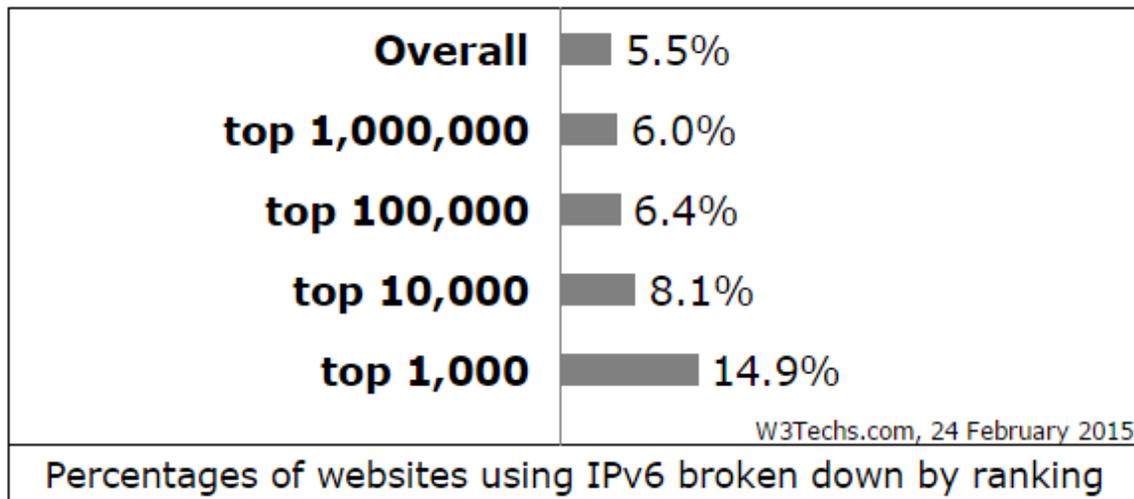
Projection

Global



More Stats

Websites



Even More Stats

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Allocated IPv4 Addresses (Millions)	174.4	168.1	203.9	203.3	189.4	248.8	201.0	114.9	65.1	63.9
Relative Annual Growth	8.0%	7.7%	8.8%	8.0%	6.9%	8.4%	6.3%	3.4%	1.9%	1.8%

Table 1 - IPv4 Allocated addresses by year

RIR \ YEAR	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
APNIC	53.6	51.4	69.6	87.8	86.9	120.2	105.2	1.0	1.3	3.7
RIPE NCC	61.2	55.0	60.7	44.0	43.4	56.0	43.1	40.0	2.0	2.5
ARIN	47.2	46.5	53.0	57.1	41.1	45.2	23.5	45.0	26.5	26.0
LACNIC	10.4	10.7	14.2	12.0	10.5	13.0	24.4	21.0	28.5	19.1
AFRINIC	0.9	2.6	5.5	1.6	5.9	8.5	9.2	7.9	6.8	12.5

Table 2 - IPv4 Allocated addresses (millions) - Distribution by RIR

<http://www.potaroo.net/ispcol/2015-01/addressing2014.html>

It Should Be Clear

- The “marketplace” (IPv4 Internet) where you interact with your customers, suppliers, business partners etc. doesn’t rise any longer.
- Anything that limits (Internet) access and hinders communication might have some impact on, well... growth.



Main Activities We See

Related to IPv6, in our customer space.



- Planning
- Process Integration
- Preparation of Infrastructure

Activities We See

Planning Level



- Road map
- Main strategy elements
- Address plan

Activities We See

Process/Project Integration



- Include IPv6 in vendor/tool selection process
- Include IPv6 in RF(IIP)s & tendering processes
- Align with other projects within \$ORG
 - “Employee of the Future“
 - “Our products as IoT gadgets“ program
 - “Global collaboration will increase our productivity by 50%“ initiative
 - “some_bullshit_buzz_with_cloud“ project

Activities We See

Preparation of infrastructure



- Evaluate carriers' capabilities
- Test lab
- Network devices (inventory, upgrade etc.)
- Monitoring infrastructure
- CMDB
- IPAM

Planning Stuff

Road Map, Sample



Name of Phase	Objectives	Time frame / To be (mainly completed) until	Estimated Operational Effort / OPEX
Internet Edge	Enable IPv6 for Internet services to maintain full availability of \$ORG services.	31.12.2015	Low
Network Infrastructure ("Internet Branch" as of address plan)	Prepare global \$ORG network infrastructure for IPv6, incl. being able to enable IPv6 on customer links & business partner connections.	31.12.2016	Low
Network Infrastructure (all) + Operating Systems	"Be ready" incl. monitoring infrastructure	31.12.2017	Medium
Intranet & Applications	Enable IPv6 throughout the whole \$ORG network and elevate the \$ORG IT landscape to IPv6 to the largest possible extent.	31.12.2018	High
Sunsetting IPv4	Phase out of IPv4 to reduce complexity induced by dual stack mode and to fully leverage IPv6 benefits.	31.12.2020	Medium

Decide Strategy

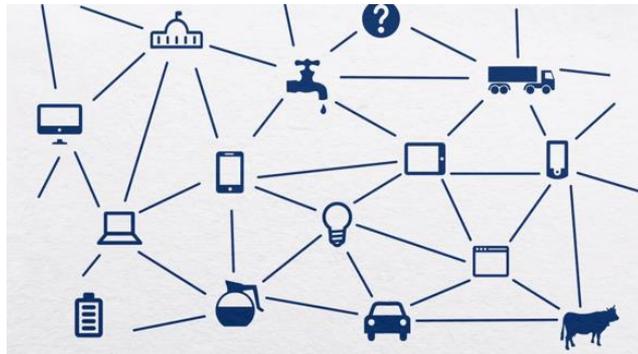
Right or left?

- SLAAC vs. DHCPv6
- /64
- Privacy Extensions
- ULAs
- NAT
- MTU 1280 / PMTUD



Address Planning

Some Notes



- Decide “global allocation strategy” 1st
- Pursue the right objectives
 - And re-fine/discuss plan several times.
- From our perspective, most “publicly available resources” are **not** very helpful for large enterprises
 - We’ve yet to see one that considers multi-site VRFs or regional data centers.

Decide on “Global Allocation Strategy” 1st



- Most organizations we know have become (or been before) LIR @RIPE.
- This makes sense and can be done with manageable effort.
- But...

Global Allocation Strategy (II)

... this brings up additional questions:



- “What can we reasonably expect on the Internet routing level when it comes to using this address space for subsidiaries/parts of our network outside of Europe and potentially announcing prefixes from local break-outs or regional hubs?”
- “(When) Does it make sense to apply for an IPv6 address space allocation at/from other Regional Internet Registries (RIRs)? All of them or 'the main ones'?”
- “If we opt for following the path of applying for allocations from several RIRs, what are the specifics/prerequisites/pitfalls of these procedures at the individual RIRs? What about initial/recurring effort & costs?”

Global Allocation Strategy (II)

And the respective answers...



- It depends ;-)
- Seriously,
we don't have a crystal ball.



C'mon, that's not fair

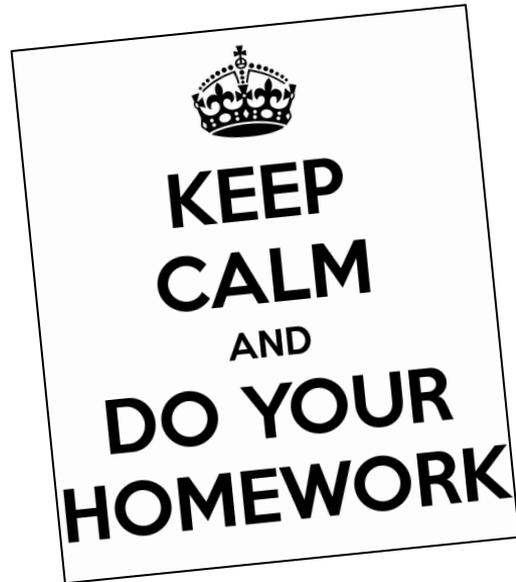
Ok, ok, let's try. Here's the 30-second/
"One sentence per question" answer.



- Out-of-region use is a mess, as of RIR policies/statements. Wrt real-life Internet routing we tend to expect problems though.
 - Don't nail us on this. U know, there's that crystal ball thing...
- Most organizations we know have become member (to apply for an IPv6 allocation) at RIPE, ARIN and APNIC.
 - There's some caveats as for LACNIC and AFRINIC; pls approach me over lunch if interested.
- When applying for membership at RIRs, most issues are "home-made", not on the RIRs' side.
 - See next slides.

Membership at \$RIR

Your home work



- Identify “suitable subsidiary in \$REGION”, incl.
 - Point of contact who has rough understanding why this stuff is happening.
 - Certificate of registration
 - Person with signing authority
 - Be prepared to explain role & function of RIRs (or what IPv6 is) to them.
- Payment!

Payment of RIR Fees

This one deserves a dedicated slide



- There's a one-time fee and there's yearly membership fees.
- The invoice will be issued (but not necessarily sent) to \$ORG_IN_REGION.
 - Evidently so, as they are the members.
- Someone has to pay it (usually within some time frame...)
 - Try to centralize this, with functional mail addresses. Doing so can be very helpful in discussions with \$CEO_OF_REGIONAL_ORG, too.

Payment of RIR Fees

What could possibly go wrong? (I)



- Corporate Purchasing (in Budapest, Manila etc.) will contact you:
 - “We don’t have a quote from \$RIR, so we can’t act on this.”
 - “\$RIR has to undergo vendor screening, sign up in our supplier portal etc.”
 - “What’s that weird IPv6 or RIR stuff anyway?”

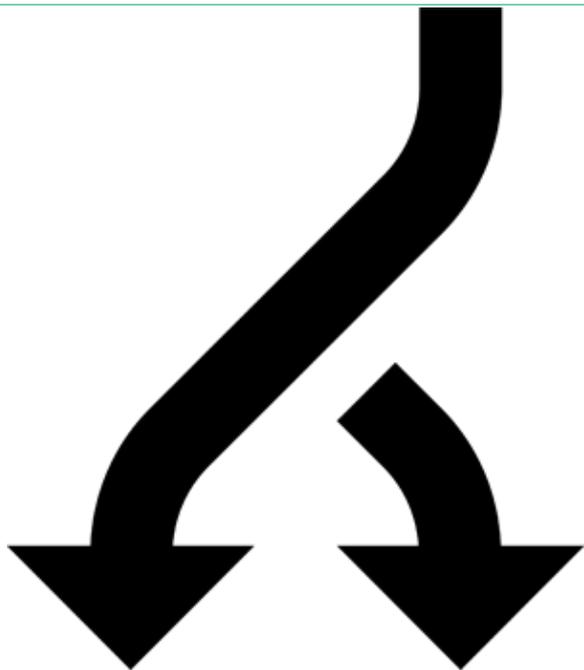
Payment of RIR Fees

What could possibly go wrong? (II)



- If you process payment through some 3rd party (in Budapest, Manila etc.), be prepared to...
 - Provide proof to \$RIR that this payment relates to ~~your application~~ the application of \$ORG_IN_REGION.
 - Keep the regional guys in the (cc:) loop.
- Did I already mention there's a limited time frame within the procedure?
- Just in case you missed that: there's a yearly renewal fee, too ;-)

Main Objectives



- Ability to aggregate
- Persistence
- Significance / Legibility
- Applicability
- Ability to delegate
- Allows for growth

See also:

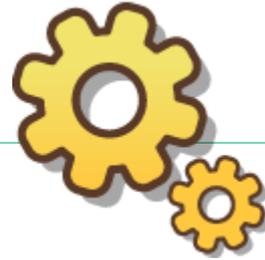
<http://www.insinuator.net/2014/05/ipv6-address-plan-considerations-part-3-the-plan/>

Address Plan

The outcome could look like this

Prefix Length	Category	Max. Entities	Description	Examples	Comments	Sufficient Reserve?
/32		-	Full prefix assigned by RIRs	RIPE, ARIN, APNIC, LACNIC	in case of RIPE use one /32 out of allocated /29	
/40	Large site or data center	256	Data center or large sites spanning multiple VRFs, dedicated infrastructure like "remote access", "extranet", "guest WLAN" etc.	Corp HQ site, Brussels datacenter	/40 prefix might facilitate (global) routing	yes
/48	"Normal" site or VRF within large site	65536 sites or 256 VRFs within large site	sites without VRFs or individual VRFs within large site	\$\$SOME_PLANT1, \$OTHER_PLANT2 etc.		number of sites: yes. VRFs within large site: yes
/56	"system type"	256	clients wired/wireless, peripherals, phones, "Produktionssysteme"		keep it simple. Split in 0-7 for "reachable", 8-F for "internal"	yes
/64	individual VLANs	256 per service group				yes

Process Integration



Include IPv6 in Vendor/Tool Selection

Sample (Part I)



- Do you run IPv6 in your own corporate network? Please provide details.
- When displaying, storing or exporting IP addresses, can your solution correctly handle IPv6 addresses of all types (link-local, ULAs, GUAs)?
- When receiving IP addresses as input or processing them (e.g. in a database), can your solution correctly handle IPv6 addresses of all types (link-local, ULAs, GUAs) and of variable length?
- Does your solution implement RFC 5952 in the sense that input (of IPv6 addresses) can be in any format, but output (e.g. in log files) follows the RFC 5952 recommendation?
- Can your solution handle both A and AAAA records from DNS?
- Does your solution use link-local or GUAs/ULAs for intra-subnet communication? Which is the default and can both types of addresses be configured?

Include IPv6 in Vendor/Tool Selection

Sample (Part II)



- Does your product/offering comply with any of the profiles in the ripe-554 requirements specification? [<http://www.ripe.net/ripe/docs/ripe-554>]
- Do all security-related functions of your solution (e.g. traffic filtering/ACLs, blacklisting, logging) fully support IPv6, with performance being equal to that of IPv4?
- Do all implementations of management interfaces & protocols (SNMP, syslog etc.) used within your solution fully support IPv6?
- Does your solution have a built-in webserver? Can this be configured to listen on an IPv6 address and has it been tested to successfully work in an IPv6-only or dual-stack setting?
- Has your solution been thoroughly tested in an IPv6 only or in a dual-stack setting? Please provide proper test documentation.
- In dual-stack settings which approach (e.g. Happy Eyeballs as of RFC 6555) does your solution follow as for preferring IPv6 over IPv4 or vice versa? Can this be configured/adjusted if needed?

IPv6 in Vendor/Tool Selection Process

The most crucial question is the one about dog food.

- “In case your product supports IPv6, do you have IPv6 enabled in your own corporate network?”

Please provide proper documentation.”



Preparation of Infrastructure



Evaluate Carriers



- As of early 2015 pretty much all major carriers support IPv6 and offer “IPv6 capable” services.
- As so often, the devil is in the details though.
- You **MUST** carefully evaluate those.
 - In this space things going wrong today might cost you dearly later.

Number	Category	Requirement	XY Expectation	Weight	Provider's Answer	Comment
1	General	IPv6 service level agreements (SLAs) meet or exceed existing/IPv4 SLAs.	Yes	Very high	No	
2	General	IPv6 circuit bandwidth, latency, packet loss, and jitter specifications meet or exceed existing/IPv4 specifications/properties.	Yes	Very high	No	
3	QoS	The QoS policies (queuing/discard) applicable to both IPv4 and IPv6 traffic are identical.	Yes	Very high	No	
4	Metrics	IPv6 performance metrics of \$PROVIDER's network will be made available.	Yes	Medium	No	
5	Monitoring	\$PROVIDER hosts and provides access to a "looking glass" IPv6 BGP router and/or similar functionality (e.g. an access-controlled monitoring portal) for troubleshooting purposes.	Yes	High	No	
6	MPLS	Full support of MPLS 6VPE (RFC 4659) throughout \$PROVIDER's MPLS network.	Yes	High	No	
7	Internet Access	\$PROVIDER is willing to accept IPv6 prefix advertisements from XY's RIPE PA space allocation up to /48 _without_ a covering aggregate, provided appropriate route6 objects exist.	Yes	Very high	No	
8	Internet Access	In case answer to previous question is "No", what would be the maximum prefix length that XY can advertise without a covering aggregate?	/48	Very high	No	
9	Internet Access	\$PROVIDER does not impose any restrictions on IPv6 prefixes accepted as long as their length is shorter or equal /48 and appropriate route6 objects have been created (that means: "strict filtering" like described in http://www.space.net/~gert/RIPE/ipv6-filters.html will <i>not</i> be applied to XY's IPv6 prefixes).	TRUE	Very high	No	
10	Internet Access	XY's IPv6 own address space can be used in the transit network between \$PROVIDER's and XY's BGP router(s)?	Yes	Medium	No	
11	MTU	What is the maximum MTU of IPv6 packets that can be transported without fragmentation through \$PROVIDER's network? Different for MPLS network?	Pls specify	Very high	No	
12	MTU	All network devices/hosts under \$PROVIDER's control originate ICMPv6 PTB messages when needed.	Yes	Very high	No	
13	MTU	All network devices under \$PROVIDER's control pass any ICMPv6 PTB messages in transit which are originated from other devices/hosts.	Yes!	Very high	No	

Evaluate Carriers

Sample

Test Lab

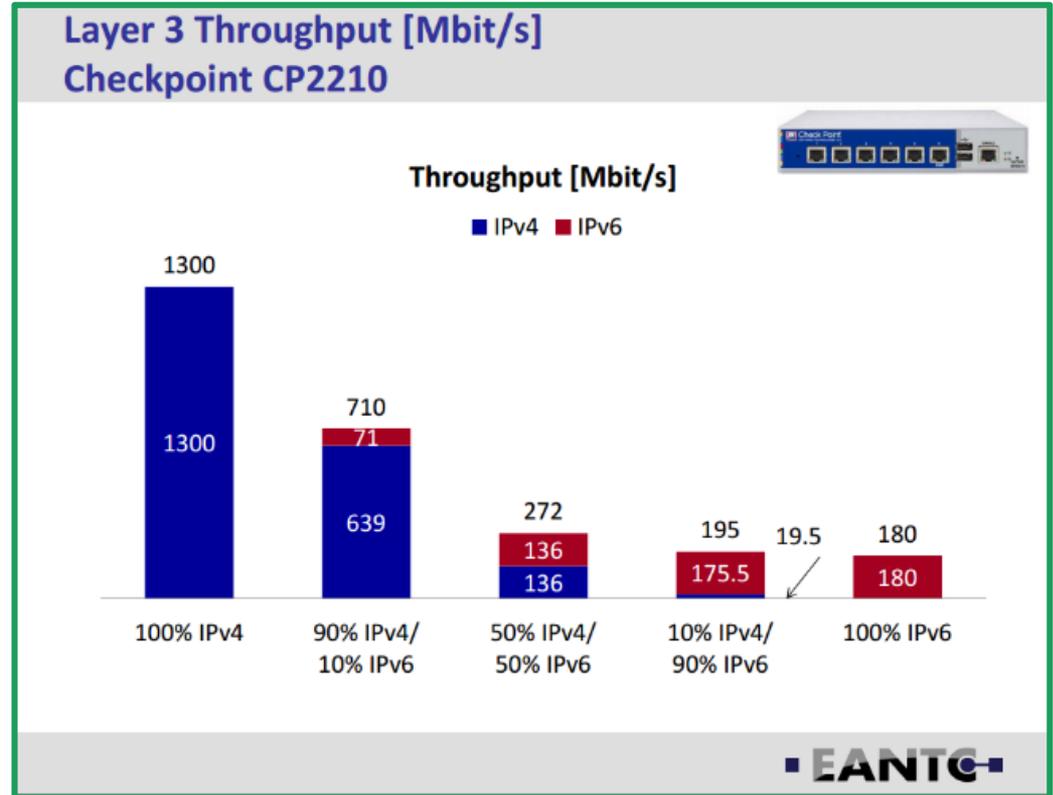


- Activities might include:
 - Announce /48 out of your allocated space and monitor global routing/availability.
 - Perform out-of-region announcement of /32 from your RIPE PA allocation outside Europe.
 - Performance testing, namely of security devices...
- It's usually helpful to have some budget for this.

IPv6 Performance Testing

Sample from a publicly available report

Source: <https://a13725d0-a-62cb3a1a-s-sites.googlegroups.com/site/ipv6hackers/meetings/ipv6-hackers-1/zack-ipv6hackers1-firewall-security-assessment-and-benchmarking.pdf>



Monitoring Infrastructure

Some things to keep in mind here, from a customer doc



- The ability to use IPv6 as “transport” (layer/protocol) in the course of requesting information (for example via SNMP).
- Gathering of IP-related values (e.g. “number of packets”) separately for IPv4 and IPv6.
- Support of IPv6-specific parameters (“Number of Router Advertisements received”).
- In case SNMP is used either so-called protocol-version independent (PVI) MIBs/“unified MIBs” or IPv6-specific MIBs must be present on the respective components.

CMDB



- You have a fully functional, up-to-date CMDB in your organization, right? Right?
 - “Which of those (many) do you mean“?
- If so, that would be a good place to store “IPv6 capability information“.
 - From our perspective collecting this information doesn't work well in many organizations anyway. Once you have it, it might already be outdated.

“IPv6 Capabilities”

Sample



- System is *IPv6 ready*, which means IPv6 can be enabled at need.
 - In case this requires additional licenses or extra memory this must be annotated accordingly, same for potentially needed major system modifications (like re-compiling the kernel on Linux/Unix systems etc.).
- System is *IPv6 enabled*, which means IPv6 is enabled in a dual stack setting.
- System is *IPv6 only*.
- System is (capability-wise) *IPv4 only*.

CMDB

From an RfI



- The offering has to fully support IPv6 on its external data import/export interfaces. This includes:
 - the capacity to establish connections in a dual-stack or IPv6-only network.
 - the capacity to handle IP-related parameters in an IPv6-compatible way (128bit fields for the IP address, address can be of differing format/length etc.).
 - the ability to adjust data import to IPv6 specifics (e.g. determining which address to import in case an external agent has collected several addresses from an individual system).

CMDB

Some (more) things to keep in mind



- At which abstraction layer (in data model) to include “IPv6 capability information”
 - “Service”, “System”, “Software” etc.
 - Respective responsible party might not know IPv6 specifics (or IPv6 at all)...
- How to enter/maintain IPv6 related information, in particular (address) configuration information.
 - This is a process thing. A CMDB is (just) a tool.
 - We think “machine based” (agent or “spider”) pretty much only reasonable way to go.

IPAM



- Here's what I wrote to the IPv6 project lead in a customer environment:
 - "Given the future (3-5 years scale) number of IPv6 enabled devices within the global \$CORP network and the fact that most of them will have multiple addresses incl. dynamically generated ones, we strongly recommend to have a suitable IPAM solution in place from the early stages of a deployment effort. Please make sure that appropriate roles & responsibilities are in place also."

IPAM

No talk at \$SOME_BUSINESS_EVENT
without a Gartner quote, right?



Usage of a commercial DDI solution can reduce opex and lead to savings of full-time equivalents (FTEs) in larger organizations, particularly those with 10,000 or more employees.

Gartner Market Guide for DNS, DHCP and IP Address Management

IPAM



- Keep an eye on IPv6 specific capabilities.
- Start early
 - Deployment will take time, especially if you change from another IPAM.

IPAM

IPv6 Specific Capabilities, Sample

types. Sorting all different types of addresses must be also supported. As last mandatory requirement, all addresses must be displayed in RFC 5952 compliant manner. [4]

The following list will give an overview about all mandatory requirements: [5]

- Track all dynamic IPv6 address assignments by polling the neighbor cache from network devices
- Support of SNMPv3
- Display connected switch port including devices' names or CDP type info for all addresses
- Sorting addresses according to their categories
- Full support of RFC 5952

2.2 Recommended Requirements

https://www.ernw.de/download/newsletter/ERNW_Newsletter_46_Evaluation_of_Commercial_IPAM_Solutions_IPv6_Capabilities.pdf

Finally, a Word on Resources

From:

<https://ripe68.ripe.net/presentations/294-cern-ipv6-deployment.pdf>

Approval and resources

IPv6 deployment approved in Q1 2011

Allocated resources:

- Network design/testing/deployment:
1x Network Engineer FTE for 2 years.
- Network database and NMS applications:
2x Software Developers FTE for 2 years

- Name “IPv6 Transition Officer” overseeing project in next three to ten (!) years.
 - Ceterum censeo magistratum rerum rete IPv6 gerendarum ab \$CORP_NAME instituendum esse.
- Dedicated (extra) resources might be needed
 - Your CIO might not like this message.

Conclusions



- Starting soon and sensible planning will help to avoid tangible interruptions of core network services.
- The transition path won't be easy and will require significant resources.
 - Think: changing the wheels of a car while in full motion.
- Enabling IPv6 is the only way to provide a future-proof, resilient network at \$0RG.

Questions & Discussion

→ Thanks for your time!

