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Best Practice Forum
on
Creating an Enabling Environment for IPv6 Adoption

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Summary

Generally speaking, devices connect to the Internet via Internet Protocol addresses (IP addresses). The first pool of IP address numbers was created in the 1970s and contained approximately 4 billion unique numbers. This is the Internet's legacy addressing system - Internet Protocol version 4 (**IPv4**). The growth of the Internet has virtually exhausted the IPv4 address pool.

A new addressing system, Internet Protocol version 6 (**IPv6**), was developed in 1995 to deal with **IPv4 exhaustion.** The IPv6 address pool is *huge* by comparison.

Historically, the adoption rate of IPv6 has been slow-growing, but now things are starting to pick up.

At the same time, there is still a long way to go. Anyone running the old protocol needs to adopt the new one, in order to support the increasing demand on the global network as more people - and more machines, and "things" - come online.

There are different costs of switching from IPv4 to IPv6 - from upgrading networks, to training, planning, and the plain adaptation to change. Technologies - for example "**NAT**" and "**CGN**" - have been developed to extend the life of IPv4. They should be considered only as **temporary solutions**, but are sometimes relied upon to forestall what should be considered as ultimately inevitable for a business, a government, or end users: **IPv6 adoption**.

The Best Practice Forum (BPF) on *Creating an Enabling Environment for IPv6 Adoption* explored, on a global, open, participatory, and multistakeholder basis, different "best practices" that have been used in relation to increasing IPv6 adoption.

IPv6 Task Forces were a key focus during the BPF. Task Forces are organized at **national, regional,** and **global** levels. They are useful meeting places for different stakeholders to meet and collaborate on IPv6 adoption. As such, the IPv6 Task Force is not only a best practice in itself, but a **platform for** the creation of **best practices** as well.

Task Forces can be **organized ad hoc**, by the community, or **supported by government**. They conduct various activities and serve various purposes, from **raising awareness** about IPv6, to **providing advice** on how to deploy it, to developing fully-informed **policy recommendations to government** that should result their country seeing higher IPv6 use. Common **challenges** cited by Task Force leaders include **funding**, **coordination** and **lack of participation by local industry**. Those involved continue to seek ways to alleviate these challenges. Awareness raising should help.

Capacity building on IPv6, both in terms of **technical training** for engineers and operators, and **awareness for non-technical policymakers, law enforcement,** and **business decision-makers**, is fundamental to creating an enabling environment for IPv6 adoption. Many different organisations, for profit and not-for-profit, provide IPv6 training, including "**RIRs**" and "**NRENs.**" Most will find no shortage of **commercial options** to chose from.

Discussion relating to **best practices in the private sector** - for ISPs and content providers in particular - resulted in a set of high-level suggestions. Planning for IPv6 deployment might begin with a **review** of **existing infrastructure** and an assessment of **vendor IPv6 readiness. Employee training** is necessary, certainly in the case of technical employees but, depending on the business, some non-technical personnel as well (e.g. customer service representatives). As for IPv6 deployment, businesses should consider **working from the outside, in**; deploying IPv6 via **dual stack technology** for **public-facing services first**, and then migrating to IPv6 on **internal networks**, **second**. To make the transition easier, they should **set internal deadlines** and **engage with customers**, keeping them notified, if not engaged, during the deployment process. **Anecdotes** from Malaysia and Japan described these in context.

One policy option for encouraging IPv6 adoption suggested was for ISPs to use **cost incentives**, for example raising the price for IPv4, a scarce resource that is becoming costly to maintain, and providing IPv6 to the customer without extra charge. Finally, **collaboration** with others in deploying IPv6, as happened during the 2012 IPv6 World Launch, has shown to be effective.

National Research and Education Networks (**NRENs**) and **universities** conduct valuable research on IPv6. They are important resources for information and knowledge on the subject. NRENs are often ISPs themselves and provide IPv6 services. They also **participate at the IETF** and work to **develop RFCs**. Universities can help promote IPv6 by **supporting student research projects.**

Governments are in a powerful position to create an enabling environment for IPv6 adoption. They can lead by example by **requiring the public administration to adopt IPv6**. They can require IPv6 in Information and Communications Technology (ICT) **procurement policies** which, in turn, obligates businesses tendering for government contracts to provide IPv6-capable products and services. The development of **IPv6 Profiles** (Germany) can assist public administration in its own procurement processes and evaluation of tenders, and **requiring vendors to themselves use IPv6** (United States) results in businesses needing to be able to "walk the walk" - not only providing IPv6 services to their clients but running IPv6 themselves.

Submissions to the BPF on national deployment strategies feature different approaches, from working with the private sector on **pilot projects** that showcase best practices for the benefit of all (Saudi Arabia), to organizing a **national IPv6 launch** with IPv6-ready groups (Finland), to creating a **national IPv6 mandate** across the public and private sectors (India). Governments can help industry by **publishing an IPv6 adoption guide** that tailors relevant information to different stakeholder groups (Singapore). Collaboration with industry through government-supported national **working groups** (Norway), **study groups** (Japan), or **outsourcing experiments** to the private sector (Japan) has yielded successful results.

End users and consumers play a role in IPv6 adoption by **purchasing IPv6-enabled products**, a growing market in light of the Internet of Things. **Voluntarily-adopted** IPv6 **certification standards**, or even new "indicators" showing the customer he or she is using an IPv6 product or service (like the "LTE" indicator in the case of mobile phones) can help raise consumer awareness.

Finally, **IPv6 measurements** are useful, illustrative tools that IPv6 advocates can use when engaging with policymakers. Measurements can also be used, of course, to gauge the effectiveness of a best practice. Measuring IPv6 usage before and after the implementation of a policy can help reveal that policy's impact.

1. Introduction and Background

1.1. About the Best Practice Forum on *Creating an Enabling Environment for IPv6 Adoption*

The Internet Governance Forum (IGF) at the United Nations is an open, global forum where different participants from various stakeholder groups – governments, the technical community, civil society, academia, and the private sector – discuss, on equal footing, Internet Governance and policy issues.

The purpose of the Best Practice Forums (BPFs) at the IGF is to collect, discuss and share Internet Governance and policy "best practices" applied around the world, thereby helping us to learn from each other by sharing our successful, as well as our not-so-successful, approaches to policy issues.

The 2015 BPFs focused on six different Internet Governance topics: 1) regulating spam; 2) establishing and supporting Computer Security Incident Response Teams (CSIRTs); 3) establishing and supporting Internet Exchange Points (IXPs); 4) developing meaningful multistakeholder participation mechanisms; 5) countering the online abuse of women; and 6) creating an environment that encourages the widespread adoption of Internet Protocol version 6 (IPv6) by those who are currently using Internet Protocol version 4 (IPv4). This last topic, which is the focus of this document, is relevant for wired and mobile access Internet Service Providers (ISPs), content providers, CDN operators, web hosting providers, residential gateway makers, VPN service providers, and corporate Information Technology (IT) networks, for example, whether operating in the private sector or public administration.[1]

We hope this document will help people and organisations in their various efforts relating to IPv6 adoption.

1.1.1. What we mean by "practices"

By "practices," we mean the actions that different people and organizations take to create an enabling environment for IPv6 adoption in their locality, region, industry, or network. Practices can come in the form of case studies, examples, or anecdotes supported by evidence, and they describe the activities, policies, or other measures taken by stakeholders to encourage IPv6 adoption.

1.1.2. Methodology

Participation in the BPF on *Creating an Enabling Environment for IPv6 Adoption* (BPF on IPv6 Adoption) was open to all.[2] This **outcome document** (document) is the result of the BPF. Its contents are based upon best practice examples collected by means of a public survey, which launched in mid-July 2015 and closed the following November.[3] The document was developed based upon discussion that unfolded on an open mailing list, over several calls, and during a face-to-face session at the IGF2015. This document incorporates volunteered comments made on previous drafts, which were submitted via the IGF's online review platform. Organisers also collected content and expert insight through e-mail correspondence.

1.1.3. Contributors

This document is the result of a combined effort involving many people. But for the volunteerism and expertise of a handful of core contributors it would not exist. In lieu of adding

[1] Contribution on IGF review platform, Ross Chandler.
[2] The BPF mailing list was open to all who wish to participate. The list archives are publicly available here: http://mail.intgovforum.org/mailman/listinfo/bp_ipv6_intgovforum.org.
[3] The compilation of survey submissions is available in the Appendices Section at the end of this document.

citations to every contribution from the individuals below, we wish to thank and acknowledge them as a group:

Alejandro Acosta, Olivier Crepin-Leblond, Glenn Deen, Miwa Fujii, Aaron Hughes, Marco Hogewoning, Hascall "Chip" Sharp, Sander Steffann, Nathalie Trenaman and *Paul Wilson.*

We wish to thank all survey respondents and other contributors for their time and thought. Your submissions are referenced within the text.[4]

The BPF on *Creating an Enabling Environment for IPv6 Adoption* was coordinated by IGF Multistakeholder Advisory Group (MAG) members *Izumi Okutani* and *Susan Chalmers*, and supported by the work of *Wim Degezelle*, Consultant to the IGF Secretariat. With thanks to Michael Oghia for assistance in reviewing the text.

1.2. About IPv6 adoption

This section provides a brief introduction to the issue of IPv6 adoption, beginning with a description of what IP addresses are, explaining how the old IP addressing system (IPv4) is running out of numbers, how the new addressing system (IPv6) solves for this problem, and how the two systems relate to each other. The section concludes by introducing the organisations that manage the allocation of IP addresses around the world.

1.2.1. Internet Protocol addresses

Devices connect to the Internet through Internet Protocol addresses (IP addresses). An IP address is a unique numerical address (e.g., 69.65.11.25) used to identify devices on the Internet.[5] Currently, almost all devices use the Internet Protocol version 4 (IPv4) address system to connect to the Internet. IPv4 was developed in the mid-1970s. The IPv4 address system has approximately 4 billion possible address combinations.[6]

1.2.2. IPv4 exhaustion

Since the 1970s, the Internet has undergone a degree of growth those involved in creating IPv4 could not have foreseen. As the number of online devices continues to grow, the available pool of IPv4 addresses, naturally, shrinks.[7] A recent forecast by Cisco projects that, by 2019, "the number of devices connected to IP networks will be three times as high as the global population."[8] This is almost six times the number of available IPv4 addresses. Simply put, we need more IP addresses to accommodate the growing Internet.

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[4] We have made every effort to accommodate all submissions based upon their relevance to the text. We regret that we could not incorporate all points submitted.

[5] This definition is simplified for the purposes of this paper. As one contributor said: "Technically, an IP address identifies an interface on a device, not the device itself."

[6] As defined by the IPv4 address length of 32 binary digits, or bits.

[7] To see statistics on what remains of the IPv4 address pools, see the site of computer scientist Geoff Huston, available at: http://www.potaroo.net/tools/ipv4/.

[8] Cisco Visual Networking Index: Forecast and Methodology, 2014–2019 (May 2015), page 2, available at: http://www.cisco.com/go/vni.

1.2.3. Network Address Translation

Network Address Translation is an umbrella name for a variety of technologies.[9] On the topic of IPv4 exhaustion, here we mention conventional Network Address Translation (NAT), which was developed to save IPv4 address space. This technical function allows multiple devices inside of a network to share one or more exterior "public" IP address(es).[10]

For example, an ISP assigns an IPv4 address to a residential customer and then, via the NAT function, that single IPv4 address is used across a number of different devices - laptops, tablets, lightbulbs, even - in the customer's home. Each of these devices uses an internal, or "private," IP address.

This type of NAT can be thought of as an old-style PABX (Private Automatic Branch Exchange) used in office settings. People can be reached within the office through one public phone number, plus a private extension number. Internal office phones use private numbers. Like a PABX, NAT prevents full connectivity between internal devices and the public Internet.

Carrier Grade NAT (CGN) is a more recent development. CGN allows ISPs and mobile carriers to provide Internet services through an IPv4 address that can be shared not only across a number of different devices in a single network, but also between multiple networks as well.

1.2.4. IPv6 development

IPv4 exhaustion may be a novel issue for the general public, but it has been a concern of the Internet engineering community since the 1990s. By the end of 1995, the community had already specified a new version of the Internet protocol – IPv6. IPv6 specifications were published by the Internet Engineering Task Force (IETF) in a document called Request for Comments 1752 (RFC 1752).

Similar to how we create more phone numbers by adding digits to them, the engineers who developed IPv6 made the addresses longer (128 bits, as opposed to the 32 bits in an IPv4 address).[11] IPv6 theoretically increases the number of unique IP addresses to 2^{128} which means 340,282,366,920,938,463,463,374,607,431,768,211,456 unique combinations.[12] The practical size of the IPv6 address space can be equated roughly to 32 billion times that of the current, IPv4-based Internet.

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[9] The distinctions between NAPT, NAT46, NAT64, NAT464, NAT444, 464XLAT, etc., LSN, and CGNAT, are not made in this non-technical paper.

[10] Note that there are public IP addresses and private IP addresses. "A public IP address is an IP address that can be accessed over the Internet. Like a postal address used to deliver mail to your home, a public IP address is the globally unique IP address assigned to a computing device. Your public IP address can be found at http://whatismyipaddress.com. Private IP addresses, on the other hand, are assigned to computers within a private space, without letting them directly connect to the Internet. See IPlocation.net, available at: https://www.iplocation.net/public-vs-private-ip-address.

[11] An IPv6 address is represented by 8 groups of hexadecimal values, separated by colons (:). The IPv6 address size is 128 bits. A bit is a digit in the binary numeral system and the basic unit for storing information. The preferred IPv6 address representation is: xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx where each x is a hexadecimal digit representing 4 bits. "X" ranges from "0-9" or from "a-f."

[12] In real-world terms, for example, the number of IPv6 addresses available amounts to approximately 5×1028 addresses for each person alive today, or 2^{52} addresses for every observable star in the known universe. See: Ivy Wigmore, *IPv6 Addresses: How Many is that in Numbers?* (January 2009), IT Knowledge Exchange, available at: http://itknowledgeexchange.techtarget.com/whatis/ipv6-addresses-how-many-is-that-in-numbers/.

1.2.5. IPv6 and IPv4 compatibility

IPv4 and IPv6 are two different protocols. IPv6 is not backwards compatible with IPv4. Devices that communicate using only IPv6 cannot communicate with devices that communicate using only IPv4. For an IPv4-only endpoint to interwork with an IPv6-only service, and vice-versa, translation between IPv4 and IPv6 is required.

A different type of NAT than mentioned above, called NAT64, is used to translate between IPv4 and IPv6 networks, connecting the two incompatible protocols. This function allows users of IPv6 to connect to services that are still only available via IPv4. While this translation can introduce negative effects to the traceability of overall network performance, and impact Domain Name System (DNS) resolution, as well as DNSSEC, it is widely regarded as an acceptable technology to aid in the deployment of IPv6. Various 4G/LTE mobile access providers have chosen to deploy this technology as part of their IPv6 deployment.[13]

Ultimately, only when all services are able to support IPv6, NAT will no longer needed. One can then begin to switch off IPv4.

1.2.6. IP address management

The Internet Assigned Numbers Authority (IANA), a function housed within the Internet Corporation for Assigned Names and Numbers (ICANN), manages the global pool of IP addresses. IANA allocates blocks IP addresses to the Regional Internet Registries (RIRs). The RIRs then allocate smaller blocks of IP addresses to ISPs and network operators within their regions, and in some cases to Local Internet Registries (LIRs) or National Internet Registries (NIRs)..

There are five RIRs, each of which is responsible for managing IP addresses in their geographic region:

- AFRINIC — African Region
- APNIC — Asia-Pacific Region
- ARIN — Canada, USA, and some Caribbean Islands
- LACNIC — Latin America, including some Caribbean Islands
- RIPE NCC — Europe, the Middle East, and parts of Central Asia

RIRs are not-for-profit organisations which are sustained by the fees that they charge for the registration or transfer of Internet number resources.

The Number Resource Organization (NRO) is the coordinating body for the RIRs.[14]

[13] In later sections of the paper, we explain "dual stack" technology, which essentially means that IPv4 and IPv6 are provided at the same time. Some providers use dual stack, while others use NAT64.
[14] The management of the Internet Numbers Registry system is described in RFC 7020, available at: https://tools.ietf.org/html/rfc7020.

1.3. Why adopt IPv6?

In this section we explain in greater detail why IPv6 needs to be adopted. Then we discuss "stopgap" measures that were developed in light of IPv4 exhaustion – measures that, while helpful, are ultimately unsustainable. Finally, we outline some of the benefits that different stakeholders stand to gain by adopting IPv6.

The availability of IPv4 addresses is now extremely limited, and the demand for IP addresses will only increase as time goes on, as the Internet expands, as more devices are connected, and as more people come online.

The availability of IPv6 addresses is, with proper management, effectively limitless.

The Internet's sustainable growth depends on IPv6 adoption; the booming mobile market and the Internet of Things (IoT), especially, will require much more IP address space than is available with IPv4.

While these circumstances alone should motivate businesses, governments, and all others invested in the Internet to adopt IPv6, the new protocol's adoption rate has been more sluggish than some had hoped. Today, the global uptake of IPv6 compared to IPv4 is still relatively low.[15]

1.3.1. IPv4 is running out

The availability of IPv4 addresses is now severely limited. As at June 2015, all RIRs, except for AFRINIC, had essentially run out of IPv4 addresses. Some RIRs developed policies to allocate limited quantities of IPv4 addresses to new network operators, but the demand for IP addresses will eventually exhaust this remaining supply.

1.3.2. "Stopgap" measures are not solutions

The BPF discussed two "stopgap" measures that developed in response to the impending exhaustion of IPv4. First, a new "market," where IPv4 addresses are bought and sold in private transactions. Second, techniques like NAT, which allow multiple devices to share a single IP address to connect to the Internet - a temporary solution that comes with drawbacks.

1.3.2.1. The "aftermarket" for IPv4 addresses

IP addresses are allocated to RIRs in the first instance from IANA. RIRs then allocate them to ISPs and other organisations. Most RIRs have run out of IPv4, so, in lieu of taking the steps to adopt IPv6, some networks that find themselves in need of more IP addresses have been turning to an "aftermarket" for IPv4.

These "aftermarkets" developed in 2011. IPv4 addresses and address blocks are bought and sold in private transactions between parties, or with the help of so-called "IPv4 address brokers." These sales are private. Prices vary and are not always made public, but some sources mention

[15] One contributor noted that, despite the fact that more than one-half of the end-user equipment on the Internet is capable of supporting IPv6, less than 10% of this equipment connects to the Internet via IPv6.

prices of 9 USD – 10 USD per address.[16] One commentator has elaborated on the (indirect) effects of this aftermarket, warning that the "current unstructured nature of the secondary market risks hiding the true cost of such secondary market transactions".[17]

Large amounts of money are being paid to acquire IPv4 addresses. For example, Microsoft paid Nortel 7.5 million USD for IPv4 addresses in 2011.[18] Government departments are buying and selling IPv4 addresses as well.[19]

Initially, these deals happened outside of the RIR system. RIRs responded by developing policies in that guide such transfers.[20] For organizations under contract with an RIR for its IP address space, "aftermarket" IPv4 transfers are managed via the RIR policy. Most transfers of IPv4 addresses are free from incident, but there have been cases of routing misbehavior and hijacks.[21] Sometimes, IPv4 address transfers can complicate geolocation services.[22]

One contributor said that the IPv4 market is currently growing, but that some expect a downturn in transfers to begin by 2016 – speculating that its "overall viability will begin to degrade within a relatively short time frame."[23]

1.3.2.2. The downsides of NAT and CGN

NAT and CGN increase network complexity. They can also increase latency on the network.[24] Their use raises operational support costs, introduces complications for law enforcement (for example in tracking IP addresses), and requires additional computing and memory resources.[25] While such particular disadvantages are localized to NAT users, the aggregate cost of NAT on the Internet is significant.[26] Finally, the widespread use of NAT can harm Internet openness by limiting future innovations that depend on being able to see how machines in a network connect at the IP level.[27]

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[16] See: Doug Madory for Dyn Research, *IPv4 Address Market Takes Off* (April 2015), available at: http://research.dyn.com/2015/04/ipv4-address-market-takes-off/.
[17] See: Dr. Ajay Kumar, *Understanding the IPv4 Secondary Market*, available at: http://blog.apnic.net/2015/11/27/6765/
[18] See: Julie Bort for Network World, *Microsoft pays Nortel $7.5 million for IPv4 addresses* (March 2011), available at: http://www.networkworld.com/article/2228854/microsoft-subnet/microsoft-pays-nortel--7-5-million-for-ipv4-addresses.html.
[19] See: Mark Ward for BBC News, *UK sells off unused net addresses* (May 2015), available at: http://www.bbc.com/news/technology-32826353.
[20] Each RIR has published its policy on address allocation and transfer. See, for example, RIPE NCC's policy, available at https://www.ripe.net/publications/docs/ripe-606. For a bird's eye view of RIR transfer policies in all regions, see the NRO's summary page, available at: https://www.nro.net/rir-comparative-policy-overview/rir-comparative-policy-overview-2015-03#1-3-2.
[21] See n 15, above.
[22] For more information on the geolocation problems associated with non, inter-RIR transfers, see: https://en.wikipedia.org/wiki/Geolocation_software; CAIDA *Internet Protocol Address Geolocation Biography*, available at: http://www.caida.org/projects/cybersecurity/geolocation/bib/.
[23] See: v4 Escrow *v4 Escrow's prediction comes true* (February 2015), available at: http://v4escrow.net/v4escrows-prediction-comes-true/.
[24] Latency is the time elapsed between the transmission of IP packets from the originator and reception of those IP packets at the receiver.
[25] For an explanation about how conventional NAT can impede the Internet's global integrity and reach, see: Leslie Daigle, *On the Nature of the Internet* (March 2015), Global Commission on Internet Governance (GCIG) Paper Series, Paper No. 7, available at: https://www.cigionline.org/publications/nature-of-internet.
[26] Contribution, Paul Wilson, APNIC, Australia.
[27] List, Marco Hogewoning, RIPE NCC, the Netherlands.

NAT and CGN are not solutions for IPv4 exhaustion.[28]

Having considered some costs of avoiding IPv6 adoption, we now turn to the benefits of deploying the new standard.

1.3.3. The benefits to IPv6 adoption (per stakeholder)

Until recently, there has been little immediate benefit in deploying IPv6 and, in competitive terms, no "early adopter" advantage. This contributed to the slow deployment of IPv6, prior to around 2012.

However, now, more Internet users are connecting via IPv6. As at the date of writing, Google measurements, for example, indicate that nearly 25% of end users in the United States now use IPv6. More content is being made available over IPv6. Nearly 8% of Google's traffic is delivered via IPv6. The immediate benefits to deploying the new protocol are gaining visibility, which should help drive the rate of IPv6 adoption.

1.3.3.1. For content providers and publishers

As a content provider, it is entirely possible to host and deliver all content over IPv6.[29] When content is made available via IPv6, IPv6-using end users will immediately start to receive their content via the new protocol, in preference to IPv4. In many cases, performance will be improved for them; traffic will not be flowing through NAT or CGN devices, but directly to their device. In one example, Facebook measured a direct performance benefit to IPv6-enabled mobile handsets. "Users' News Feeds load[ed] 20 to 40 percent faster."[30]

1.3.3.2. For network operators

By providing end users with IPv6 services, they can, in turn, access content available over IPv6. This will remove the traffic load on CGN infrastructure and bypass NAT functions in customer NAS (Network Access Server) devices.

1.3.3.3. For end users

Provided their ISP offers IPv6 services, users with IPv6-enabled devices can access content from IPv6-ready content providers, with improved performance. IPv4 connectivity may still be required by some software and services. In this case, an end user's ISP will continue to provide IPv4 services, which will be used automatically by a connected device as needed.

1.3.3.4. For mobile carriers and their customers

Today, almost every mobile device is connected to the Internet via a private IPv4 address, meaning that it relies on CGN technologies within the mobile operator network. If a mobile

[28] A traditional NAT between the customer's network and the service provider puts all devices on the customer's network behind one public IP address. CGN adds another NAT within the service provider's network, and assigns private IPv4 addresses to the different customers within the network rather than public and globally unique IPv4 addresses.
[29] Content providers can also reach users of the legacy protocol using NAT technologies. See: T. Anderson and Redpill Linpro, *SIIT-DC: Stateless IP/Internet Control Message Protocol (ICMP) Translation for IPv6 Data Centre Environments* (April 2015), IETF, available at: https://tools.ietf.org/html/draft-anderson-v6ops-siit-dc-01.
[30] Dan York for the Internet Society's (ISOC) Deploy360 Blog, *Facebook News Feeds Load 20-40% Faster Over IPv6* (April 2015), available at: http://www.internetsociety.org/deploy360/blog/2015/04/facebook-news-feeds-load-20-40-faster-over-ipv6/.

connection is shared (whether from a smartphone, tablet, or a dedicated mobile hub), then this introduces a second layer of NAT, which adds to the complexity of the connection.

However, the most recent mobile phones and devices use operating systems that fully support IPv6. "Some of the big mobile operators now provide IPv6-only service, which by means of "translation [technologies]", allow full functionality to both IPv4-only, IPv6-only and IPv4/IPv6 applications."[31]

1.4. Hurdles to IPv6 adoption

Hurdles to IPv6 adoption should be taken into consideration when developing IPv6-related policies, or planning to deploy IPv6. Below are examples of hurdles provided during the BPF.

1.4.1. Managing network configuration

Supporting IPv6 in the network can increase the complexity of troubleshooting and maintenance processes. Existing devices, servers, and software that are IPv4-based need to be upgraded or replaced to be IPv6-compliant. While this can be done in stages, and often at little cost (due to increasing IPv6 availability in normal upgrade cycles), planning is required, particularly as most networks need to keep operating while undergoing upgrades.[32]

1.4.2. Wholesalers providing IPv4-only bitstream services to retailers

In some cases, depending on the market, an access wholesaler might have the exclusive right to activate a fiber optic network for the purpose of providing bitstream access. In the event that the bitstream access provided only supports IPv4-based services, it is impossible for the retailer (the ISP the end customer has chosen) to provide IPv6. Even if a retailer is able to support IPv6, the wholesale provider might effectively block that ISP's IPv6 deployment by only offering them a product that supports IPv4.[33]

At the same time, if the customer's Customer Premises Equipment (CPE) is capable of "tunneling," it would be possible to offer the customer an IPv6 service via a tunneling technique, over the IPv4 bitstream service. The increase in complexity, however, could make the service offering not financially feasible.[34]

1.4.3. Hardware and software support

Development of IPv6 in equipment incurs a cost on a vendor. In general, a vendor has many competing claims on its resources, in addition to IPv6 support. To justify prioritizing IPv6 support over other features requires a business case (e.g., customer demand) that shows an acceptable return on investment in an acceptable timeframe. Lack of perceived demand and

[31] Contribution on IGF review platform, Jordi Palet.
[32] For one description of the costs involved in transitioning to dual stack, see: Lee Howard, Time Warner Cable, *The Cost of IPv4-IPv6 Transition* (April 2013) (PowerPoint), available at: http://www.rmv6tf.org/wp-content/uploads/2013/04/1-The-Cost-of-IPv4-IPv6-Transition.pdf.
[33] Swedish ISP Bahnhof, for example, is having issues deploying IPv6 to a customer in Sundbyberg, Sweden, as discussed by the Swedish competition authorities, available at: http://www.konkurrensverket.se/beslut/15-0220.pdf (in Swedish).
[34] Contributions on IGF review platform, Chip Sharp and Jordi Palet.

return on investment are a hurdle for vendors to prioritize IPv6 development. As a result, number of business-level vendors continue to treat IPv6 as a "feature request" in lieu of a baseline.

To assist vendors, customers should make their IPv6 requirements as specific as possible for the given use case.[35]

1.4.4. Slow adoption by content and application providers

Websites and applications may require updating in order to support IPv6. Older sites may also have hard-coded assumptions about IP addresses and, thus, will not work with IPv6. "Removing these assumptions and preventing any new systems from making the same mistake is a key best practice."[36] Similarly, CDN and webhosting providers have a valuable role to play by enabling IPv6 by default in the services they provide.

It took some time before operating systems and software were made to be IPv6 compatible, but such support now exists. Now, IPv6 oftentimes cannot be disabled on these platforms. Apple, for example, now requires all iOS 9 applications sold via the App Store to support IPv6."[37]

1.4.5. Training people

Engineering, operations, and customer support staff will need to be trained on IPv6. On a global scale, the required expertise to develop and maintain stable, efficient, and secure IPv6 services and applications is in relatively short supply. The dearth of human resources and capacity with regards to IPv6 is a significant impediment to deployment globally, particularly in developing countries. As one contributor noted, IPv6 training is:[38]

> *A key area if the rate of IPv6 deployment is to be accelerated. Not only is the training of engineers important but the training of awareness of upcoming engineers is important.*

Capacity building efforts are discussed in further detail in Section 3.

Creating an environment that encourages coordination between different actors in the Internet value chain is the key to supporting the adoption of IPv6 within the local community. In Section 2, we look at how IPv6 Task Forces encourage such coordination.

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[35] For example, "Support DHCPv6 prefix-delegation request on WAN interface" or "Support IPv4 tethering through 464XLAT clat in mobile device." Contribution to IGF review platform, Ross Chandler.
[36] Contribution on IGF review platform, Ross Chandler.
[37] See: Iljitsch van Beijnum, ArsTechnica, *Apple to iOS devs: IPv6-only cell service is coming soon, get your apps ready* (June 2015), available at: http://arstechnica.com/apple/2015/06/apple-to-ios-devs-ipv6-only-cell-service-is-coming-soon-get-your-apps-ready/; Dan York for ISOC's Deploy360 Blog, Apple Will Require IPv6 Support For All iOS 9 Apps (June 2015), available at: http://www.internetsociety.org/deploy360/blog/2015/06/apple-will-require-ipv6-support-for-all-ios-9-apps/.
[38] Contribution on IGF review platform, Kasek Galgal.

2. IPv6 Task Forces: A platform for best practices

The "IPv6 Task Force" – in and of itself – is best practice for creating an enabling environment for IPv6 adoption. The local Task Force is also normally the best place for different stakeholders to come together to discuss and develop best practices to share with the community

Generally speaking, IPv6 Task Forces work to promote IPv6 deployment in their country or region by raising awareness, providing advice, conducting outreach, and making recommendations to government on national IPv6 policy. Task Forces are usually comprised of people from industry, government, network operator groups (NOGs), national research and education networks (NRENs), universities, and Internet organizations such as the Regional Internet Registries (RIRs) or Internet Society (ISOC) chapters. People participate within Task Forces as volunteers or as part of their employment.

There is no fixed formula for an IPv6 Task Force, but they all have the same goal: to bring people and knowledge resources together in order to advance the support for and adoption of IPv6 in the local or regional ICT sector.

In this section of the document, we take a look at IPv6 Task Forces, their different models, activities, and the common challenges they face.

2.1. Different Task Force models

IPv6 Task Forces come in different shapes and sizes. They vary in terms of geographic scope and organizational type. For the most part, IPv6 Task Forces are multistakeholder in nature, meaning that the membership is composed of different stakeholders, including network operators, academia, government officials, and the private sector, among others.

2.1.1. Geographic scope

Many countries have a **national** IPv6 Task Force and, in the case of some larger countries, **regional** or **state-specific** Task Forces (e.g. the Rocky Mountain or Texas IPv6 Task Forces in the United States).

National IPv6 Task Forces often collaborate on a regional basis. A pioneer effort in this regard was the EU IPv6 Task Force[39], other examples are the Asia Pacific IPv6 Task Force, the LAC IPv6 Task Force in the Latin American and Caribbean region, or the North American IPv6 Task Force. Regional meetings enable participants to exchange information with members of other Task Forces who, while from different countries, may operate in similar cultural, economic, and regulatory environments. Thus, participants are able to identify and solve for common challenges. For instance, network operators who are active in multiple or neighboring countries can discuss how to deploy IPv6 on cross-border network infrastructure.

In addition to the venues and efforts described above, the Luxembourg-based IPv6 Forum, was established in 1999 as an open, global consortium of vendors, industry experts, and network and

[39] See the website of the European Commission's IPv6 Task Force Steering Committee, available at: http://www.ipv6tf-sc.org/html/index.php.

service providers. The IPv6 Forum acts as an umbrella organisation, working with people in different countries to establish local IPv6 task forces. The Swiss IPv6 Council, for example, is a chapter of the IPv6 Forum that "provides a platform to support IPv6 deployment in Switzerland."[40] The certification activities of the IPv6 Forum are discussed in Section 7, below.

Irrespective of geography, there is an overarching type of engagement and collaboration that occurs between individual Task Force members who participate in regional and international meetings, for example, Network Operator Groups (NOGs), RIR community meetings, and the Internet Engineering Task Force. These individuals play important roles in connecting local efforts to global and regional discussions.

Lastly, various industry consortiums have established projects or dedicated time to IPv6 in their normal activities. For example the Industrial Internet Consortium, which is "currently working on IPv6 issues with many hardware manufacturers,"[41] or the Consumer Electronics Association which is doing a key effort in IPv6."[42]

2.1.2. Organisational type

Some IPv6 Task Forces are organized on a formal basis, while others are less formal. In any event, Task Forces are, "by their very nature...volunteer/industry-led, hence not-for-profit. It's already hard enough to put the message out there, it would be pretty hard to make a profit doing it. That said, there are several for-profit courses for IPv6 implementation."[43]

Some Task Forces have been established and continue to be supported by their government, as is the case in **Indonesia,** for example.[44] The **Spanish** IPv6 Task Force, the first national task force established, is also supported by the government.[45] In **the Netherlands**, the Ministry of Economic Affairs established the Dutch Task Force in 2005.[46]

2.1.3. Membership composition and participation

As mentioned above, Task Forces are composed of various stakeholders in the ICT sector, including network operators, government officials, academics, and software and hardware vendors. In some instances, global vendors support the participation of local staff in IPv6 Task Forces, which is useful because this enables more effective communication and collaboration with large vendors that are headquartered overseas.

Task Forces are typically initiated by people who have a technical focus (engineers, operators, developers, and Chief Technology Officers (CTOs)). There is much to be said for broadening this technical group to include participants with roles that are non-technical in nature, for example, the Chief Financial Officer (CFO) of an organization planning to deploy IPv6.

[40] Survey, Silvia Hagen, Swiss IPv6 Council, Switzerland.
[41] Contribution, Olivier Crepin-Leblond, ICANN ALAC, United Kingdom.
[42] Contribution on IGF review platform, Jordi Palet, Consulintel.
[43] Contribution, Olivier Crepin-Leblond, ICANN ALAC, United Kingdom.
[44] Survey, Satriyo Wibowo, ID-IPv6TF, Indonesia.
[45] Contribution on IGF review platform, Jordi Palet, Consulintel. See the website of the Spanish national Task Force here: http://www.es.ipv6tf.org/
[46] Survey, Erik Huizer, SURFnet, The Netherlands.

Broadening the group will also allow task forces to leverage a wider range of skills and networks. As one BPF participant explained:[47]

> *[For most organizations], migrating to IPv6 or enabling "dual stack technology"[48] is going to cost a great deal of money, including many hidden costs ... Therefore, having a CFO with the skills appropriate for managing budget and financial planning should be present, early on.*

An additional aspect of Task Forces worth noting is that, as is the case in some other Internet Governance venues, Task Force members normally participate in their individual capacities, as opposed to representing the specific positions or objectives of their employers.[49]

2.2. Task Force activities

IPv6 Task Force members meet to share best practices, collaborate on new ideas, tackle deployment barriers, share updates on their own deployment efforts, and more. Many IPv6 Task Forces operate websites and mailing lists to archive and distribute information, as well as to facilitate discussions in between meetings. Some groups meet once a year, while others may meet as often as twice a month. Usually, Task Forces adhere to an open model, which means that anyone interested in IPv6 deployment is welcome to participate.

During the Best Practice Forum (BPF) discussion, IPv6 Task Force organisers identified a number of activities that they have in common. In this section, we consider these shared practices.

2.2.1. Creating a space for collaboration

In one example, the IPv6 Council in **Belgium** provides a space for collaboration on IPv6, where participants meet to share information on the status of IPv6 deployment, organise outreach and awareness raising activities, and share their knowledge and experience on IPv6 deployment. In its survey response, the IPv6 Council listed characteristics of its programme that have contributed to its success:[50]

- *A policy of open communication during meetings, giving the floor to anyone who wants to step up*
- *Having a social event after the meeting*
- *Hosting meetings at member venues, changing location each time*
- *A policy of open participation, where everyone is welcome*

[47] Contribution, Aaron Hughes, 6connect, USA.
[48] "Dual stack" refers to the simultaneous recognition of IPv4 and IPv6 by a network.
[49] Survey, Azael Fernandez, IPv6 Forum, Mexico.
[50] Survey, Carl Wuyts, IPv6 Council Belgium, Belgium.

2.2.2. Raising awareness

IPv6 Task Forces work to raise awareness on IPv6 deployment in various ways. One example, submitted from the Swiss IPv6 Council, showed how an information-gathering exercise can also be used to raise awareness and lead to action.[51]

The survey we did among the Top Alexa 75 websites in Switzerland gave the opportunity to call people and ask them about their plans, which again created opportunity to tell them why it could be important to them. This actually led to the dual-stacking of several major websites in Switzerland, which can again be used to convince others.

2.2.3. Providing advice to businesses

In general, the local IPv6 Task Force is a good first port of call for resources and advice on IPv6 deployment. The IPv6 Forum in **Thailand**, for example, is currently "working with the Government to create an IPv6 Nation[al] Roadmap,"[52] whilst the Task Force in **the Netherlands** maintains a web resource for different stakeholders, including the public sector. They provide the following simple checklist for government employees planning IPv6 deployment across a network:[53]

- *Assign a project manager*
- *Go talk to your ISP*
- *Determine which network components should be replaced or upgraded*[54]
- *Identify what the project manager will need to train your team*
- *Determine what the possible hardware and software replacements will cost*
- *Look for qualified suppliers and consultants to conduct the transition*
- *Compile a project plan*
- *Submit your cost estimate to the person who is responsible for budgeting and decision-making*

Note that during the BPF, one contributor suggested adding considerations to this list, including defining, early on in the process, "a strategy for IPv6 integration, and a target architecture. Based on that a requirement list can be created as a base for assessment of replacements, investments and cost."[55]

2.2.4. Making policy recommendations to governments

Government involvement in IPv6 adoption is critical, as explained further in Section 5 of this document. IPv6 Task Force members are an excellent resource for governments, because they are almost always the most knowledgeable and motivated people in the area when it comes to IPv6. Concerned about IPv4 exhaustion, the limitations of NAT and CGN,[56] and aware of the opportunities created by IPv6, they invest time and resources into producing policy recommendations for and providing advice to governments.

[51] Survey, Silvia Hagen, Swiss IPv6 Council, Switzerland.
[52] Survey, IPv6 Forum Thailand.
[53] Website of Nederlandse IPv6 Task Force. (Google translation).
[54] One contributor also recommended adding an assessment of current servers, applications, and network components.
[55] Contribution, Silvia Hagen, Swiss IPv6 Council, Switzerland.
[56] For information on NATs and CGNs, see Section 1, above.

For example, the IPv6 Task Force in **Venezuela** provided a set of recommendations to their government, suggesting that government services be required to support IPv6 (concurrently with IPv4, referred to as "dual stack technology"), and that hardware in the country, whether imported or produced domestically, be required to run dual stack technology. The Task Force offered other recommendations relating to CONATEL, Venezuela's telecommunications regulator, suggesting that it explore ways "to encourage ISPs to deploy IPv6 … one way is to give tax discounts to ISPs [for using IPv6]."[57]

In addition to the Task Force examples above, RIRs and other bodies provide recommendations to governments regarding IPv6. APNIC, for example, has outlined various ways in which governments can create an enabling environment for IPv6 adoption:[58]

- *Mandate for IPv6 readiness in all government procurement processes for ICT products and services*
- *Conduct research on IPv6 readiness in the industry*
- *Develop policies, guidelines, and roadmaps to enable IPv6 in government and network infrastructure*
- *Subsidize IPv6 skills training for industry members to support human capacity development*
- *Lead the industry by example in adopting IPv6 for delivery of e-government services*
- *Encourage the development of partnerships between government and industry*
- *Emphasise the necessity for IPv6 deployment in official policies and statements*

2.3. Common challenges identified by Task Force leaders

Many Task Force organisers cited **funding** and **coordination** as challenges to maintaining an IPv6 Task Force. In one contributor's experience, "financing is very hard, [and] sponsorship has dropped substantially since 2010. People appreciate initiative, but nobody wants to contribute financially."[59]

Starting an IPv6 Task Force can be challenging as well. Speaking from experience, one contributor advised that, in order to get an IPv6 Task Force off of the ground, one needs "to find some core work people, even in a small number" who are willing to dedicate their time to the exercise. "[I]f they are good enough," he explained, "[i]t can kick off."[60]

Some survey participants also cited the **lack of key stakeholder participation** as a challenge for their Task Force in promoting national IPv6 deployment. For example, one contributor said: "In our country, the dominance of the [two] big ISPs, and their lack of interest and promotion of IPv6 is what [has delayed IPv6] deployment."[61] Another contributor added: "Looking at ISPs

[57] The recommendations of the Venezuelan IPv6 Task Force can be accessed at: http://wiki.ipv6.org.ve/doku.php?id=politicapublica. While not from an IPv6 Task Force, a related publication is ISOC's, *IPv6: Why and how governments should be involved* (2009), available at: http://www.internetsociety.org/ipv6-why-and-how-governments-should-be-involved.
[58] List, Miwa Fujii, APNIC Australia. See also: https://www.apnic.net/community/ipv6-program/ipv6-for-governments.
[59] Survey, Silvia Hagen, Swiss IPv6 Council, Switzerland.
[60] Survey, Rafael Ignacio Sandoval Morales, IPv6 Forum, Colombia.
[61] Survey, IPv6 Forum, Mexico.

that have deployed IPv6, there is usually an easily identifiable champion [that has already] driven [deployment] through, without which [the ISP] would also not be ahead of the game."[62]

This situation was echoed among other (though not all) survey respondents:[63]

> *ISPs are not interested in promoting [IPv6 activities], and the government does not invest in the [task force].*

When asked why this was the case, another contributor responded by explaining that, once an ISP has its infrastructure installed and running, it will seek the highest possible return on its investment. Adopting IPv6 requires major changes to the network and business operations, and these changes cost money.[64] In the absence of a requirement by a government or abusiness incentive, the ISP will defer adopting IPv6 – even though adoption and investment is what is required to ensure the sustainable growth of the Internet, as well as the ISP's future business.[65]

In light of these challenges, one contributor suggested increased inter-networking of the IPv6 Task Forces, beginning with an understanding of "how the IPv6 TFs [are] seeded, for example. How did each of the existing TFs make people aware of their existence? … Using other/existing lists that may have overlapping interested parties [could be used] to send an 'announce-style' message to notify the regional group of a new TF's existence."

We elected to begin with an introduction to IPv6 Task Forces because they (or their members) often engage in other best practices described throughout the document. A non-exhaustive list of IPv6 Task Forces is provided in the Appendix.

3. Capacity building

"Capacity development" has been described by the United Nations Development Programme (UNDP) as "the process through which individuals, organisations, and societies obtain, strengthen, and maintain the capabilities to set and achieve their own development objectives over time. Simply put, if 'capacity' is the means to plan and achieve, then 'capacity development' describes the ways to those means."[66] People also refer to capacity development as "capacity building." In this document, we will use the latter term – capacity building – in the parlance of BPF contributors.

Capacity development is critical to the successful deployment of IPv6. Perhaps most important is technical capacity building for network operators, but developing an appreciation for the

[62] Contribution on IGF review platform, Ross Chandler.
[63] Survey, IPv6 Forum, Colombia.
[64] However, another contributor explained "The assumption that major changes are required is highly disputable. This may be more a perception than a reality. Minor changes may seem major when there is little business support." Contribution on IGF review platform, Ross Chandler.
[65] ISPs are commercial entities where training staff on IPv6 involves cost, and "the curve of knowledge about IPv6 takes time: preparing their equipment, services, employees, and products." Email, IPv6 Forum, Colombia.
[66] *Capacity Development: A UNDP Primer,* page 5, available at: http://www.undp.ro/download/Capacity%20Development%20PrimerReport%202010.pdf.

importance of IPv6 adoption at a non-technical level, by the CFO of a company for instance, is also important.

In this section of the document, we explore technical and non-technical capacity building activities, which carry the capacity development process described by the UNDP above into the arena of IPv6 adoption.

3.1. Providers of IPv6 capacity building programmes

A number of different organisations, not-for-profit and for-profit, provide IPv6 capacity building programmes.

National Research and Education Networks (NRENs) and **Regional Internet Registries** (RIRs) – not-for-profit organizations – deliver IPv6 capacity building workshops.[67] In the latter case, **AFRINIC** (the Internet Numbers Registry for Africa), for example, conducts hands-on IPv6 training throughout the continent. Each year, AFRINIC trains more than 600 "network engineers in at least 17 countries on practical skills required to plan and deploy IPv6 networks."[68] These workshops, led by AFRINIC with the participation of ISP associations, government agencies, and members of academia, are free-of-charge to participants.

Having conducted IPv6 trainings since 2010, AFRINIC offered a number of insights in its survey response, suggesting that others interested in organising their own IPv6 capacity building workshops consider the following:[69]

- *An effective IPv6 foundations training session requires at least two full days*
- *Participants must be pre-screened for requisite knowledge before attending*
- *Content must be 50:50 theory/practice*
- *Rigorous feedback must be put in place and used to update the content*

AFRINIC's IPv6 training courses have yielded positive results. As explained by Training Manager Mukom Akong Tamon:[70]

> *Some higher-level participants have gone on to deploy IPv6 after attending the training and a few countries are doing mini-sessions based upon the content [AFRINIC] created.*[71]

RIPE NCC (Réseaux IP Européens Network Coordination Center) regularly provides two IPv6 training courses – basic and advanced – as "a standard service to promote and encourage the use

[67] From an NREN: "We perform training sessions for our member institutions, providing an overview of IPv6 addressing, routing, security, implementation and other topics. This is a mix of lecture and hands on." Survey, Jeff Harrington, NYSERNet, USA; some ISOC Chapters also host IPv6 Deployment workshops, for example the Bangladesh chapter, as explained in a survey response from Mohammad Kawsar Udin, ISOC Bangladesh.
[68] Survey, Mukom Akong T., AFRINIC, Mauritius. For more information on AFRINIC's training programmes, visit: http://learn.afrinic.net/en/.
[69] Ibid.
[70] Ibid.
[71] For more information on IPv6 development in the African region as well as analysis and recommendations, see: Mukom Akong Tamon, *Why IPv6 development is slow in Africa and what to do about it,* (2015) Circle ID, available at: http://www.circleid.com/posts/20151018_why_ipv6_deployment_is_slow_in_africa_what_to_do_about_it.

of IPv6 in the western hemisphere."[72] The two-day advanced course teaches attendees how to implement IPv6 in their core network, understand the differences and similarities between IPv4 and IPv6 security, configure IPv6 on network equipment, and understand different transition mechanisms.

Over the course of her work as RIPE NCC IPv6 Program Manager, Nathalie Künneke-Trenaman has seen how many people who are new to IPv6 approach the idea of deployment. She offered the following advice:

> *One of the big problems with IPv6 deployment is that people think they have to do everything at once and that too much new knowledge is needed. It is of vital importance to break a deployment into smaller tasks and evaluate them step-by-step.*

Another important element is ensuring that training efforts are made sustainable, by training others to train others. In 2015, together with telecom regulators in Saudi Arabia and the United Arab Emirates, RIPE NCC organised a "train the trainer" program to further embed IPv6 knowledge in the local community and expand the capacity building activities by having local trainers deliver the courses.[73]

In addition to trainings by RIRs and NRENs, **national governments** can also support capacity building efforts. In **Spain**, the national government, in collaboration with other stakeholders, conducted twenty IPv6 training sessions across the country. The sessions were well-attended with an average of 300 people attending each session.[74] This national training effort came as a result of the 2011 law which approved a national Development Plan for the incorporation of IPv6 in Spain's public administration.[75] Government initiatives in IPv6 adoption are explored further in Section 6.

The need for technical training is widespread. A few groups deliver training in geographic areas where engineers would otherwise have limited access to the knowledge and information required to successfully deploy IPv6.

APNIC (Asia Pacific Network Information Centre) conducts detailed technical training throughout the Asia Pacific region, covering Internet operational practices including many aspects of IPv6 deployment. In collaboration with local and regional agencies, and events such as regional and national NOG (Network Operator Group) events, APNIC provides training to around 2 thousand engineers each year[76].

As a Guest of the APEC TEL working group, APNIC has conducted a series of IPv6 workshops during TEL working and ministerial meetings, over several years. An essential aspect of this work was to associate the need for IPv6 with the stated APEC TEL goals for regional broadband

[72] Contribution, Marco Hogewoning, RIPE NCC, the Netherlands.
[73] Ibid. See: RIPE NCC *RIPE NCC Announces "Train the Trainer" Initiative in Partnership with CITC in Kingdom of Saudi* (2015), available at: https://www.ripe.net/publications/news/about-ripe-ncc-and-ripe/ripe-ncc-announces-train-the-trainer-initiative-in-partnership-with-citc-in-kingdom-of-saudi-arabia.
[74] Contribution, Jordi Palet, Consulintel, Spain. For more information on these training efforts, including a list of cities and dates, as well as course material and videos, visit: http://www.ipv6.es/es-ES/transicion/Paginas/Fomento.aspx.
[75] The text of this law is available at: http://www.boe.es/buscar/doc.php?id=BOE-A-2011-10786 (in Spanish).
[76] For more information on APNIC's training programmes, visit: https://training.apnic.net/home.

Internet deployment. The success of these efforts was demonstrated by the adoption by APEC TEL of a set of IPv6 guidelines, and the references to IPv6 in Ministerial declarations in 2010[77] and 2012.[78]

Finally, APNIC maintains an ongoing collaboration with the Asia Pacific regional office of the International Telecommunication Union (ITU), and provides another example of IPv6 capacity building.[79] Over the past five years APNIC and the ITU's Telecommunications Development Bureau (ITU-D) have worked together to deliver IPv6 capacity building workshops for "network engineers, the technical staff of regulators, and government policymakers in developing economies in the Asia Pacific region."[80]

APNIC Senior Technology Advisor Miwa Fujii summarised the trainings on the BPF mailing list:

> *The workshop content focuses on IPv6 transition strategies and technologies and IPv6 infrastructure security, including hands-on workshop[s] and teamwork exercises. The course is designed to provide practical and useful IPv6 knowledge and skills that participants can bring back to their home economy and apply in their networks.*

In a non-RIR example, the **Network Startup Resource Center** (NSRC), based at the University of Oregon, "works directly with the indigenous network engineers and operators who develop and maintain the Internet infrastructure in their respective countries and regions by providing technical information, engineering assistance, training, [and] donations of networking books, equipment, and other resources."

The goal of NSRC's work "is to make it easier for local scientists, engineers, and educators to collaborate via the Internet with their international colleagues by helping to connect communities of interest. By strategically working with universities, research institutes, Internet Service Providers, Regional Internet Registries, government agencies, supranational agencies, industry, private foundations and non-governmental organizations, the NSRC helps develop national and regional Internet infrastructure for collaborative research, education, and international partnerships."[81] NSRC is mainly funded by the U.S. National Science Foundation and Google.

In addition to the trainings for network operators listed above, there are a number of **commercial providers** of IPv6 trainings that cater to businesses. Businesses that operate their own IT systems and/or networks require technical training for their network and IT operations staff on network design, configuration, operations, troubleshooting, support systems, and security. Offerings normally include general technology training on IPv6 and vendor-specific training on how to configure IPv6 on specific equipment.

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[77] The Eighth APEC Ministerial Meeting on the Telecommunications and Information Industry (TELMIN 8) (30-31 October, 2010, Okinawa, Japan) Okinawa Declaration "ICT as an Engine for New Socio-economic Growth," available at: http://mddb.apec.org/Documents/2010/MM/TELMIN/10_telmin8_jms.pdf

[78] 2012 APEC Telecommunications and Information Ministerial Meeting, available at: http://www.apec.org/Meeting-Papers/Ministerial-Statements/Telecommunications-and-Information/2012_tel.aspx

[79] Opinions supporting IPv6 capacity building were issued from the ITU's World Telecommunication Policy Forum in 2009 and again in 2013.

[80] List, Miwa Fujii, APNIC, Australia.

[81] NSRC's website is available at: https://nsrc.org/.

In addition to formal training, whether from a commercial provider or other entity, information should be made sufficiently available to the technical staff to allow them to make informed decisions on equipment purchases and updates (both software and hardware). This includes clear documentation and support from vendors. IT support staff will need to be included in the training to support users of the business applications and network, and customer support staff will need training to manage cases that involve IPv6.[82]

3.2. Capacity building for non-technical stakeholders

While most of the above-mentioned examples focus on network operators, IPv6 training for **law enforcement officials**, **policymakers**, and corporate-level (C-level) **business decision-makers** (e.g., CEOs, COOs, CFOs, etc.) is also very important for creating an enabling environment for IPv6 adoption.

For business decision-makers, training and education are essential to help mitigate risk to business operations. The extent and type of training or education will depend on the type and size of the business. Generally speaking, businesses need to consider investment in training as part of their business and operations plans. This requires education of business decision-makers with the type of information needed to develop these plans.[83]

A few recommendations from BPF contributors for business decision-makers included the following:

- *Build confidence at the decision-making level that IPv6 is "proven technology" and (perceived) risks are manageable;*
- *Work with decision-makers directly to help them understand the importance of IPv6 deployment, at a level where they can make a meaningful risk assessment for their business;*
- *Ensure that non-technical staff understand the long-term, positive effect of IPv6 deployment on their business goals (for example, enabling growth and the potential for reducing costs); and,*
- *For product developers and marketing staff, clarify the benefits for organisations that adopt IPv6.*

On working with decision-makers, one contributor added:[84]

> *It should be more than just "understand the importance of IPv6 deployment". In consulting with decision-makers, I try to make them understand that, actually, they have no choice; IPv6 is the current Internet Protocol, while IPv4 is the legacy protocol. So, investing in IPv4 means investing in a end-of-life technology while investing IPv6 is investing in current technology. Their choice is actually in how they want to deploy it – carefully, with time, laying a clean foundation for their future network, or quick and*

[82] Contribution, Hascall "Chip" Sharp, Cisco, USA.
[83] Ibid.
[84] Comment on IGF review platform, Silvia Hagen, Swiss IPv6 Council, Switzerland.

dirty, creating extensive unnecessary operational cost in the future or even having to redesign at some point.

Somewhat similar to the "train the trainer" approach mentioned above, **SURFnet**, the Dutch National Research and Education Network (NREN), documented their best practices on creating an IPv6 addressing plan. SURFnet then made this information freely available to other businesses.[85] Thus, businesses can learn from SURFnet's experience. Additionally, in 2013, SURFnet published a document outlining the business case for IPv6.[86]

As mentioned above, APNIC has worked with both ITU-D and APEC TEL to bring IPv6 awareness to Government officials and policy-makers in the Asia Pacific region. Also, **APNIC** has a dedicated section on its website that provides IPv6 information for business decision-makers and service providers in the Internet industry.[87]

4. Lessons from the private sector

In Section 4, we examine best practices identified within private sector organizations - namely by ISPs and content providers.[88] BPF discussion revealed that ISPs and content providers share many best practices in common. This section reviews those practices.

Approaches to deployment depend on local considerations. As with other illustrations in this document, the practices described below are offered only as suggestions.

4.1. Review existing infrastructure

ISPs and content providers can begin planning for IPv6 deployment with a detailed review of their existing infrastructure, including software, services, support systems (including sales and customer support), and administrative processes. As one contributor noted:

During this process, it is common to learn a great deal about your underlying supporting infrastructure, and either establish a better relationship with existing vendors or … establish new relationships with vendors who support IPv6 and want to be your partner through this transition.

The review will ideally result in the identification and assessment of any and all dependence on IPv4. This will then allow the identification of all impacts of IPv6 adoption, as it impacts on the identified dependencies on IPv4.

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[85] See: RIPE NCC, *Preparing an IPv6 Addressing Plan* (2010), available at: https://labs.ripe.net/Members/steffann/preparing-an-ipv6-addressing-plan.
[86] SURFnet, *Business case for IPv6: The Internet adds Trillions of Addresses to the Web* (2013), available at: https://www.surf.nl/binaries/content/assets/surf/en/2013/rapport_201309_Business+Case_IPv6_eng.pdf.
[87] These parties include Internet transit providers, access network providers, hosting providers, data center operators, content distribution network operators, mobile network operators, and content providers. See: APNIC, *IPv6 for Decision-Maker*s, available at: https://www.apnic.net/community/ipv6-program/ipv6-for-decision-makers.
[88] BPF discussion revealed that few case studies on enterprise-wide deployment of IPv6 are available.

4.2. Determine whether vendors are IPv6-ready

One challenge identified during the BPF related to the capacity of vendors to support IPv6 products and services. According to one contributor:[89]

> *There is still a long way to go in terms of IPv6 support in a lot of the equipment out there. A lot of network gear is still IPv4 only on the management interface. Many vendor implementations are buggy.*

When working with vendors, organizations must be prepared to test every function and feature equipment to ensure that it meets their needs. Based on the discussion during the BPF, IPv6 is not yet well understood by the majority of vendors. One contributor suggested that companies confirm vendor expertise in IPv6 before engaging in a contract. One contributor said "many vendors will tell you they are IPv6 ready, but this may not [necessarily] mean that parity exists for features which exist in IPv4." Another survey response explained:[90]

> *Don't buy any equipment that doesn't have the IPv6 features that you need. If a manufacturer says that IPv6 is "coming," don't take their word for it. Make sure they at least show you a working beta.*

Vendors' expertise and ability to fully support IPv6 will make a critical difference for businesses engaged in IPv6 deployment. In Singapore, ISP StarHub explained that the roll-out of IPv6 was not without challenges, but its vendor was were there to assist:[91]

> *There were challenges along the way, mostly dealing with the scaling of routing tables to deal with a larger than expected deployment of IPv6-capable Customer Premise Equipment. Our vendor's quick turnaround time and support allowed us to get back on track quickly, and we are happy to see continual growth in IPv6 traffic as our rollout continues.*

Thus, it is critically important for the business to know whether its vendor supports IPv6, and if not, whether and when that vendor is willing to take steps to become IPv6-ready. One option, of course, is to contractually require vendors to be IPv6-ready. As discussed further below, in Section 5, the US Department of Defense requires the vendors they work with to have dual-stacked their own websites. While this may not be directly relevant to the services required from such vendors, it provides an important indicator of their commitment to and capabilities in relation to IPv6.

Finally, another notable measure which was cited during the BPF, relating to IPv6 readiness requirements is that, since the introduction of iOS 9, Apple *requires* iPhone and iPad applications to support IPv6 in order to be carried by the Apple App Store.

[89] Survey, Tim St. Pierre, Communicate Freely (ISP), Canada.
[90] Ibid.
[91] Email correspondence, Seng Chye, StarHub, Singapore.

4.3. Provide employees with training and knowledge

IPv6 expertise among technical staff is, of course, an absolute necessity for smooth deployment and operation of IPv6 capabilities. In terms of employees with non-technical roles, who interact directly with customers in the sales, account management, and customer service departments, they should possess an awareness if not a high-level understanding of IPv6. This recommendation of course relates primarily to ISPs, content providers, and other business in the ICT field. The manager of a restaurant, for example, need not be required to understand IPv6 issues, but their technical staff must.

Capacity building in IPv6 is discussed in greater length in Section 3, above.

4.4. Deploy IPv6 for public-facing services

ISPs and content providers should aim to offer end users IPv6 services through a dual stack approach, meaning that both IPv6 and IPv4 are used.[92] "Many organisations take small steps into this transition."[93] Organisations can begin work on dual stack implementation by taking inventory of all outside, public-facing IPv4 services. This should help to define the steps that need be taken to enable dual stack technology. As one contributor summarised:

> *The simplest approach is to work from the outside in.*

When content providers enable IPv6 access to their public-facing services, they immediately enable better access to their content; all IPv6-ready end users will immediately and automatically bypass the IPv4 bottlenecks of NAT and CGN. Dual stacking public-facing services improves the experience of IPv6 end users without affecting IPv4 end users.

ISPs and content providers who use Content Distribution Networks (CDNs) should contact their CDN about IPv6. Many CDN providers today offer dual stack services by default, though some will only enable IPv6 services upon request. For businesses who do not work with CDNs, enabling dual stack means ensuring that all load balancers, name servers, mail servers, web-servers, app servers, etc., are available over both IPv6 and IPv4.

After deploying dual stack access to their public-facing services, Facebook saw an increase in performance for its mobile end users. In a March 2013, it was reported that certain users connecting to Facebook via IPv6 were doing so "on average … about 30% faster" than users connecting via IPv4.[94] As software engineer Paul Saab explained, "This is great for our users because that means their news feed loads faster, their pictures load faster – everybody's happier when things are faster."[95]

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[92] The Canadian ISP Communicate Freely decided to deploy IPv6 in 2011 after the company encountered problems securing IPv4 addresses. The company considered "IPv6 adoption [to be] the 'new normal' for all IP connected systems." The company explained in its survey response that it has since made IPv6 available to 100% of its customers via dual stack technology.
[93] Contribution on IGF review platform, Tim Martin.
[94] Paul Saab, Facebook, presentation at v6 World Conference (31 March 2015), video available at: https://www.youtube.com/watch?v=An7s25FSK0U&feature=youtu.be&t=19m. (note that this example references speeds observed on the iPhone 6. Saab provides a number of further examples in the video).
[95] Ibid.

As of September 2015, 50% of Facebook's traffic to 4G smartphone users in the U.S. was being delivered via IPv6.[96]

Once public-facing services are dual stacked, then businesses should consider "work[ing] inwards, making sure that all back-end gear is singled stacked" – in other words, using IPv6 exclusively.[97]

4.5. Migrate to IPv6 on internal networks

Why maintain two stacks in your entire network [when it is] much easier to handle two stacks at the edge and one internally? [98]

During the 2014 v6 World Conference, Facebook presented on the company's internal migration to IPv6.[99] The case study canvasses the challenges that were encountered along the way, so it is a useful reference for more technical readers.[100]

At the time, 75% of Facebook's internal traffic was IPv6. Today, Facebook no longer builds new machines with v4 connectivity, and the small amount of IPv4 that remains in use on Facebook's internal network will be migrated soon.[101]

Facebook of course maintains a very large network, but IPv6 adoption yields benefits to businesses of all sizes. Local ISP Communicate Freely, based in Ontario, Canada, said in its survey response that eliminating NAT helped with managing customer devices, and added:[102]

> *Where possible, remove NAT and replace with IPv6 only on management networks. You will quickly find this makes management far easier.*

4.6. Set internal deadlines

Given that the pool of available IPv4 addresses continues to shrink, BPF contributors recommended that all businesses plan for the inevitability of no IPv4.

> *Planning for the inevitable unavailability of IPv4, and the complete adoption of IPv6, with eyes wide open, will make planning for and implementation of IPv6 far easier. Importantly, it will allow for your customers to plan accordingly.*

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[96] Paul Saab, Facebook, presentation at @Scale conference (14 Sept 2015), video available at: https://youtu.be/_7rcAIbvzVY. For a written summary of Mr. Saab's presentation, see: Gabriel Brown, Lightreading.com, *Facebook: IPv6 is a Real-World Big Deal* (25 Sept 2015), available at: http://www.lightreading.com/ethernet-ip/ip-protocols-software/facebook-ipv6-is-a-real-world-big-deal/a/d-id/718395.

[97] In its survey response, BDCOM, an ISP in Bangladesh, took the opposite approach, implementing IPv6 in its internal networks in 2013, and working on deploying public-facing IPv6 resources more recently. Survey, Mohammad Abdul Bashar, BDCOM, Bangladesh.

[98] Paul Saab, Facebook, presentation slides from the v6 World Conference 2014, available at: http://www.internetsociety.org/deploy360/wp-content/uploads/2014/04/WorldIPv6Congress-IPv6_LH-v2.pdf.

[99] Dan York, ISOC, *Case Study: Facebook Moving To An IPv6-Only Internal Network* (6 June 2014), available at: http://www.internetsociety.org/deploy360/resources/case-study-facebook-moving-to-an-ipv6-only-internal-network.

[100] Paul Saab, Facebook, presentation slides from the v6 World Conference 2014, available at: http://www.internetsociety.org/deploy360/wp-content/uploads/2014/04/WorldIPv6Congress-IPv6_LH-v2.pdf.

[101] Twitter conversation with Paul Saab, Facebook, USA.

[102] Survey, Tim St. Pierre, Communicate Freely (ISP), Canada.

Though simple, the phased plan outlined below was offered by a BPF contributor as one place to start:

1. *Begin with IPv6 education and outreach to customers and partners*
2. *Support customers in their transition to IPv6*
3. *Require IPv6 adoption by customers, but allow for dual stacking and IPv4 support at the same time*
4. *When the time is right, support IPv6 only*

4.7. Reach out to customers

One survey response from an ISP described how it sent an "email blast" to its business customers, "explaining the reasons for considering IPv6 adoption."[103] While the outreach effort, "did raise some level of awareness … very few people were interested" and "a few customers were confused."[104]

This experience suggests that a steady and repetitive approach to distributing information about IPv6 adoption to customers may be more effective than a one-off email campaign. Updating all customer-facing communications (e.g., invoices, maintenance notifications, marketing material, website, email signatures, etc.) with a note on IPv6 adoption or a link to further information would also be useful. One participant suggested creating and maintaining a wiki as a Frequently Asked Questions page for customers:

> *There is no better way to answer the same questions from all of your customers than to document them publicly in once place. Not only will you be building a repository for your customers, but you will also be educating your staff on the common issues that your customers face.*

For business customers in particular, another suggestion for ISPs was to engage more directly, by inviting them to an on-site training. IPv6 education is a fantastic reason to have a "lunch and learn" with customers. This is also a useful practice for staff.

4.8. Consider different approaches to pricing (for ISPs)

The amount of IPv4 address space available will continue to decline, and the cost of supporting IPv4 will rise. To encourage customers to adopt IPv6 over IPv4, ISPs may want to consider passing on the cost of supporting IPv4 by charging the customer for IPv4 but not for IPv6. This approach may suit ISPs with non-residential customers.[105]

In this case, it is important to give the customer clear notice and to explain the rationale supporting the price increase. This is also an opportunity to raise awareness about IPv6 adoption.

For example, the customer could receive a notice on their invoice similar to:

[103] Survey, Anonymous, USA.
[104] Ibid.
[105] Note that this practice is not being recommended by the BPF, but only noted in discussion as an example.

In order to support the growing Internet, we at [ISP] encourage the use of IPv6. Because IPv4 addresses are running out, the monthly cost for an IPv4 address will increase next month to [X]. However, IPv6 will be provided at no cost to you. If you would like to know more about IPv6, please click "here."

The above listed practices can be applied not only to ISPs and content providers, but to other businesses as well.

Enterprise-wide IPv6 deployment, however, is a major undertaking that only a few enterprises have experienced. Few examples were identified during the BPF. Contributors suggested that, should the BPF continue, enterprise-wide IPv6 deployment be a future focus area for discussion and research into best practices.

4.9. IPv6 adoption anecdotes from ISPs

4.9.1. Malaysia

The below anecdote was contributed from TM Net in Malaysia:[106]

Telekom Malaysia´s deployment of IPv6 was driven by two factors, namely; the responsibility to propagate IPv6 adoption as the nation's leading communication service provider, and to ensure business continuity for our customers in view of the global IPv4 address exhaustion. Taking the inside-out approach, our deployment of an IPv6-compliant network began years ago by first enabling the core IP network and moving outwards to the edge and customer endpoints. The biggest challenge was in going full swing for the mass adoption of dual-stack Internet broadband services, circa 2013.

The saying 'If it's not broken, don't fix it' comes to mind; older generations of hosts and CPEs do not support IPv6, and it was rather costly to provide 1-to-1 replacement. Starting in 2012, prior to launching its dual stack service, TM had already begun to commission compatible CPEs to automatically assign dual-IP when the time came. Our migration strategy was to give room to existing users to make their own, graceful switch to IPv6, while new users would be using IPv6 whether they realized it or not.

Two years has passed and, while there is increasing traffic and awareness on IPv6, the demand is still considerably low. Without clear incentive or drastic push, customer CPEs remain as-is, and we have to continue to support IPv4. Thus, the next focus should be on increasing the IPv6 footprint, and exiting IPv4. Without a doubt, our transition to IPv6 affected the organization as a whole. Kudos also to our regulatory body for putting up strict guidelines that provided the necessary push required for all ISPs to move to IPv6.

4.9.2. Japan

Two ISPs from Japan shared their IPv6 deployment anecdotes, on an anonymous basis:

[106] Contribution, Azura Mat Salim, Telekom Malaysia, Malaysia.

4.9.2.1. Anecdote 1

We assumed that our ISP business would be affected adversely by IPv4 address exhaustion and started planning for IPv6 adoption in 2010. The goal of this plan was to provide IPv6 connectivity to end users through dual stack technology.[107] We collaborated with some of our vendors to test equipment functionality to ensure that our equipment met our IPv6 requirements prior to purchase. We started deploying IPv6 on our network in 2011, enabling dual stack on our backbone first. In 2012, we provided IPv6 connectivity to end users after testing IPv6-ready end user devices.

We did not set a clear deadline for these deployment plans because we started this plan before IPv4 address exhaustion. As a contingency plan to cope with challenges that might occur if we could not secure Internet connectivity over IPv6, we identified measures to disable IPv6 on user equipment.

4.9.2.2. Anecdote 2

First, we considered if our customers required an additional subscription for IPv6 services, or if we should provide IPv6 services as a default, by combining it with the existing services. We decided to provide IPv6 services as a default in order to enable smooth IPv6 adoption in the future.

Starting point for Deployment
We clearly defined which services would be on IPv6. We chose to deploy IPv6 for our services on "Fibre to the Home" (FTTH), as we expected subscription growth in this service. We also targeted services that we can provide using our own networks.

Confirming IPv6-readiness of network equipment vendors
We verified availability of end-to-end communication routes in order to identify equipment with limited IPv6 capability (e.g., equipment which could not manage IPv6 packets at the hardware level, equipment without IPv6 Quality of Service, etc). We identified work-around measures to cope with any lack of IPv6 functionality so that we could avoid any negative impacts on performance in forwarding IPv6 packets.

Staff skill-up with IPv6
We conducted staff training on IPv6 as a new service. Our staff are currently stably managing large data traffic on dual stack networks.

Setting internal deadlines toward the IPv6 deployment plan
We set our internal deadline of IPv6 deployment on the timing of IPv4 address exhaustion at JPNIC/APNIC. Although Japan experienced a major earthquake in March 2011, we were able to proceed and successfully launched IPv6 services in April 2011.

Preparing for unexpected events
We managed network equipment, servers, Home Gateway (HGW) and Customer Premises Equipment (CPE) that do not comply with RFC standards by changing parameters. We applied low cost (cost, time, required number of processes) methods for managing unexpected events.

[107] Via PPPoE, or Point-to-Point Protocol over Ethernet.

4.10 Collaboration

As illustrated elsewhere in this document - for example in Section 2 on IPv6 Task Forces - cross-stakeholder collaboration is an important and effective part of creating an enabling environment for IPv6 adoption. One notable example of collaboration was the work done around World IPv6 Day (2011) and World IPv6 Launch (2012).[108] Organised by the Internet Society, the World IPv6 Day brought together large websites and Internet service providers from around the world (Google, Facebook, Yahoo!, Akamai and Limelight Networks), who were joined by more than 1000 other participating websites, to trial IPv6 deployment together, on a global scale. "By providing a coordinated 24-hour "test flight", the event helped demonstrate that major websites around the world are well-positioned for the move to a global IPv6-enabled Internet, enabling its continued exponential growth."[109]

The following year, World IPv6 Launch participants, which included website and network operators and home router vendors, permanently enabled IPv6 by default, respectively, on their main sites, in their services for new subscribers, or in their products as of June 6, 2012.

Note only has "global IPv6 traffic has grown more than 500% since World IPv6 Launch,"[110] but, as a survey respondent from the University of New Hampshire's IT department noted, "World IPv6 day did help build some excitement around getting IPv6 into production."[111]

5. Research and Education Networks, and Universities

National Research and Education Networks (NRENs), provide specialised Internet services to learning institutions inside their country. NRENs are usually pioneers in introducing and deploying new protocols and technologies.

Like many NRENs, the China Education and Research Network (**CERNET**) has "universities, institutions and schools" as customers. CERNET provides IPv6-enabled Internet services to the Chinese student population. In its survey response, the NREN explained that "the connectivity between IPv4 and IPv6 networks (via translation) is the way to transit[ion] the Internet from IPv4 to IPv6."[112] CERNET also participates within the IETF and has worked to develop a number of RFCs.[113]

GÉANT is the pan-European network serving Europe's research and education community. It is co-funded by the European Commission and European NRENs. GÉANT has been running IPv6 since 2002. The organisation's website is an excellent resource for finding information on the IPv6 work of other European NRENs.

[108] Contribution on IGF review platform, Tsuyoshi Kinoshita, Internet Association, Japan.
[109] ISOC, *Archive: 2011 World IPv6 Day*, available at: http://www.internetsociety.org/ipv6/archive-2011-world-ipv6-day//.
[110] World IPv6 Launch website, available at: http://www.worldipv6launch.org/.
[111] Survey, Scott, University of New Hampshire, USA.
[112] Survey, Xing Li, China Education and Research Network, China.
[113] RFC6219, RFC6145, RFC6052.

In addition to its broader work on IPv6 deployment,[114] in 2012, the **University of New Hampshire** (UNH) in the United States started sponsoring IPv6 projects for senior students in its Computer Science Department.[115] The first of these projects built an IPv6 test network, while a follow up project implemented NAT64.[116] The University maintains a webpage that shows its current IPv6 deployment progress.

During the BPF, one contributor shared:

> *In recent discussion with several people at UK universities, I have found out that whilst some departments...might have rolled out IPv6 as long as several years ago, they have found it very hard to have IPv6 accepted University-wide, due to the ever-increasing complexity of service level agreements and risk management at University's management level.*

The contributor went onto explain that it is easier for a single university department to deploy IPv6 because the decision making process is less formal, and the responsibility for quality of service remains within the department. University-wide deployment is seen as a different level of responsibility, which rests with decision-makers who may not necessarily know what IPv6 is.

On a similar note, another contribution explained that "moving [the entire University network] to IPv6 is not high priority, though it does have the support across the IT department."[117]

Best practices for IPv6 deployment in the university sector, in addition to enterprises, were identified as useful areas for future focus by the BPF.

6. Government initiatives

Governments can create an enabling environment for IPv6 adoption in different ways. As one BPF contributor explained:[118]

> *Some governments prefer a more "hands-off" approach, expressing their support but wishing the private sector take the lead. Others go a step further by mandating IPv6 compatibility for any government procurement contract, some a little further by offering all government online services over IPv6, and some go [all] the way by taking a very active role in financing research and implementation projects for IPv6 adoption.*

With the exception of the "hands off" approach, the practices mentioned above are covered in this section of the outcome document.

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[114] UNH is working towards University-wide IPv6 support, having started by implementing dual stack beginning in 2011. According to an intervention made during the in-person session at the IGF, the University of Nairobi has also implemented dual stack. One of the greatest challenges, the contributor explained, was replacing legacy equipment.
[115] Survey, Scott, University of New Hampshire, USA.
[116] See Section 1.2.5., above.
[117] Ibid.
[118] List, Olivier Crepin-Leblond, ICANN ALAC, UK.

6.1. Procurement policies

When a government requires IPv6 in its ICT procurement policies, it sends a signal to the industry about the importance of adopting the new protocol. The wide variety of websites, Internet-based services, and networks that the public sector owns, operates, or commissions should support IPv6, requiring vendors who tender for government contracts to provide for and understand IPv6.

BPF contributors mentioned a number of countries that require their public administration to run IPv6 and/or all vendors tendering for government contracts to provide for IPv6-capable products and services.[119] Below, are just a few examples of government initiatives aimed at creating an enabling environment for IPv6 adoption.

6.1.1. Germany - Developing "IPv6 Profiles"

In Germany, the Federal Ministry of the Interior (Ms. Constanze Bürger) led, with the support of Cassini Consulting (Mr. Tahar Schaa), an IPv6 research project that in 2013 culminated in the publication of a set of documents designed to support IPv6 adoption by the public administration. As described in the *IPv6 Transition Guide for the Public Administration* (Transition Guide), "the pur-pose of [the IPv6] project was to de-fine pro-files for dif-fer-ent cat-e-gories of de-vices, and ex-am-ine and doc-u-ment strate-gies for the mi-gra-tion to IPv6."[120]

The *IPv6 Profiles for the Public Administration* document and the *Profile Table* itself facilitate the public procurement of IPv6-ready products and services by Germany's public sector, not only by providing "rec-om-men-da-tions for the in-tro-duc-tion and pro-cure-ment of com-po-nents which sup-port IPv6," but also by "supporting the acquisition of [IPv6-enabled devices], and [encouraging the] evaluation of existing devices for [IPv6 readiness]."[121]

The *Profile Table* distinguishes between necessary and mandatory use of IPv6 in different situations. It also specifies requirements in terms of device (routers, firewalls, etc.) and use (stationary, mobile, etc.).This helped to simplify the government's assessment of whether a given tender meets the requirements.

The information in the documents from Germany's IPv6 project "can be used for procurement processes of new devices, the evaluation of existing hardware and software, and in the implementation of and transition to IPv6."[122] While the IPv6 profile is not mandatory for the procurement activities of the different authorities in Germany, it is very well recognised.

English translations of the *Transition Guide* as well as the *IPv6 Profiles* document and *Profile Table* are available online and were published under a Creative Commons license.[123]

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[119] Other countries mentioned included the Netherlands, Spain, Sweden.
[120] See the website of the BVA, available at: http://www.bva.bund.de/EN/Themen/Information_technology_bit/IPv6/node.html.
[121] Contribution, Tahar Schaa on behalf of the German federal government.
[122] BVA, *IPv6 Profiles for the Public Administration* (2013), Creative Commons 3.0 license (CC BY-NC-ND 3.0), page 7, available at: http://www.bva.bund.de/DE/Organisation/Abteilungen/Abteilung_BIT/Leistungen/IT_Beratungsleistungen/IPv6/best_practice/ipv6begleitdokument_EN/download/fue_profildokument.pdf?__blob=publicationFile&v=5.
[123] See: the website of the BVA, available at: http://www.bva.bund.de/EN/Themen/Information_technology_bit/IPv6/node.html.

6.1.2. United States - Requiring vendors to themselves use IPv6

In 2010, the United States Office of Management and Budget (OMB) issued a memorandum (M-05-22) to executive departments and agencies that described "specific steps for agencies to expedite the operational deployment and use of IPv6."[124] Among other requirements, executive agencies had to ensure that any procurement they made of networked information technology complied with government standards for "the completeness and quality of [its] IPv6 capabilities."[125]

During the BPF, one contributor recognised that the U.S. government requires all procurements to be IPv6-ready, but also pointed out that some departments go even further by requiring their vendors to use IPv6 themselves.[126]

> *The reasoning here is twofold. First, vendors should consider actively demonstrating their commitment to fully supporting IPv6. Second, in the long-term, vendor websites that are only accessible over IPv4 will force their customer to keep supporting IPv4 as well, thereby hindering the ultimate decommissioning of IPv4.*

Governments and other public sector actors are often service providers themselves. Therefore, it is equally important for governments to deploy IPv6 in the services and infrastructure they own. Showing leadership in this area can help build confidence in other stakeholders to deploy IPv6 as well.

6.2. National deployment strategies

6.2.1. The Kingdom of Saudi Arabia

The **Kingdom of Saudi Arabia's Communications and Information Technology Commission** (**CITC**) is responsible for national IPv6 Strategy. The objectives identified in the IPv6 Strategy for Saudi Arabia are to:[127]

- *Prepare for the IPv4 exhaustion by supporting IPv6 and ensure stability, business continuity, and room for continued growth of the Internet in Saudi Arabia;*
- *Ensure a smooth adoption of IPv6 by stakeholders so as to minimize risks; and,*
- *Raise overall IPv6 awareness nationwide by approaching stakeholders of both the public and private sectors, highlighting the necessity to adopt IPv6.*

A phased timeline with milestones for IPv6 deployment is a critical part of the strategy. The CITC's IPv6 timeline comes via an action plan of initiatives categorized into two tracks: an **i**nfrastructure track, and an awareness track.[128]

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[124] U.S. Office of Management and Budget, *Memorandum for Chief Information Officers of Executive Departments and Agencies* (28 Sept 2010), available at: https://www.whitehouse.gov/sites/default/files/omb/assets/egov_docs/transition-to-ipv6.pdf.
[125] Ibid. Requirements include the "USGv6 Profile and Test Program."
[126] Dan York for ISOC's Deploy360 blog, *US DoD's DREN Will Only buy Products With an IPv6 Website*, (11 Sept 2014), available at: http://www.internetsociety.org/deploy360/blog/2014/09/us-dods-dren-will-only-buy-products-with-an-ipv6-website/.
[127] Ibid.
[128] Survey, Adeeb Albraidi, CITC, Saudi Arabia. For more information, consult the CITC keynote from MENOG14 but Dr. Ibraheem Al-Furaih *IPv6 Promotion and Deployment in Saudi Arabia* (2014), available at: http://www.menog.org/presentations/menog-14/263-CITC-Keynote.pdf.

As described in its response to the BPF survey:[129]

> *Meeting the milestones would facilitate the deployment and further penetration of IPv6 on a nationwide basis so as to eventually realize an IPv6-ready Internet infrastructure in the Kingdom of Saudi Arabia.*

Early CITC IPv6 activities focused only on ISPs. In 2013, however, the CITC expanded its IPv6 initiative to include Saudi business enterprises. As part of this effort, the CITC took practical steps to promote IPv6 deployment by implementing a set of **pilot projects** within selected entities in order to showcase best practices for the benefit all stakeholders.

The CITC often benchmarks the status of IPv6 deployment in the Kingdom against international trends, and assesses those regulatory and technical aspects of the national Internet ecosystem that obstruct the smooth adoption and deployment of IPv6 in the Kingdom.[130]

6.2.2. Finland

The **Finnish Communications Regulatory Agency** (FICORA) hosted Finland's **national IPv6 launch** day in June 2015, in order to promote IPv6 adoption in Finland and to bring the country's deployment rate in line with other central European countries.[131] The only condition of participation in the launch was that the attendees had to have deployed IPv6 themselves.

As explained in FICORA's response to the BPF survey:[132]

> *After discussing the topic for 10 years, ISPs were rather ready to take IPv6 into use. It just needed clear goals, some leadership, and definitely marketing, publicity, and peer pressure.*

The planning process for the launch began one year in advance. "Organizing a national launch takes time," explained Klaus Nieminen from FINCORA, who led the project. He suggested:[133]

> *Make a proposal and see what response it gets. Get at least some ISPs to commit. When it is safe, [engage a] bigger audience. Try also to get broad shoulders to back you, it helps. But still a lot of marketing, talking, and there you go. Try also get some benefits for those ISPs that are taking part in the launch, or example with press releases and media contacts.*

One challenge observed during the launch was the hesitance of some ISPs "to take IPv6 into use automatically" because of "security and quality of service concerns."[134] The organisers, however, remain optimistic:[135]

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[129] Ibid.
[130] Ibid.
[131] See: FICORA's webpage on the national IPv6 launch, available at: https://www.viestintavirasto.fi/en/ficora/news/2014/ipv6enablesmoreefficientuseofinternetconnectionsandservices.html.
[132] Survey, Klaus Nieminen, FICORA, Finland.
[133] Ibid.
[134] Ibid.
[135] Ibid.

I think that industry is just rather ready to take the step if given just a little push.

6.2.3. India

Governments can lead by example by planning for and requiring IPv6 deployment in their public administrations.[136] India is one such government.

In light of IPv4 exhaustion, and "the many inherent advantages of IPv6," **India's Department of Telecommunications** (DoT) "mandated … timelines for [a] time-bound and phased manner [of] implementation of IPv6 across all stakeholders - service providers, content and application providers, device manufacturers, end user device vendors, cloud service providers, and government organisations."[137] As explained in a survey response, "as IPv4 addresses are already exhausted, and in view of [machine-to-machine communications] and [the Internet of Things] in the country, the uptake of the IPv6 will increase rapidly."

Nearly all stakeholders "have been asked to abide by the timelines of the National IPv6 Deployment Roadmap v-II (March 2013) and complete the transition by the mandated timelines. Many of the service providers, content providers, and Government organisation[s] are ready right now, [and] almost all end user devices launched after June 2014 in India are IPv6-ready."[138] The DoT is also tracking progress and engaging with stakeholders.

In the south Indian state of Kerala, the Kerala State IT Mission (KSITM) launched an initiative aimed at upgrading the state's core IT infrastructure, which was the first step for the transition to state-wide IPv6 deployment. As explained in a recent article:[139]

> *The IPv6 migration in the initial phase involves transition of State Data Centres (SDCs), e-governance applications, portals and website services hosted in SDCs, and [the] Kerala State Wide Area Network. The remaining government offices...will be covered in the next phase and integrated with the existing national networks and infrastructure like the National Knowledge Network, National Data Centre for Disaster Recovery, and National Optical Fibre Network.*

6.3 Providing guidance

The Infocomm Development Authority of **Singapore** (IDA) spearheaded an IPv6 Transition Programme to address IPv4 exhaustion and facilitate a smooth transition to IPv6. The programme promotes readiness and adoption of IPv6 in the local industry, through a series of projects.[140]

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[136] As for example was done in Ecuador (link, link) or Columbia (link)
[137] Survey, Government of India.
[138] Ibid.
[139] T. Nandakumar *State to switch to new IP* The Hindu (2015), available at: http://www.thehindu.com/news/national/kerala/state-to-switch-to-new-ip/article7672683.ece.
[140] For more information on IDA's efforts supporting IPv6 adoption, visit: https://www.ida.gov.sg/Tech-Scene-News/Technology/IPv6.

As part of this programme the IDA developed the *IPv6 adoption guide for Singapore*. This document sets out detailed IPv6 adoption guides, tailored to assist each stakeholder group in translating their strategic IPv6 objectives into practical implementation.[141] The guide explains IPv4 exhaustion, takes into account the findings of the national IPv6 readiness survey for Singapore and includes technology roadmaps.

6.4. Collaboration with industry and other stakeholders

Government collaboration with industry, academics, and other interested stakeholders was described as best practice in BPF discussion. IPv6 Task Forces, covered in Section 2, are obvious venues for government officials to collaborate with other stakeholder groups. This Section provides two additional examples.

6.4.1 Norway - National Working Group

In 2011, the **Norwegian Communications Authority** (Nkom) established a national working group on IPv6 deployment. The purpose of this working group, attended mainly by government officials and ISPs, was to "identify key issues and discussions associated with the transition to IPv6."[142] Similar to the work of IPv6 Task Forces, addressed above in Section 2, Nkom's working group served as a platform to help different groups plan for IPv6 deployment. The initiative then led to further collaboration in the industry between IKT-Norge (Norway's ICT industry representative), ISPs, and other stakeholders.[143]

6.4.2 Japan - National Study Group

In 2009, in light of the imminent exhaustion of IPv4, the **Ministry of Internal Affairs and Communications of Japan** (MIC) established an IPv6 Study Group (Study Group) as part of its national plan to address IPv6 adoption.[144] The Study Group served as a platform for experts and key industry players to discuss and identify IPv6 issues.

In 2009, 2010 and 2011, the Study Group produced a series of three reports, which provide a comprehensive picture of how to prepare for IPv4 exhaustion in Japan.[145] The reports feature expert analysis, outline key milestones within the broader industry effort for accelerating IPv6 adoption, give progress reports on previously identified actions by the Study Group, and provide readouts on the overall IPv6 adoption status in Japan. To date, the Study group has published periodical updates. In addition, it produced two progress reports in 2012 and 2013, on the issues and actions identified, to review progress which has been made since the publication of three reports.

It is worth noting that process employed by the Study Group incentivized participants to make

[141] This approach was also identified as a practice in Japan: The Ministry of Internal Affairs and Communiications (MIC) provides guidelines on deployment of IPv6 network for "Small and Medium ISPs,"Enterprizes","Local Governments", with seperate documents on IPv6 Specification Models for enterprizes and local governments : http://www.soumu.go.jp/menu_seisaku/ictseisaku/ipv6/index.html

[142] Survey, Ørnulf Storm, Norwegian Communications Authority, Norway.

[143] Ibid.

[144] For further information on the MIC's Study Group, see: http://www.soumu.go.jp/menu_seisaku/ictseisaku/ipv6/. (in Japanese).

[145] These reports are available at: http://www.soumu.go.jp/menu_seisaku/ictseisaku/ipv6/index.html

progress; the Study Group identified actions to be taken by different stakeholders. Each stakeholder which took action on a volunteer basis was required to provide status updates to the broader group. In the event that action items were not met, then explanations were required. Additionally, the process helped identify issues which required a concerted effort - issues that could not successfully be addressed by one single stakeholder alone, but which needed other stakeholders in the Study Group to work on, were put on the table.

The MIC restarted its Study Group in July 2015. Its latest scope of work includes an evaluation of the status of IPv6 adoption in Japan, future plans for encouraging IPv6 adoption in the mobile industry (while the fixed broadband continues to show steady progress), and an evaluation of additional measures to support IPv6 adoption in light of the rising Internet of Things (IoT); IPv6 is one of the essential elements supporting the IoT.

In another example of collaboration, the Japanese government, outsourced IPv6-related experiments to the private sector in order to develop, for example:

- Guidelines on IPv6 deployment per stakeholder (small to medium ISPs, corporations, and local governments);
- Equipment purchase specifications for corporations and local governments; and
- A list of IPv6 ready equipment and equipment where its security has been tested.

Japan's Computer Emergency Response Team (JPCERT) cooperated in this effort.
As discussed during the in-person session of the BPF in Joao Pessoa, Brazil, an important part of this effort is conducting experiments to test how certain features of IPv6 ready products work in real world, and published its results, under public-private sector collaboration.

7. The role of the end user / consumer in IPv6 adoption

End users support IPv6 adoption when, as consumers, they buy IPv6-enabled devices and sign up for IPv6 services. Growing end-user demand for IPv6-ready goods and services, especially in light of the developing "Internet of Things," should result in more upstream providers and device manufacturers providing IPv6-enabled offerings to meet this demand. This Section canvasses related considerations.

7.1. The developing market for the Internet of Things

In the opinion of some, discussions on the Internet of Things too often assume that IP address space is an unlimited resource, and that it will scale as the IoT does. But, as we know, "IP address space is not unlimited. In fact, the IPv4 address space has been depleted since February 2011. And [this may be] the single best reason to consider IPv6 … for the future of IoT."[146]

[146] Sébastien Ziegler, Peter Kirstein, Latif Ladid, Antonio Skarmeta, and Antonio Jara, IEEE Internet of Things Newsletter, *The Case for IPv6 as an Enabler of the Internet of Things* (14 July 2015), available at: http://iot.ieee.org/newsletter/july-2015/the-case-for-ipv6-as-an-enabler-of-the-internet-of-things.html.

The International Telecommunication Union has defined the "Internet of Things" (IoT) as "a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies."[147] As one commentator described:[148]

> *The Internet of Things revolves around increased machine-to-machine communication; it's built on cloud computing and networks of data-gathering sensors; it's mobile, virtual, and instantaneous connection; and they say it's going to make everything in our lives from streetlights to seaports "smart."*

More "things" are coming online and the Internet is growing because of it. As one contributor explained:[149]

> *Projects that interconnect devices to reduce power consumption, increase efficiency, and generally make better use of the world's existing resources will require the allocation of vast numbers of IPv6 addresses. Ubiquitous connectivity of these devices using IPv6 is paramount to a simple roll-out in consumer markets, from [Intelligent Transport Systems (such as interconnected cars)], to home automation (e.g. light bulbs, refrigerators, and power, water, and gas meters), to medical devices to allow patient monitoring. The back-end cloud services needed to service this high growth, high innovation ecosystem will also need IPv6.*

New markets are emerging in response to a small but growing demand for IPv6-enabled products - the "smart house," for example, which has IPv6-enabled home appliances, for example printers, thermostats, refrigerators, and light bulbs.

For early adopters however, in their capacity as consumers of IPv6-enabled products, the market is still young. Product availability and consumer choice remains limited. Further, when products are found and purchased, they must be configured. Unlike other consumer electronics IPv6-enabled home appliances are not "plug and play." There are no interface standards for configuration. Non-technical consumers require help.

7.2. Consumer awareness

BPF contributors identified consumer awareness as one area that could benefit from best practices. It is not easy to raise and maintain the average consumer's interest in the technical standards that their electronic devices use. As one contributor explained:

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[147] Recommendation ITU-T Y.2060 (06/2012), International Telecommunication Union (ITU) Internet of Things Global Standards Initiative (IoT-GSI), available at: http://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx.
[148] Daniel Burrus, Wired Magazine, *The Internet of Things is Far Bigger than Anyone Realizes* (2014), available at: http://www.wired.com/insights/2014/11/the-internet-of-things-bigger/.
[149] Contribution, Olivier Crepin-Leblonde, ICANN ALAC, U.K. For further reading on IPv6 and IoT, see Sébastien Ziegler et al., *The Case for IPv6 As an Enabler for the Internet of Things* (July 2015), Institute of Electrical and Electronics Engineers (IEEE) website, available at: http://iot.ieee.org/newsletter/july-2015/the-case-for-ipv6-as-an-enabler-of-the-internet-of-things.html. For more information on Intelligent Transport Systems, see the Car 2 Car communications consortium, available at: https://www.car-2-car.org; See also the European Commission's page on Intelligent Transpot Systems, available at: http://ec.europa.eu/transport/themes/its/index_en.htm.

> *Most consumers aren't aware of IPv6; no surprise there, as consumers also aren't aware of what [quadrature amplitude modulation (QAM)] standard their TV uses or other technical details about the technology they use every day. That's very likely never to change.*

And:

> *There is no standard or even best practice for how the device alerts the consumer that it is using IPv6. For example, there isn't an IPv6 equivalent to the 4G LTE shown on cell phones.*

BPF discussion then turned to whether a "buzzword like 'v6 enabled' would be a good thing to provoke [the] curiosity of … end users that care about such details." The same contributor added:[150]

> *That said, it's one thing to put such promotional words/logo on devices, it's another thing for it to have meaning to the buyer. At the moment, a typical end user just wants to be able to access his/her favourite services … So long as the device is tested to do that, they would be fine.*

A standard, logo, or some form of certification was raised as one solution to the problem of low consumer awareness.

7.3. Certification

A well-recognised, voluntary standard for certification of IPv6-readiness in consumer devices was raised as a best practice. It is important that such standards are voluntarily adopted, one contributor explained, because mandated standards - for example through Type Approval schemes - "add overhead cost to placing equipment on the market, as well as to feature development and testing." Further, as Type Approval schemes have not heretofore been required for IPv4, any such mandate for IPv6 only will disincentivize and impede IPv6 deployment:

> *Equipment vendors will see an extra cost for deploying IPv6 in its products. It will cost less for them to place IPv4-only equipment on the market, since they would not incur the expense of IPv6 Type Approval.*

BPF discussion identified the IPv6 Forum's "IPv6-Ready Logo Program" as an example of a voluntary certification standard for various IPv6 aspects (devices, as well as training courses, etc.). The program focuses on IPv6 conformance and interoperability testing. Its goal is "to increase user confidence by demonstrating that IPv6 is available now and ready to be used."[151]

The program is managed by the IPv6 Ready Logo Committee, which is composed of representatives from vendors, service providers, academic institutions, IPv6 organisations, and others. As explained on the program's website:

[150] List, Seun Ojedeji, Federal University Oje-Ekiti, Nigeria.
[151] Email correspondence, Yannick Pouffary, IPv6 Forum, United States.

The IPv6-Ready Logo Committee's mission is to define the test specifications for IPv6 conformance and interoperability testing, to provide access to self-test tools, and to deliver the IPv6-Ready Logo. The key objectives and benefits of the IPv6-Ready Logo Program are to:

- *Verify protocol implementation and validate interoperability of IPv6 products;*
- *Provide access to free self-testing tools; and*
- *Provide IPv6-Ready Logo testing laboratories across the globe dedicated to provid[ing] testing assistance or services*

In the final Section of this document, we briefly address the role of IPv6 measurement as best practice.

8. Tracking success: Measurements

One possible future work area for the BPF on IPv6 Adoption is to examine the role of IPv6 measurements. In future work, measurements should be able to help us to track the relative success of different best practices on IPv6 adoption. Measurements can also be used to raise awareness about IPv6 adoption, including for key decision makers, when discussing IPv6 policies.

APNIC has done extensive work on IPv6 measurement, conducting "a broad-based, long term measurement of the level of uptake of IPv6 across the Internet."[152] Outside of providing valuable data for reference, APNIC's website also visualizes the data it collects, making it easy for visitors to see IPv6 deployment rates on a country-by-country basis. **Google** also measures IPv6 activity, tracking user use of IPv6 on a worldwide basis.[153] **Cisco's** 6Lab was also mentioned during the BPF as another resource for IPv6 measurement, as well as the website of **World IPv6 Launch**.

For readers who are interested in knowing more about IPv6 measurement activities, one resource mentioned during the BPF was the AMC's Internet Measurement Conference. This annual event focuses on Internet measurement and analysis. "The aim is that papers presented at the conference contribute to the current understanding of how to collect or analyze Internet measurements, or give insight into how the Internet behaves."[154]

[152] See: APNIC's IPv6 measurement page, available at: http://labs.apnic.net/measureipv6/.
[153] See: Google's IPv6 Statistics, available at: http://www.google.com/intl/en/ipv6/statistics.html#tab=per-country-ipv6-adoption&tab=per-country-ipv6-adoption.
[154] See: ACM Sigcomm website, available at: http://www.sigcomm.org/events/imc-conference.

9. Conclusion and Next Steps

The Best Practices Forum on *Creating an Enabling Environment for IPv6 Adoption* explored different best practices that have helped to create an environment that promotes and supports the adoption of IPv6. Amongst other topics, the BPF looked at IPv6 Task Forces, capacity building initiatives, best practices in the private sector, and the role that governments, National Research and Education Networks, and Universities can play.

The BPF outcome document intends to be a source of information and examples for people and organisations in their various efforts to promote, deploy and spread IPv6.

Within the timeframe of the 2015 intersessional work it was necessary to limit the scope of the document to certain 'best practices' and to be selective in the examples. Ideally, the IGF continues this work towards the IGF in 2016, so that this best practices document becomes a living document, and is further completed and actualised. Moreover, a continuation of the BPF on IPv6 would allow the Internet community to broaden the scope and focus on areas that haven't yet been looked at, for example the economic decision-making process that sits behind the decision to deploy IPv6, as was suggested during the IGF Main session on Intersessional activities in Joao Pessoa, Brazil.

10. Appendices

10.1. BPF IPv6 - way forward

Contribution by Marco Hogewoning

Main Session on IGF Intersessional work:
Policy Options and Best Practices for Connecting the Next Billion
11 November 2015, Joao Pessoa, Brazil

Outcome and next steps of the Best Practices Forum on IPv6

As one of the contributors, it is my pleasure to share some of the outcomes of the IPv6 best practices forum.

Of course that is the most important and very obvious conclusion that can be drawn from this process, and many people before me have stated the same: in order to connect the next billion people, we need IPv6.

That said the BPF in particular focussed on those elements that we think could create an environment that enables and promotes the deployment of IPv6.

What is especially important, besides international coordination, is to cooperate on a national level as well. A local IPv6 task force provides an efficient way to exchange experiences and distribute knowledge amongst the local operators, also it is a great way to coordinate amongst the different parties involved. In the BPF discussions we have identified several dependencies that exist, for example between providers of access services and those who provide content. Coordination on milestones and cooperation to align efforts could greatly increase the effect of IPv6 deployment in a national context.

That said and focussing on the topic of this afternoon session, which is the policy options that could contribute to this, our group identified two areas where governments specifically can contribute to create an environment that has a positive attitude towards IPv6.

The first thing would be to deploy IPv6 yourself. Governments are a large user of the Internet themselves and by deploying IPv6 on their own networks and services, they can provide an incentive for equipment manufacturers and service providers to deploy IPv6. Showing leadership

can provide the local market with confidence that IPv6 is an option and stimulate them to adopt IPv6 in their products and services as well.

The second policy option our group would like to bring forward is to carefully evaluate existing policies and regulations for a protocol bias and more importantly any obstacles that would prevent or discourage people from deploying IPv6.

A local IPv6 task force could provide a great venue to discuss identify any issues and to discuss solutions that would be satisfactory to the objectives of all stakeholders involved and which lead to a more widespread adoption and use of IPv6.

Finally, we also discussed the continuation of the IPv6 best practice forum itself and more importantly any areas which we think this future work could focus on.

We think the inter sessional work and the tangible outcomes it produced, are a great contribution to human and institutional capacity building, the draft document we have open for comments was very well received by the community and several stakeholders have submitted comments in support of this work.

We therefore would like to the ask the IGF to continue this work towards the 2016 session. More specifically we would like to suggest to focus more on the economic decision making process that sits behind the decision to deploy IPv6. We feel that the potential financial impact of IPv6 adoption is key factor for the decision many businesses and other stakeholders have to make and further studying and documenting these mechanisms could be a great contribution to achieve our goals of the global deployment of IPv6 and finally in connecting the next billion users to the Internet.

10.2. Non-Exhaustive list of IPv6 Task Forces

This non-exhaustive list of IPv6 Task Forces was compiled based on the input received during the BPF. Additional IPv6 Task Forces were able to be mentioned through comments on the review platform, or submitted via the survey. A global IPv6 Task Force map is available at http://www.ipv6tf.org.

Table: Non-Exhaustive list of IPv6 Task Forces

Organization	State / Country / Industry / Region	Website
APIPv6TF	Asia-Pacific	http://www.ap-ipv6tf.org
IPv6 Forum	Australia	http://www.ipv6forum.com.au
IPv6 Council	Belgium	http://www.ipv6council.be/
IPv6 Canada	Canada	http://www.ipv6canada.ca/
IPv6 Forum	Chad	https://www.facebook.com/pages/IPV6-FORUM-CHAD/341444906009204
IPv6 Council	Colombia	http://www.co.ipv6tf.org/
ID-IPv6TF	Indonesia	
LAC IPv6 TF	Latin America and the Caribbean	http://portalipv6.lacnic.net/flip-6-lac-ipv6-tf/
IPv6 Forum	Mexico	http://www.ipv6forum.com.mx; http://www.ipv6summit.mx/
IPv6 Task Force**	New Zealand**	http://www.ipv6.org.nz/
North America IPv6 Task Force	North America (Canada, US, Mexico)	http://www.nav6tf.org/
Spanish Chapter of the IPv6 Task Force	Spain	http://www.spain.ipv6tf.org/html/index.php
Swiss IPv6 Council	Switzerland	http://www.swissipv6council.ch
IPv6 Forum	Thailand	http://www.thailandipv6.net/
IPv6 Task Force	The Netherlands	http://new.ipv6-taskforce.nl
IPv6 Council	United Kingdom	http://www.ipv6.org.uk/
CAv6TF	USA - California	http://cav6tf.org/
Rocky Mountain IPv6 Task Force	USA - Colorado, etc.	http://www.rmv6tf.org/
IPv6 Task Force Hawai'i	USA - Hawaii	http://ipv6hawaii.org/
MidAtlantic IPv6 Task Force	USA - New York, Pennsylvania, Delaware, New Jersey, Maryland, Washington, DC	http://midatlanticv6tf.org/
TXv6TF	USA - Texas	http://www.txv6tf.org/
** *Task Force decommissioned*		

10.3. Best Practices Survey Responses

The Best Practice Survey was launched to collect examples of practices that help to create an enabling environment for IPv6 adoption. The survey opened in mid July 2015 and was available to all via the IGF website until the last day of the IGF meeting. Respondents were asked to select their stakeholder group. We respect the wish of respondents who wished to remain anonymous.

1. Outreach and awareness raising, Incentives in LAC (Latin America and the Caribbean)
2. www.ipv6council.be (Belgium)
3. Support & awareness Interlan customers (Sweden)
4. Knowledge and information Sharing with clients (Pakistan)
5. IPv6 Capacity building by the China Education and Research Network (China)
6. Learning to implement IPv6 in an ISPs network (Bangladesh)
7. IPv6 as a mandate in India (India)
8. IPv6 deployment workshop (Bangladesh)
9. Enable IPv6 in Domain Registry (Sri Lanka)
10. Hands-on IPv6 Training in Africa (Mauritius)
11. Dutch IPv6 Task Force (the Netherlands)
12. National IPv6 launch (Finland)
13. 2015 IPv6 Best Practices (IPv6 Forum BP eBook)
14. IPv6 University Core Network and Services Deployment (Venezuela)
15. Swiss IPv6 Council (Switzerland)
16. North American IPv6 Summit (USA)
17. 2012/2013 IPv6 Research and Development project (Germany)
18. General IPv6 Evangelism (US)
19. Email blast to direct-connect customers (US)
20. AFRINIC IPv6 Task Force (Africa)
21. IPv6 adoption by Network Operator (US)
22. National Working Group - deployment of IPv6 (Norway)
23. Member training workshops (research & education network) (USA)
24. IPv6 Adoption and Deployment in the Kingdom of Saudi Arabia (Saudi Arabia)
25. MAP-T implementation for Broadband Service on IPv6 (India)
26. Deploying IPv6 - University of New Hampshire (USA)

1. Outreach and awareness raising incentives in LAC

Description

- Company and government BIDs should always ask for IPv6, it means that is they are going to buy something (Devices, Links) these things should always support IPv6.
- Governments should lead by example enabling they networks and websites with IPv6
- We created a video in Spanish in order to help understand the importance of IPv6 within ISPs. https://www.youtube.com/watch?v=BswW2uVHoX0
- We also created an IPv6 song to promote IPv6: https://www.youtube.com/watch?v=99Qw9cfpyEg

Start date Many different years

Is still ongoing? Yes

Additional information

- https://www.youtube.com/watch?v=99Qw9cfpyEg
- https://www.youtube.com/watch?v=BswW2uVHoX0

Geographic Scope Global

Category Outreach and awareness raising, Incentives stimulating IPv6 uptake

Main stakeholders Government, private sector, technical community, civil society and academia

Who initiated? Lacnic

Who manages? Alejandro Acosta

Target audience? Government, private sector, technical community, civil society and academia

Contribution to IPv6 deployment?

- We create awareness
- We train hundred of people per years in IPv6
- In Lacnic we have also a kind of _light_ join venture to help some ISPs to implement IPv6

What worked well? Trainings and the _light_ join venture to help some ISPs to implement IPv6

Contribution by Alejandro Acosta, Venezuela, Lacnic, Technical Community

2. www.ipv6council.be (Belgium)

Description

- Open communication
- Social event following meeting
- Hosting meetings @ interested members, changing location each time
- everyone welcome, not only big ISPs/Telco
- Open floor to everyone who wants to step up

Start date 2010

Is still ongoing? Yes

Additional information www.ipv6council.be

Geographic Scope Global, Local

Category	Measuring and sharing information on the status of IPv6 deployment, Outreach and awareness raising, Knowledge and experience sharing, Incentives stimulating IPv6 uptake
Main stakeholders	all sectors, public as well as industry, small as well as large companies
Who initiated?	Univ + enterprise
Who manages?	small board has been set up for this
Target audience?	anyone who wants to come

Contribution to IPv6 deployment?
Belgium #1 in IPv6 access
All ISPs playing along today, this opens possibilities to others

What worked well? the "social"/"open" part, lots of discussion afterwards with a beer

What didn't work as expected?
Enterprise remains problem, mobile and content as well, although some progress last couple of months

Unintended positive effects? better co-op with opensource

Lessons learned / suggestions.
Make sure the sessions don't get to "technical", i.e. create a pleasant, open environment, leaving the floor to anyone stepping up in your country

Contribution by Carl Wuyts, Belgium, Co-chair IPv6 Council Belgium, Technical Community

3. Support & awareness Interlan customers (Sweden)

Description
We have helped our customers since 2007 to deploy IPv6 for their public services and interlan network. Interlan's own network have been dual stacked since 2007.

Start date	2007
Is still ongoing?	Yes
Additional information	On many places. www.dnssecandipv6.se is a collection of some of my IPv6 pages. Others are http://secureenduserconnection.se/wp-content/uploads/2015/02/SEC-Secure-End-user-Connection-2015-02-12.pdf , google for "IPv6 christmas goat" and I can't remember all.
Geographic Scope	Regional, Sweden
Category	Measuring and sharing information on the status of IPv6 deployment, Capacity Building, Knowledge and experience sharing, Incentives stimulating IPv6 uptake, IPv6 training

Main stakeholders All examples above + ISP's.

Who initiated?	Often Interlan but sometime the customers
Who manages?	Interlan

Target audience? See Q3.4

Contribution to IPv6 deployment?
Easy - Inventory, training under deployment and monitoring.
Enable IPv6 is very easy when you start take a look at it.

What worked well? Almost everything. www, MX and DNS. Deployment of IPv6 for every workstation and almost every server.

What didn't work as expected?
Some CMS and some "IPv6-ready" wifi and firewalls who don't where ready at all.

Unintended positive effects?
Yes, it's funny to see how much % the internal -> external IPv6-traffic it is. In a wifi guest network it's sometime over 80% IPv6.

Unintended negative effects?
Just do it, It's fun, you learn a lot, and you will be an expert and we don't have so many who can IPv6.
Yes, some Swedish authorities who have a AAAA RR on www have very unstable IPv6 and some of them has never worked. See http://www.myndighetermedipv6.se

External events/initiatives that contributed to success or failure?
Yes, some municipalities have talked about it.

Contribution by Torbjörn Eklöv, Sweden, Interlan, Private Sector

4. Knowledge and information Sharing with clients (Pakistan)

Description We pitch the solution of ipv6

Start date 2 years

Is still ongoing? Yes

Geographic Scope Regional, Local

Category Measuring and sharing information on the status of IPv6 deployment, Knowledge and experience sharing

Main stakeholders Banking sector, and user end

Who initiated? Our Team

Who manages? Me

Target audience? Enterprise Client

Contribution to IPv6 deployment? Good

What worked well? we made the solutions

External events/initiatives that contributed to success or failure?
We did the enterprise solutions

Lessons learned / suggestions. having different kind of information

Contribution by Fahad Khan, Pakistan, Cisco, Private Sector

5. IPv6 Capacity building by the China Education and Research Network

Description
The China Education and Research Network (CERNET) is an academic network in mainland China, with the universities, institutes and schools as the customers. The student population in mainland China is about 320 million and there are no enough public IPv4 addresses available. The cloud computing, the mobile Internet and the Internet of Things make the IPv4 address exhaustion situation even worse. Eighteen years ago, the CERNET joined 6Bone. Ten years ago, we have deployed an IPv6-only backbone named CERNET2 and eight years ago, we have developed the IPv4/IPv6 stateless translation technology called IVI [RFC6219], which becomes the proposed IETF standard of the IPv4/IPv6 stateless translation [RFC6145], [RFC6052], etc. In order to improve the customer experience for the IPv4-only applications and application with the address literals embedded, we have developed double IPv4/IPv6 stateless translation technology called dIVI, which becomes the mapping address and port with translation (MAP-T) [RFC7599]. Our experience indicates that the MAP-T (double translation), IVI (single translation) can provide a smooth and transparent transition to IPv6-only Internet.

Start date 1997

Is still ongoing? Yes

Additional information

- http://dl.acm.org/citation.cfm?id=1971170
- http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=1631982&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D1631982
- http://datatracker.ietf.org/doc/rfc6219/
- http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6005444&url=http%3A%2F2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6005444
- https://datatracker.ietf.org/doc/draft-xli-v6ops-cernet-deployment/

Geographic Scope Global

Category Capacity Building

Main stakeholders academia, the China Education and Research Network is providing Internet connectivity for the universities and schools.

Who initiated? Minister of Education

Who manages? Minister of Education and universities community

Target audience? Universities and schools

Contribution to IPv6 deployment?
There are more than 300 universities connected using IPv6 and the number of end users is more 5 million.

What worked well? The Ipv6-only backbone and the stateless IPv4/IPv6 single (IVI) and double (MAP-T) translation technologies.

What didn't work as expected?
Even we have deployed an IPv6-only network, the IPv4 as a Service will be required for a long time.

Unintended positive effects? No.

Unintended negative effects? No.

External events/initiatives that contributed to success or failure? No.

Lessons learned / suggestions.

(1) The IPv6 can provide stable services today.
(2) The connectivity between IPv4 and IPv6 networks (via translation) is the way to transit Internet from Ipv4 to IPv6.

Contribution by Xing Li, China, China Education and Research Network (CERNET), Academia

6. Learning to implement IPv6 in an ISPs network (Bangladesh)

Description
At 2013 we were implementing the IPv6 in our network. Our DNS server, Mail server, DHCPv6 already running in our network. Recently we are planning to provide the IPv6 address for our clients.

Start date 2013

Is still ongoing? Yes

Additional information Not yet

Geographic Scope Global, Local

Category Measuring and sharing information on the status of IPv6 deployment, Outreach and awareness raising, Knowledge and experience sharing

Main stakeholders Internet Service Provider (BDCOM Online Limited)

Who initiated? BDCOM

Who manages? BDCOM NOC Team

Target audience? BDCOM NOC Team

Contribution to IPv6 deployment?

1. DNS
2. BGP
3. DHCPv6
4. Planning
5. Allocation
6. Mail

What worked well? DNS, BGP and Mail services are working well

What didn't work as expected?

DHCPv6 and Bandwidth management didn't turn out as our expected!!

Contribution by Md. Abul Bashar, Bangladesh, Internet Service Provider, Technical Community

7. IPv6 as a mandate in India

Description
In India Govt of India has mandated the timelines for time bound and phased manner implementation of IPv6 across all stakeholders. Govt have released two road maps in this regards. and accordingly could achieve good progress.

Start date 2009

Is still ongoing? Yes

Additional information http://dot.gov.in/ntcell

Geographic Scope Global

Category Measuring and sharing information on the status of IPv6 deployment, Capacity Building, Outreach and awareness raising, Knowledge and experience sharing, Incentives stimulating IPv6 uptake.

Main stakeholders In India we considered all major stakeholders on board for proper and timely implementation of IPv6 across all stakeholders for creating complete Eco-system on dual stack viz. Service Providers, Content & Application Providers, Device Manufacturers, End user Device Vendors, Cloud Service Providers, Government Organization etc.

Who initiated? Government of India, DoT

Who manages? DoT

Target audience? All Major Stakeholders as mentioned above.

Contribution to IPv6 deployment?
Almost al the stakeholders have been asked to abide by the timelines of the National IPv6 Deployment Road map v-II which was released in March, 2013 and complete the transition by the mandated timelines. many of the Service Providers, Content Providers, and Government Organization are ready right now, almost all the end user devices launched after June, 2014 in India are IPv6 ready. efforts are being made to track and help all the stakeholders in the country by DoT while discussing in the meetings etc.

What worked well? Government Mandate for the stakeholders as well as persuasions by DoT

What didn't work as expected?
The stakeholders whose are not directly under control of DoT. however after persuasion they are also gearing up since we have mandated all the Government Organisation for taking any project which must be on IPv6 too which helped the other to come on IPv6.

Unintended positive effects?
yes, as IPv4 addresses are already exhausted and in view of M2M and IoT in the country the uptake of the IPv6 wiill inclrease rapidly.

Unintended negative effects?
always being quoted by the stakeholder the chicken and egg stories but in view of the mandate and persuasion from Government now they started to work.

External events/initiatives that contributed to success or failure?
no

Lessons learned / suggestions.
in view of the IPv4 addresses exhaustion, and many inherent advantages in IPv6 world has to go for IPv6 which is said to be more secure etc.

Contribution by India; Stakeholder Group: Government

8. IPv6 deployment workshop (Bangladesh)

Description
From ISOC Bangladesh Dhaka chapter, we arranged IPv6 deployment workshop regularly with the help of APNIC.

Start date 2011

Is still ongoing? No, we have finished

Additional information
We published news related to IPv6 deployment workshop in the Bangladeshi Newspaper.

http://www.internetsociety.org/articles/internet-society%E2%80%99s-bangladesh-dhaka-chapter-holds-ipv6-deployment-workshop

Geographic Scope Local

Category Measuring and sharing information on the status of IPv6 deployment, Community Building, Capacity Building, Outreach and awareness raising, Knowledge and experience sharing.

Main stakeholders Internet Society, APNIC, Bangladesh ICT Journalist Forum etc.

Who initiated? ISOC BD Chapter

Who manages? ISOC officers

Target audience? Mainly Internet Engineers

Contribution to IPv6 deployment? After training IPv6 deployment rate increased in Bangladesh.

What worked well? Hand-on Training & Workshop

Contribution by Mohammad Kawsar Uddin, Bangladesh, ISOC Bangladesh Chapter, bdNOG, Civil society

9. Enable IPv6 in Domain Registry (Sri Lanka)

Description
As the ccTLD registry we wanted to enable IPv6 in our primary DNS servers. We requested our DNS server hosting partners to enable IPv6 in the network. After enabling IPv6 in .lk secondary DNS server, we wanted to enable IPv6 at our main office network and server network. We requested the ISP to enable IPv6 in our network. It took sometime to enable IPv6 as their service management servers were not ready with IPv6. After enable IPv6 in the link, we configured our main firewall with IPv6. We used Dual stack mechanism as our DNS servers should be able to cater services for both IPv6 and IPv4.

Start date 2014

Is still ongoing? Yes

Geographic Scope Local

Category Measuring and sharing information on the status of IPv6 deployment, Community

Building, Capacity Building

Main stakeholders Private Sector – ISP

Who initiated? Our CEO Prof Gihan Dias and my self

Who manages? Me

Target audience? DNS users and Internal customers

Contribution to IPv6 deployment?
As our firewall is not supporting well, IPv6 autoconfiguration was not fully worked. It stops at router solicitation and we used manual IP configuration

Contribution by Chamara Disanayake, Sri Lanka, LK Domain Registry, Private Sector

10. Hands-on IPv6 Training in Africa

Description
We run the best IPv6 training program in Africa. Training 600+ network engineers in at least 17 countries each year on practical skills required to plan and deploy IPv6 networks.

We've developed robust processes for organising a workshop, getting feedback and using it to improve the continent. All workshops are at least 50% hands-on and they are free of charge to participants.

Start date 2010

Is still ongoing? Yes

Additional information learn.afrinic.net

Geographic Scope Regional, Africa

Category Community Building, Capacity Building, Outreach and awareness raising, Knowledge and experience sharing

Main stakeholders
- AFRINIC Ltd
- ISP Associations
- Government ICT agencies
- Academia

Who initiated? Part of our mission as an RIR

Who manages? Mukom Akong Tamon

Target audience? Network Engineers

Contribution to IPv6 deployment?
For each country we've been to, we can count on at least 30 people qualified to plan and start an IPv6 rollout.

What worked well? Skills and knowledge transfer on the mechanics of IPv6

What didn't work as expected?

Taking action based upon those skills. Main reason being that it doesn't matter how competent at IPv6 the engineers are, if the managers and executives don't 'get it', they won't make available the resources (time, money, etc) required to actually deploy IPv6. We have a plan to dealing with that too that should come into place by next year.

Unintended positive effects?

The demand for the training is often more than we can handle given our limited resources. Some higher level participants have gone on to deploy IPv6 after attending the training and a few countries are doing mini sessions based upon the content we created.

Lessons learned / suggestions.

- An effective IPv6 Foundations training needs at least 2 days
- Participants must be pre-screened for requisite knowledge before attending
- Content must be 50:50 theory:practice
- Rigorous feedback must be put in place and used to update the content

Contribution by Mukom Akong T., Mauritius, AFRINIC Ltd, Technical Community

11. Dutch IPv6 Task Force (the Netherlands)

Description

A Dutch TF IPv6 was created in 2005. This TF is open to all who want to participate. The TF has focussed on awareness (2005-2011) and subsequently on support for introducing IPv6 (2011-2015).
TF created a mailing list to answer questions and/or discuss issues and to prepare position statements (sometimes necessary to force government decisions and or large company decisions).
There is als a Web site with information on IPv6
Regularly the TF organizes seminars targeted at different stakeholders.

Start date 2005

Is still ongoing? Yes

Additional information http://new.ipv6-taskforce.nl

Geographic Scope Other (e.g. industry-specific, community specific), National

Category Measuring and sharing information on the status of IPv6 deployment, Community Building, Capacity Building, Outreach and awareness raising, Knowledge and experience sharing, Incentives stimulating IPv6 uptake, Political/government interaction.

Main stakeholders Government: Supports the TF, no active role
technical community: Most active participants. do most of the work
private sector: Participates to learn

Who initiated? Government and private sector

Who manages? Erik Huizer and ecp.nl

Target audience? Dutch society

Contribution to IPv6 deployment?

The results are meager if we only measure IPv6 packets. this is because the two major and dominating ISPs in NL only just started deploying IPv6. (Despite lots of pressure from the TF).
However many commercial ventures are prepared, Government is prepared and has mandated IPv6 in all tenders, Local governments have been educated and trained. etc. etc.
So level of preparedness is high, actual implementation depends on two major ISPs

What worked well? Political pressure on government. Approaching members of parliament to ask nasty questions thus forcing the government to:
- get their own ICT in order
- Demand IPv6 in every tender
- put pressure on large ISPs

What didn't work as expected? Simple awareness raising through press and radio/TV.

Unintended positive effects? None

Unintended negative effects? Not that I am aware of

External events/initiatives that contributed to success or failure?
Most if not levants happened because of initiatives/pressure from the IPv6 TF

Lessons learned / suggestions.
An IPv6 TF is national and works according to the culture of a country. In Belgium that works different from The netherlands. In The Netherlands there is much individuality and much is achieved through meetings. This takes a long time.

Contribution by Erik Huizer, Netherlands, SURFnet bv, Technical Community

12. National IPv6 launch (Finland)

Description
I got two years ago the responsibility of chairing our national IPv6 WG (IPv6 council) and first we did recommendations for IPv6 adoption. After they there ready, I asked if the people were willing to do the launch.

After discussing the topic for 10 years, ISPs were rather ready to take IPv6 into use. It just needed clear goals, some leadership and definitely marketing, publicity and peer pressure.

Start date launch 2014, council around early 2000.

Is still ongoing? Yes

Additional information www.ipv6now.fi

Invitation from our DG:
https://www.viestintavirasto.fi/attachments/Kutsu_osallistua_IPv6n_kansalliseen_kayttoonottoon.pdf

Recommendation is also unfortunately available only in Finnish:
https://www.viestintavirasto.fi/attachments/suositukset/200_2014_S_Suositus_IPv6_n_kayttoonotosta_kuluttajaliittymissa.pdf

Geographic Scope Local, Finland

Category Measuring and sharing information on the status of IPv6 deployment, Outreach and awareness raising, Knowledge and experience sharing, Incentives stimulating IPv6 uptake

Main stakeholders We as NRA and our main ISPs and content and web service providers. Also some experts having personal/professional interested in IPv6.

Who initiated? Me

Who manages? Me

Target audience? ISPs and content and web service providers, but also media

Contribution to IPv6 deployment?

1) Defined a clear and ambitious goal
2) Together with our major stakeholders
3) Got our management (director general) support
4) Unofficial discussions and preliminary promises
5) Invitation with broad distribution with different channels
6) Media release, news and gathering peer pressure
7) Had enough time (1 year) for this

What worked well?

1. We got a broad coverage and support so it was not just me sending the invitations.
2. We got 1 major ISP to join first that helped to gain peer pressure that was rather important
3. Had prepared a specification before that helped ISPs to take IPv6 into use

What didn't work as expected?

1. ISPs were rather afraid to take IPv6 into use automatically. They were afraid about security and quality of service so the launch was more limited than I first hoped for
2. UE support (existing equipments users are using) for IPv6 is still rather bad especially in mobile networks limiting also greatly the launch.
3. There was rather hard to find any benefits for IPv6 to help the marketing...

Unintended positive effects?

At least one ISP removed some port restrictions compared to IPv4 so users got more open internet.

Unintended negative effects? Have not seen any

External events/initiatives that contributed to success or failure?

IPv6 launch (global) and global measurements
I think that industry is just rather ready to take the step if given just a little push.

Lessons learned / suggestions.

Organizing a national launch takes time. Make proposal and see what response it gets. Get at least some ISPs to commit. When it is safe to start with bigger audience. Try also to get broad shoulders to back you, it helps. But still a lot of marketing, talking and there you go. Try also get some benefits for those ISPs that are taking part the launch. For example with press releases and media contancts.

Contribution by Klaus Nieminen, Finland, FICORA, Government

13. 2015 IPv6 Best Practices (IPv6 Forum BP eBook)

Description IPv6 Roadmap with contributions from many IPv6 experts around the world.

Start date 1999

Is still ongoing? Yes

Additional information see IPv6 Best Practices eBook 2 on http://www.ipv6forum.com/

Geographic Scope Global

Category Measuring and sharing information on the status of IPv6 deployment, Community Building, Capacity Building, Outreach and awareness raising, Knowledge and experience sharing, Incentives stimulating IPv6 uptake

Main stakeholders Government, Regulators, industry and IPv6 Forum experts

Who initiated? IPv6 Forum

Who manages? IPv6 Forum

Target audience? Governements and Regulators first and then industry

Contribution to IPv6 deployment?

IPv6 Forum has been initiated by the IETF IPv6 experts who designed IPv6 back in 1999 after the RFC 2460 was released by in Dec 1998 t get deployment and best practices to move forward. The IPv6 Forum has establshed over the years some 90 IPv6 Chapters (v6 Task Forces and IPv6 Councils) around the world delivering some very large conferences in Japan, South Korea, China, Singapore Malaysia, Australia, Thailand, Taiwan, India, MEA, across Europe to the US and Latin America to mention just the largest with some over 120,000 members.

What worked well? ISP motivation of large and international ISPs, OTT adoption (Google, Faceboo,..), government incentives and mandates,.. developing countries mainly with regulators mandates if they are skilled enough to justify it.

What didn't work as expected?

ISPs IPv6 skilled engineers are a rare commodity and ISP management is busy fire fighting current issues delaying v6 until the last v4 address in their own pool is getting depleted.

Unintended positive effects?

Facebook demonstrated in 2015 greater v6 benefits by showing between 20-40% better network efficiency by deploying IPv6 only in their network.

Unintended negative effects?

Deploying of NAT was under-estimated and then the move to CGN delayed further deployment of v6

External events/initiatives that contributed to success or failure? numerous.

Lessons learned / suggestions.

like v4, deployment of v6 will be based on best practices of others, see first book in http://www.euchina-fire.eu/about-fire/ipv6-best-practices/

Contribution by Luxembourg, IPv6 Forum, Academia

14. IPv6 University Core Network and Services Deployment (Venezuela)

Description Networking and services Infrastructure configuration on IPv6 deployment

Start date 2011

Is still ongoing? Yes

Additional information http://repositorio.ucla.edu.ve/index.php/record/view/12340

Geographic Scope Global

Main stakeholders University Networking Technical staff.

Who initiated? University Networking Technical staff.

Who manages? University Networking Technical staff.

Target audience? University

Contribution to IPv6 deployment?
It is now possible access from IPv6 in the world to some internal web servers.
Routing allow to reach native or dual stacked ipv6 service from LAN to anywhere in the Internet.
It is possible to verify native acces (only IPv6) to one web server for testing (palavecino.ucla.edu.ve)

What worked well?
Routing
DNS
Reverse DNS
Web

What didn't work as expected?
Firewall firmware version.
Moodle access, little tricky
"Alejandrìa" system

Unintended positive effects? Possibility of grow in IPv6 deployment for final users in the next phase of the project.

External events/initiatives that contributed to success or failure?
Service contract for firmware upgrade (Routers and Firewalls) allow us to upgrade versions that support IPv6.
Venezuelan NREN (Reacciun2) IPv6 peer capacity service
One ISP don't have IPv6 support, so we can`t do IPv6 multihoming
LACNIC, ISOC, Oracle documentation sites.

Lessons learned / suggestions.
Ask for IPv6 prefix from RIR
Ask ISP for IPv6 support (Dual Stack)
Make sure to talk with isp for Reverse DNS
Verify firmware versions of firewalls, routers, switches and options to upgrade, if necessary
Make IPv6 Addressing Plan

Contribution by Jorge Gonzalez, Venezuela, Universdad Centroccidental Lisandro Alvarado,
Technical Community

15. Swiss IPv6 Council (Switzerland)

Description
As a chapter of the International IPv6 Forum we provide a platform to support IPv6 deployment in Switzerland with all stakeholders (economy, government, education).

Start date 2001 - restart 2010

Is still ongoing? Yes

Additional information www.swissipv6council.ch
dashboard.swissipv6council.ch

Geographic Scope Regional, Switzerland

Category Measuring and sharing information on the status of IPv6 deployment, Community Building, Outreach and awareness raising, Knowledge and experience sharing, Incentives stimulating IPv6 uptake

Main stakeholders We try to engage all stakeholders. On board we have ISPs, academia and business organisations.

Who initiated? Silvia Hagen

Who manages? Silvia Hagen

Target audience? everyone that deploys networks and services

Contribution to IPv6 deployment?

Provide platforms for discussions
Publish articles
Regular member events more technical
Enable knowhow transfer among members
Annual IPv6 Business Conference (www.ipv6conference.ch)
Surveys and information on deployment status

What worked well?

Member events have good regular attendance
IPv6 Business Conference has more attendees every year
Surveys provided platform to contact businesses and raise awareness

What didn't work as expected?

Financing is very hard, sponsoring dropped substantially since 2010
People appreciate initiative, but nobody wants to contribute financially

Unintended positive effects?

The fact that we are a neutral platform opens doors to discussions with stakeholders that were harder to reach as a consultant or ISP

Unintended negative effects? No

External events/initiatives that contributed to success or failure?

The uptake of IPv6 in other countries, such as Belgium, Germany, US helps to show that IPv6 is used

Lessons learned / suggestions.

One of the most helpful points is to make providers of content/websites understand that only if they provide dual-stack access to their websites, they can ensure people have a good user-experience. This makes them go.

The survey we did among the Top Alexa 75 websites in Switzerland gave the opportunity to call people and ask them about their plans, which again created opportunity to tell them why it could be important to them. This actually led to the dual-stacking of several major websites in Switzerland, which can again be used to convince others.

Our Business conference has been very successful this year and we had great feedbacks. People appreciated to get access to case studies and indepth information. We had 130 attendees this year, and most of them were "end users" - e.g. organisations.

Contribution by Silvia Hagen, Switzerland, Swiss IPv6 Council, Technical Community

16. North American IPv6 Summit (USA)

Description
For the past several years we have run a 1-2 day, multiple track, seminar series discussing many topics related to IPv6 adoption and best practices. In the past 2 years this has also included SDN and NfV type topics as well as IoT to keep the content fresh. In the early years the bulk of the presentations were awareness and foundation type sessions which we still maintain - things like address planning and IP network design.

Start date We started the summits around 2008 as I recall

Is still ongoing? Yes

Additional information Most of our efforts are cataloged on the RMv6TF website at www.rmv6tf.org

Geographic Scope Global

Category Measuring and sharing information on the status of IPv6 deployment, Community Building, Outreach and awareness raising, Knowledge and experience sharing

Main stakeholders Really anyone with an interest in deploying IPv6 - be they government, private sector or academic.

Who initiated? Scott Hogg and CHuck Sellers were the founding members of the Task Force in Denver

Who manages? Currently, Oginian Mitev is our Chraiman

Target audience? Same audience as described in Q3.4 (main stakeholders)

Contribution to IPv6 deployment?
By running the IPv6 Summit and then making those presentations and videos available after the Summit, we have been able to reach a very wide audience with very technical information regarding all aspects of IPv6 from foundation "how-to" to in-depth training on things like the IPv6 Next header and IPv6 Multicast and IPv6 address planning, to deployment success stories in multiple verticals. We have also offered basic and advanced IPv6 training and with Nephos6 we have also offered reduced rate IPv6 certification at the event.

What worked well? The Summits have worked well, though the audience numbers have been down both due to economic factors as well as the level of IPv6 understanding seems to be higher now so the Summits are less about teaching and more on success and what's next. We have started small meetup style meetings that are still maturing.

What didn't work as expected?
Our reach has been limited - really the ability to get the word out about the IPv6 summit. We have never found the right mix of advertising methods to really drive the conference each year. We do have a core of returning folks every year, but just getting the word out has been hard.

Unintended positive effects? Not sure there have been any for us.

Unintended negative effects? None

External events/initiatives that contributed to success or failure?
The past World IPv6 events helped drive awareness and they contributed to increased attendance.

Lessons learned / suggestions.

Outreach can be really fun. Summits are hard work but the payoff is the returning folks and the first timers that tell you that it was all worthwhile. Getting the word out about meetings can be hard - finding ways of getting the word out is never easy in my mind.
Government folks with travel restrictions are hard to reach, but if the event is streamed, you may reach an audience that can't travel, but is multitasking at their desk so the value seems limited. Maybe a solution there is to hold a webcast in a room where folks have to leave the desk to sit in on things - which can cause it's own issues of coordination.

Contribution by Dan Torbet, USA, Rocky Mountain IPv6 Task Force, Technical Community

17. 2012/2013 IPv6 Research and Development project (Germany)

Description
Results of the Project are a IPv6 Transition Guide and IPv6 Profiles for the Public Administration under Creative Commons Licence

Start date 2012

Is still ongoing? No, we have finished

Additional information www.bva.bund.de/ipv6en

Geographic Scope Global

Category Outreach and awareness raising, Knowledge and experience sharing

Main stakeholders German Federal Ministry of Interior, Fraunhofer FOKUS, Cassini Consulting GmbH

Who initiated? German Federal Ministry of Interior

Who manages? German Federal Office of Administration

Target audience? Public Administration

Contribution to IPv6 deployment?
It describes IPv6 Best Practices for the Deployment und Migration from IPv4

What worked well? All

What didn't work as expected? Nothing

Unintended positive effects? No

Unintended negative effects? No

External events/initiatives that contributed to success or failure? No

Lessons learned / suggestions. All aspects

Contribution by Country: Germany, Stakeholder Group: Technical Community

18. General IPv6 Evangelism (US)

Description
In my previous job, I was paid full-time to tavel the world providing IPv6 education and training.
Today, I continue to do this as time permits, though it is no longer my full time job.

Start date 2009

Is still ongoing? Yes

Additional information If you google "Owen DeLong IPv6", you will find the documentation of many events and conferences where I spoke. This is the primary publishing. There have also been a few magazine articles.

Geographic Scope Global

Category Measuring and sharing information on the status of IPv6 deployment, Community Building, Capacity Building, Outreach and awareness raising, Knowledge and experience sharing

Main stakeholders Primarily the technical community, civil society, and private sector.
Some academia and government involvement also occurred.

Who initiated? I did

Who manages? I do

Target audience? Any audience seeking additional IPv6 knowledge or assistance in deploying IPv6.

Contribution to IPv6 deployment?
Provided clear, concise training on IPv6 deployment using real world examples and a practical lab environment that allowed students to gain actual experience with IPv6 that could be directly applied to their environments.

What worked well? Portable training lab I designed and built.
Step-by-step modular curriculum

What didn't work as expected?
Ability to get funding to support the ongoing efforts

Unintended positive effects?
I got to meet a great many people around the world all engaged in deploying IPv6.

Unintended negative effects?
Inability to convert this to a self-funding project (through billable training, etc.) significantly reduced the ability to perpetuate the practice.

External events/initiatives that contributed to success or failure?
Trying to schedule conferences, manage travel, do all of the marketing, most of the billing, prepare for and teach the classes, etc. all as one individual is not practical. Unfortunately, I could not build a staff until I could produce revenue. I could not produce sufficient revenue because staffing was inadequate.

Lessons learned / suggestions.
Secure funding for at least one year of a staff of at least 3. Have one person who can design/build and deliver curriculum. One person responsible for keeping that person busy (booking paid training as much as possible and conferences/speaking engagements otherwise). The third person should be doing the marketing and sales, developing collateral material, generating and following up on leads for paid training opportunities.

Contribution by Owen DeLong, US, Represent: Me, myself, and I... Affiliation: ARIN AC, Akamai Technologies, DeLong Consulting, AOPA, PADI, Host Virtual, Technical Community

19. Email blast to direct-connect customers (US)

Description
We sent an email out to all our business customers explaining the reasons for considering IPv6 adoption.

Start date 2013

Is still ongoing? No, we have finished

Geographic Scope Regional

Category Outreach and awareness raising, Knowledge and experience sharing

Main stakeholders private sector

Who initiated? Self

Who manages? Self

Target audience? Business customers

Contribution to IPv6 deployment?
Initial awareness -- that customer's IPv6 was willing and ready

What worked well? It did raise some level of awareness

What didn't work as expected?
Very few people were interested

Unintended positive effects? None

Unintended negative effects? A few customers were confused.

External events/initiatives that contributed to success or failure? None

Lessons learned / suggestions. Most customers are disinterested.

Contribution by Country: United States, Stakeholder Group: Technical Community

20. AFRINIC IPv6 Task Force (Africa)

Description
This community driven initiative is monitored by AFRINIC, to promote the uptake of IPv6 in Africa. It is also a communication list toward and evangelise the benefits of IPv6

Start date 2013

Is still ongoing? Yes

Additional information Not yet

Geographic Scope Regional

Category Community Building, Outreach and awareness raising, Knowledge and experience sharing, Incentives stimulating IPv6 uptake

Main stakeholders All stakeholders in the Internet Ecosystem but mostly Governments, as to push them to have a country IPv6TF

Who initiated? The African Internet Community

Who manages? AFRINIC acts as Secretariat

Target audience? The Operators in General and Government & Regulators

Contribution to IPv6 deployment?
It encourages the Government to have a national framework for the uptake of IPv6 and thus creating a better environment for the ICT environment in the country.

What worked well? Some Regulators and Government embraced the Task Force initiate on a national level.

What didn't work as expected? The continued and long term engagement.

Unintended positive effects?
An awareness on IPv6 was generated through some actions, it was not an intended campaign as such but a "collateral" positive effect.

Unintended negative effects? Not aware.

External events/initiatives that contributed to success or failure?
There were an educative "campaign" like webinars & conferences. There were collaborative efforts with sister organisations to promote IPv6.

Lessons learned / suggestions.
I think that feeding the debate with Case studies help for the comprehension of what can be done for this next generation protocol. It emphasises the importance of moving to v6 and gives a holistic view of what need to be done, e.g. network upgrade, capacity building of engineers, decision makers etc

Contribution by Vymala Thuron, Mauritius, AFRINIC, Technical Community

21. IPv6 adoption by Network Operator (USA)

Description
We saw IPv6 adoption as the "new normal" for all IP connected systems. When our network grew, we were able to get an IPv6 allocation before we could get an IPv4. Internally, we have transitioned to IPv6 as the default, with IPv4 as optional. For example, internal database, web, and file servers are often IPv6 only. Public facing resources are dual-stack, as are most desktops. By making reducing the number of dual-stack hosts, with all hosts IPv6 accessible, it reduced the administrative burden. Using /64 prefixes for every subnet also made it easier to align host addresses with other numbering systems currently in use.

Start date 2011

Is still ongoing? Yes

Geographic Scope Other (e.g. industry-specific, community specific)
Our network only serves one community

Category Community Building, Capacity Building, Outreach and awareness raising

Main stakeholders All our customers are stakeholders, and these are mostly local businesses and residences. Our technical staff were really the only ones actively involved with the initiative, but a great deal of customer awareness-raising was done, and our customers provided a largely passive role is that they provided a user base to validate our changes.

Who initiated? I did

Who manages? I do as well

Target audience? Our internal systems, with promotion of the concept to potential customers

Contribution to IPv6 deployment?

It is very difficult to adopt IPv6 when your Internet connection does not have IPv6 connectivity. By making native IPv6 available to 100% of our customers, and providing deployment assistance, there is really no reason not to deploy IPv6 any more.

What worked well?

For our customers that use our managed firewall service, we simply turned up a v6 subnet and enabled router advertisement. Most of them didn't notice any difference, but they were now IPv6 enabled. We also modified our customer host management system to create AAAA records based on either a static address or an EUI-164 address. This made it very simple to dual-stack their internal devices, such as printers and storage devices. Since we were using DNS names instead of IP addresses, many became IPv6 enabled with very little effort on our part.

What didn't work as expected?

There is still a long way to go in terms of IPv6 support in a lot of the equipment out there. A lot of network gear is still IPv4 only on the management interface. Many vendor implementations are buggy. DHCPv6 relay with prefix delegation on our routers still remains a problem. Also, a number of customers that manage their own networks refuse to acknowledge any value in IPv6 and won't turn it on.

Unintended positive effects?

Eliminating NAT made it a lot easier to manage firewall policy, as well as manage customer devices. We can now create a firewall rule allowing our NOC into customer subnets for management purposes. This used to require a VPN or a lot of NAT mapping. Now it's just a simple rule.

Unintended negative effects? Not really.

External events/initiatives that contributed to success or failure?

The difficulty in obtaining IPv4 address allocations was a bit of a push. Before that, IPv6 day brought the issue to our attention.

Lessons learned / suggestions.

Don't put it off, and dive in with both feet. IPv6 is no longer something to be tinkered with or though of as a novelty. Think of IPv4 as going out of style, and consider IPv6 to be mandatory. Don't buy any equipment that doesn't have the IPv6 features that you need. If a manufacturer says that IPv6 is "coming", don't take their word for it. Make sure they at least show you a working beta.

Contribution by Tim St. Pierre, Canada, Communicate Freely, Technical Community

22. National Working Group - deployment of IPv6 (Norway)

Description
The Norwegian Communications Authority (Nkom) established in 2011 a national working Group on IPv6 deployment. Participation is mainly from Norwegian ISPs, but also some other stakeholders attend.The working group's main tasks are to identify key issues and discussions associated with the transition to IPv6, and conducting meeting activity where the current topics are reviewed. As a genreal rule the meetings are conducted with only internal presenters but contributions from external participants / presenters are not exlueded and RIPE NCC has on several meetings participated and provided presentations. Nkom is chairing the working group and facilitates the meetings.

Start date 2011

Is still ongoing? Yes

Geographic Scope Other (e.g. industry-specific, community specific)
National scope - within the country

Category Measuring and sharing information on the status of IPv6 deployment, Knowledge and experience sharing

Main stakeholders Government, private sector and technical community such as ISPs, consultancy Companies, representatives from vendors and hosting providers

Who initiated? We as Nkom – Government

Who manages? We as Nkom – Governement

Target audience? ISPs

Contribution to IPv6 deployment?
Created awareness of the importance to start planning for IPv6 deployment. Initiated projects at ISPs to plan for IPv6 rollout and preparation.
Established a meeting place for sharing best practices.

What worked well? Kick started planning and implementation activities at ISPs

External events/initiatives that contributed to success or failure?
Our initiative spurred IKT-Norge, the interest Group for the Norwegian ICT industry, to also start an IPv6 forum in Collaboration with some ISPs and other stakeholders

Lessons learned / suggestions.
Very useful as a mechanism for the Government to create awareness of the importance of starting planning and preparation for IPv6 deployment.
The WG has also in our view been useful for the ISPs to share best practices.
The WG has been useful to highlight the importance of IPv6 and thereby initiate og kick start plans and roll outs at ISPs.

Contribution by Ørnulf Storm, Norway, Norwegian Communications Authority, Government

23. Member training workshops (research & education network) (USA)

Description
We perform training sessions for our member institutions, providing an overview of IPv6 addressing, routing, security, implementation and other topics. This is a mix of lecture and hands on.

Start date 2011

Is still ongoing?	Yes
Additional information	Regional, Local, Other (e.g. industry-specific, community specific)
Geographic Scope	Specific to the Education community
Category	Measuring and sharing information on the status of IPv6 deployment, Community Building, Outreach and awareness raising, Knowledge and experience sharing
Main stakeholders	Senior Network or Security engineers at Research or Education institutions in New York State.
Who initiated?	NYSERNet
Who manages?	NYSERNet
Target audience?	Network or Security Engineers

Contribution to IPv6 deployment?
Provides both basic and in depth knowledge on a very broad topic. Provides guidance on major milestones. Provides a point of contact going forward for implementations.

What worked well? Small class sizes allow for discussion.

What didn't work as expected? Adoption is still slower than we would like.

Lessons learned / suggestions.
IPv6 is a broad topic. It's difficult to know where to start. Providing a consistent environment has been vital to success.

Contribution by Jeff Harrington, United States, NYSERNet, Academia

24. IPv6 Adoption and Deployment in the Kingdom of Saudi Arabia

Description
CITC established The IPv6 Strategy for Saudi Arabia which identified a set of milestones to be achieved within a phased time line via an action plan of initiatives categorized into two tracks: Infrastructure and Awareness. Meeting the milestones would facilitate the deployment and further penetration of IPv6 on a nationwide basis so as to eventually realize an IPv6 ready internet infrastructure in the Kingdom of Saudi Arabia.

The identified objectives are:

- Prepare for the IPv4 exhaustion by supporting IPv6 and ensure stability, business continuity and room for continued growth of the internet in Saudi Arabia
- Ensure a smooth adoption of IPv6 by stakeholders so as to minimize risks
- Raise overall IPv6 awareness nationwide by approaching stakeholders of both the public and private sectors highlighting the necessity to adopt IPv6

While the early CITC IPv6 activities exerted some focus on service providers, starting the year 2013 the IPv6 initiative exerts focus on enterprise adoption. As part of this effort, CITC has taken practical steps in promoting the deployment of IPv6 in the Kingdom of Saudi Arabia reaching to the level of implementing a set of pilot projects at selected entities and that provide showcases for all internet stakeholders to follow.
CITC has also benchmarked the status of IPv6 deployment in the Kingdom against international trends of IPv6 deployment and address regulatory and technical aspects of the internet ecosystem which obstruct the smooth adoption and deployment of IPv6 in the Kingdom.

Start date	2008
Is still ongoing?	Yes
Additional information	Yes, www.ipv6.sa
Geographic Scope	Local
Category	Measuring and sharing information on the status of IPv6 deployment, Community Building, Capacity Building, Outreach and awareness raising, Knowledge and experience sharing, Incentives stimulating IPv6 uptake
Main stakeholders	Government, Service Providers, Vendors, Financial sector, Academic sector, and other private sector.
Who initiated?	Communications and Information Technology Commission Saudi Arabia www.citc.gov.sa
Who manages?	Internet Services department at the Communications and Information Technology Commission – Saudi Arabia
Target audience?	Government, Service Providers, Vendors, Financial sector, Academic sector, and other private sector.

Contribution to IPv6 deployment?

- Readiness of service providers
- Building an IPv6 community through the Saudi national ipv6 taskforce (more than 15 meetings, 300 mail list members, and ipv6.sa website)
- Capacity building through technical training and workshops (more than 10 hands-on training sessions and 3 major national forums)
- Readiness of national internet infrastructure services (such as Saudi ccTLD)
- Increased awareness of end user and enterprises
- Increased IPv6 service demand from customers on service providers

What worked well?

- Outreach and awareness raising
- Knowledge and experience sharing
- Service providers infrastructure readiness
- national internet infrastructure services readiness

What didn't work as expected?

- Actual IPv6 traffic and availability of the service to home and mobile users.
- Process and communication gap between technical and business/sales teams within service providers which caused issues for customers to get IPv6 services from ISPs.
- Amendment of the government purchasing laws and regulation to mandate IPv6 support in all ICT purchases.

External events/initiatives that contributed to success or failure?

- Global and regional technical community cooperation such as technical training and support by RIPE and MENOG have contributed positively to the initiative.
- Region to region transfer of IPv4 Allocated Space reduced the pressure on the IPv6 deployment.

Lessons learned / suggestions.

- Government leadership and support is important to the success to IPv6 adoption.
- Building an effective eIPv6 community with participation from key service providers and other stakeholders is key success factor for such initiative
- The importance of IPv6 skills developments.
- IPv6 should not be looked at as only a technical network issue, in fact it has a much larger impact on investment, business continuity, innovation.

Contribution by Adeeb Albraidi, Saudi Arabia, Communications and Information Technology Commission (CITC), Government

25. MAP-T implementation for Broadband Service on IPv6 (India)

Description
We are a greenfield deployment Internet Service Provider in India. I am mainly focusing on broadband services design and implementation. Being a new in the business we could not enough v4 address block for the number of population we have to serve in Indian customer base. Hence, it was mandatory for us to find solace in implementing IPv6. So we started with looking at budding technologies like MAP-T at IETF, and have been successfully able to test the pilot testing in lab and currently working towards managing vendor to do mass scale device production to support the standard and enable us to delver Broadband on IPv6.

Start date 2013

Is still ongoing? Yes

Geographic Scope Local

Category Knowledge and experience sharing, Incentives stimulating IPv6 uptake

Main stakeholders NA

Who initiated? organization

Who manages? organization

Target audience? Internet user

Contribution to IPv6 deployment?
Technically enabled the network to deliver Broadband on IPv6 to end user.

What worked well? Vendor support when the MAP-T solution was still at draft stage in IETF RFC approval process. Currently it is an IETF approved standard.

What didn't work as expected? choice of vendors supporting the standards.

Unintended positive effects? Map-T becoming an standard

Unintended negative effects? No

Lessons learned / suggestions.
It would be wise not to wait for a technology to become standard before starting to implement or test on the network. Its always a good ides to keep doing parallel work.

Contribution by Country: India, Stakeholder Group: Technical Community

26. Deploying IPv6 - University of New Hampshire (USA)

Description
Integration of IPv6 dual stack began in key Enterprise Layer-2 segments that made sense, easy to implement and low risk to production network. Projects started in 2011 by moving from a Netblock-48 to Netblock-32 allocation from ARIN. In 2012 started sponsoring IPv6 Senior Projects with Computer Science Department. First project built a IPv6 test network with network services enabled. Follow up projects have implemented NAT64, and researching IPv6 First Hop risks. IPv6 has been integrated

into several production networks that including server networks as well as public cluster machines. So far dual stack implementations are in areas that are managed by UNH-IT staff or departments such as Computer Science, Interoperbility Lab and Research Computing that all have staff dedicated to networking and system administration. Next steps to move into widespread IPv6 dual stack deployment is the campus Wireless network. As of the late 2015 initial steps in this direction are in the early stages of planning a testing in a private network environment separate for production networks.

Start date 2011

Is still ongoing? Yes

Additional information We do have a ipv6 web page that includes current IPv6 deployment progress which is ipv6.unh.edu.

Geographic Scope Global

Category Incentives stimulating IPv6 uptake

Main stakeholders It is the University of New Hampshire community in an effort to support the mission of UNH, http://unh.edu/president/mission.

Who initiated? UNH IT Network Operations

Who manages? Scott Kitterman

Target audience? UNH community

What worked well? Working with individual groups capable of implementing IPv6 in a controlled and low risk environment. Working with students to research and implement aspects of IPv6 deployment.

What didn't work as expected?
Moving to IPv6 is not high priority though it does have the support across the IT department.

Unintended positive effects?
the biggest positives other than IPv6 growth and support at UNH is building community and knowledge from other groups with IT as well as departments and college around the university.

External events/initiatives that contributed to success or failure?
World IPv6 day did help build some excitement around getting IPv6 into production.

Lessons learned / suggestions.
In general look for support from the people you report to. First go for low risk easy to implement areas of your network. It should not be hard to deploy some IPv6 that does not affect production which is great way to get started.

Contribution by Scott, USA, University of New Hampshire, Academia