IST-Africa 2014 Conference Proceedings
Paul Cunningham and Miriam Cunningham (Eds)
IIMC International Information Management Corporation, 2014
ISBN: 978-1-905824-43-4

The Role of Governments in IPv6 Transition

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Abstract: Along with the gradual depletion of the current IPv4 Internet protocol address blocs, the issue of the new version of Internet protocol transition and support is getting more and more topical. Nowadays, IPv6 does not represent a topic for IT specialists only, but also for governments and policy and decision makers that more and more aware of the IPv6 role in the process of ensuring the access to the Internet for all citizens and in the issues of competitiveness and technology neutrality. This paper is focused on the role of governments (including decision and policy makers) in preparing the IPv6 and the possibilities individual governments and the European Commission have in supporting this process, including specific examples and the evaluation of their effectiveness, which will be illustrated especially on the example of the Czech Republic. Part of the tools evaluation is also the comparison of individual public administrations'preparedness for IPv6, which has been developed within the GEN6 project (Governments ENabled with IPv6).

Keywords: IPv6; Policy; Internet Governance;

1. Introduction

IP addresses represent the basic building blocks of the Internet. Without an IP address it would not be possible to connect to the World Wide Web and therefore computers would not be able to mutually recognise each other and thus become linked within the global network. The current pool of IP address blocks in some parts of world is practically exhausted. For most of the Asia region the last spare blocs were allocated in April 2011, then in September 2012 were allocated last address blocs for the region of Europe and the Near East. As for Africa, on the one hand, there are still quite a lot of spare IPv4 addresses for this continent; on the other hand, Africa is a continent with the largest growth of Internet users who often access on-line content in Europe or Asia, which could be accessed by IPv6 only. Due to massive investments in Internet infrastructure, IPv6 is an up-to-date topic associated with preparation for future development. In this context, it is necessary to note that the demand for new IP addresses is generated both from the number of newly connected users and from the number of devices newly connected to the Internet, which are not only personal computers, laptops or tablets, but also Internet of Things (IoT) and Machine-to-Machine (M2M) devices such as sensors (e.g. for monitoring hydro and metrological information such as the water levels), web cameras, various meters (such as electricity meters) or switches (e.g. for heating or window blinds).

Without the necessary support, users with new addresses will be unable to connect to those electronic services (for example websites) that support only the old version of the protocol. Search engines will encounter a similar situation, unable to find websites that have not yet moved to the new address space. Without IPv6 support, users will experience a period of a digital twilight, being prevented from using selected services. In a sense, it would be creating a new dimension of the Digital Divide, but this time one that could affect even very computer-literate individuals. At the same time it is necessary to be aware of the fact that new users have practically no possibility to influence which protocol their Internet provider will use for their Internet connection. For example the customers of a new mobile

operator would find themselves in an unequal position, as their operator would not be able to allocate IPv4 addresses and would allocate only the new addresses which, however, would not enable its customers to access services tied to the old version of Internet protocol IPv4.

1.1 Identifying IPv6 Stakeholders

The IPv6 transition process represents a complex issue that needs the involvement of all the stakeholders. The most important are the following ones:

- ***Content providers***, the web-site (and e-services) operators of which must ensure IPv6 availability, meaning not only support on the side of the application and the server, but also a connection to the IPv6 infrastructure and listing at least one IPv6 record in DNS. As for services, it is also necessary to ensure the IPv6 support of e-mail servers in the form of MX records.
- ***Internet Service Providers (ISP)*** ensuring access to the Internet for government agencies, companies and home users as well. The task of these operators is to adapt all parts of the network in such a way that no action is required by users who need IPv6 support. For many operators, this step may require the replacement of certain network elements. The operators' IPv6 support can then be traced via the network traffic implemented through this protocol.
- ***Hardware manufacturers*** which provide the link between the website and the end user of the Internet. Hardware manufacturers involve both the modem/router manufacturers and the manufacturers of devices with integrated Internet access, such as mobile phone producers or M2M devices.
- ***Government Institutions*** (including policy and decision makers) whose interest should be to prevent the creation of a new Digital Divide made by the lack of IP addresses and thus by the impossibility to connect new users, as well as by the differences between the IPv4 and IPv6 address users.

1.2 IPv6 Policies

The severity of the issues associated with the lack of IPv6 support is understood also by international organisations such as ITU (United Nations), European Commission or OECD. The main strategic policy governing IPv6 support is the "Digital Agenda for Europe"1, according to which member states should ensure full interoperability of eGovernment services by overcoming organisational, technical, or semantic obstacles and supporting IPv6.

At the European Level, the main strategic policy governing IPv6 support is the "Digital Agenda for Europe" [1], according to its Action 89 member states should ensure full interoperability of eGovernment services by overcoming organisational, technical, or semantic obstacles and supporting IPv6.

There is no common approach to IPv6 support at the national level and the individual states and their governments support the introduction of this technology proportionally to the importance they assign to it. The level of importance can be tracked with the help of various tools, mainly:

- **Inclusion into official policies** represents a strong political commitment, based on which can be further implemented other measures including legislation. An example of this approach is the *"Digital Czech 2.0"* Strategy adopted by the Czech government, which stresses the importance of IPv6 within the national policy for the electronic communication.
- **Legislative tools** together with implementation documents (e.g. standards, methodical instructions etc.) offer, thanks to their relevance, an efficient tool with a direct impact to

individual addressees. An example of the legislative tools is the Slovak standard for information systems of public administration (current decree number 312/2010 Coll.), determining IPv6 support for public administration bodies. In the Czech Republic the IPv6 support is handled by government resolution Nr. 727 from year 2009, defining the obligation of IPv6 support for public administration central bodies no later than from 1 January 2011. Part of the resolution handles the obligation to include IPv6 within the public tenders criteria. At the end of 2012 the Czech government passed a new resolution, stating the obligation of IPv6 support at all the projects (private sector projects as well) that are financed from public resources, specifically via the EU Structural Funds.

Especially in relation to the net neutrality there are interesting examples of policy implementation *"General rules and recommendations for the use of data traffic management in the provision of Internet access service"* [2] adopted by the Czech Telecommunication Office (CTU). According to these guidelines, "the access to the Internet" means a service enabling to connect all end user points connected via IPv4 or IPv6. This definition is related to the net neutrality and CTU clearly states that net neutrality means also a freedom to choose an Internet protocol – IPv4 or IPv6 and same rights are granted for IPv4 and IPv6 users as well.

- Inclusion of IPv6 support as an evaluating criterion into the best (the highest quality) web contests. In the Czech Republic, such a competition is e.g. Zlatý Erb (Golden Crest) for the best municipality website. According to the research of CZ.NIC, in 2013 this measure helped to significantly increase IPv6 support in public administration - in the case of webservers, 54 per cent of websites support IPv6 compared to the national average of 15 per cent. 60 per cent of public administration's name servers support IPv6 as opposed to the national average of 51 per cent, and the ratio with mail servers is 18 to 15 per cent.

Another part of this paper will deal with the effectiveness of individual tools and recommendation for their implementation by other governments in Europe and in Africa in order to support IPv6 deployment and thus support the development of the information society.

2. Objectives

The objectives of this paper are to:

1. To highlight the importance of IPv6 transition and to support the integration of this issue into the agenda of the policy and decision makers.
2. To analyse the tools governments have in IPv6 deployment, including their effectiveness.
3. To provide a comparison of the chosen public administrations'preparedness for IPv6.

3. Measurement of IPv6 deployment

While measuring the IPv6 deployment and the level of its use it is necessary to measure individually the support at content providers and the support in individual ISP networks, respectively the share the IPv6 has in total IP traffic.

3.1 Support on the side of content providers

Within the technical check of IPv6 support at content providers, it is important to focus on web servers (AAAA records), DNS servers (NS records) and mail servers (MX records). While the methodology of the technical side of such a check is not questionable, inconsistency of individual studies is caused by the selection method of the URLs that are further subjected to technical check. In this regard the survey faces the justifiable protection

of lists of all URLs in the given domain (zone), due to which for national comparison individual projects define their own methodologies.

Among the examples of such projects is the IPv6 Observatory [3] using the measurement based on the top 500 most visited pages of the given country according to measurement of the Alexa server. An advantage of such a measurement is the relative ease of getting a URL sample, however, such benchmarking does not allow for credibly comparing the real conditions in individual countries, as the top 500 most visited pages sample is skewed by inclusion of international web pages such as Google or Facebook or news servers that are managed internationally.

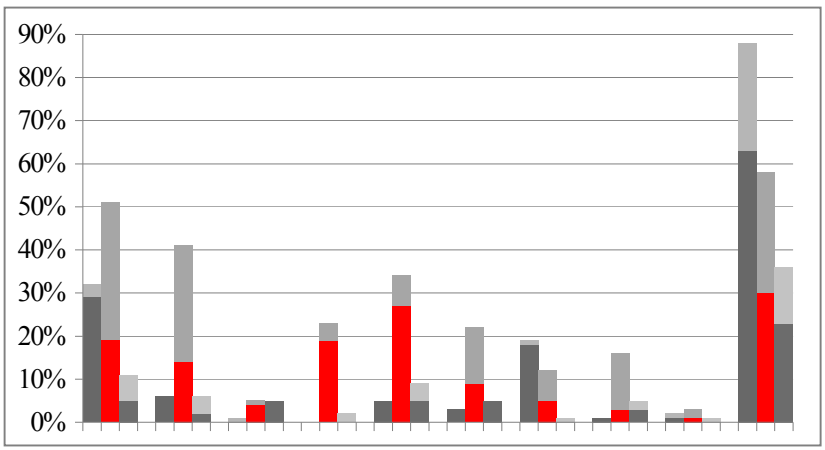
Among the examples of the second approach is the GEN6 project [4], which is focused on the state of readiness of the public administration and thus its analyses include only the public administration web pages in individual countries. Such a measurement then can be used also for comparing the effectiveness of individual tools used for IPv6 deployment support.

In order to compare the implementation and adoption of IPv6 in various countries, URLs representing government (including self-government) website and eGovernment services are divided into three main groups. The first group represents the national or federal level, the second one is focused on the regional level and the last one involves the municipal level.

Currently, the GEN6 project regularly analyses 2 372 public administration web pages in ten countries – the Czech Republic, Germany, Greece, Luxembourg, the Netherlands, Slovakia, Slovenia, Spain, the R.O.C. (Taiwan) and Turkey. In order to objectively compare the member states there was developed a universally usable methodology [5] taking into account different systems of public administration and their national specificities. At the national level are thus collected URL addresses representing the executive, legislative and judicial powers. At the local level is taken into account the size of municipalities with regard to their role in providing the e-Government services. In total there is 383 bodies at the national (central) level, 122 at the regional level and 1 868 at the local level taking part in the survey.

The last analysis done within the GEN6 project to the date of 31 December 2013 showed rather large differences among individual countries (see Graph Nr. 1).

Graph Nr. 1: Public administration preparedness to IPv6 in selected countries



Given the fact that some tools may have limited impact, it is desirable to compare individual levels of public administration and, if needed, to compare it with private sector, or a given domain average.

Table Nr. 1: Comparison of IPv6 implementation at chosen entities in the Czech Republic

	Web servers	**Name servers**	**Mail servers**
Ministries	57.1 %	64.3 %	57.1 %
Central state administration bodies	81.8 %	72.7 %	45.5 %
Regional authorities	14.3 %	71.4 %	21.4 %
Municipalities with extended powers	28.3 %	49.8 %	5.9 %
Most important companies (TOP100)	5.0 %	44.0 %	5.0 %
All .cz domains average	*19.5 %*	*55.1 %*	*15.2 %*

3.2 IPv6 readiness benchmarking in public administration in Africa

In order to analyse IPv6 support by government servers in Africa there was a simplified survey focused on internet presentations of selected ministries and parliaments in the following 12 countries most represented at the IST Africa conference: Botswana, Kenya, Mauritius, Mozambique, Namibia, Rwanda, Seychelles, South Africa, Tanzania, Uganda, Zambia and Zimbabwe. In total, this survey [6] involved 74 URLs representing (when available) official websites of national parliaments and ministries responsible for agriculture, finance, education, foreign affairs, health and tourism.

Results of this survey clearly demonstrate that IPv6 support on the content provider's site is being blatantly disregarded – from 74 URLs – there is absolutely no IPv6 support on webservers and mail servers and only one name server (Ministry of Health and Social Welfare, Tanzania) supports IPv6.

Table Nr. 2: Comparison of IPv6 implementation at public administration in some African countries

	Sample size	**Web servers**	**Name servers**	**Mail servers**
Botswana	7	0 %	0 %	0 %
Kenya	7	0 %	0 %	0 %
Mauritius	7	0 %	0 %	0 %
Mozambique	7	0 %	0 %	0 %
Namibia	7	0 %	0 %	0 %
Rwanda	7	0 %	0 %	0 %
Seychelles	4	0 %	0 %	0 %
South Africa	7	0 %	0 %	0 %
Tanzania	7	0 %	16.6%	0 %
Uganda	7	0 %	0 %	0 %
Zambia	1	0 %	0 %	0 %
Zimbabwe	6	0 %	0 %	0 %

3.3 IPv6 support within the transition networks

An important indicator of the actual IPv6 deployment and its use by end users is represented by the share of total IP traffic this new Internet protocol has. Such traffic can be monitored either by Internet Exchange Points or by the share of users accessing a certain page, which is often accessed by visitors from all countries. This fact is used by the Google

Company, which offers current IPv6 statistics [7] based on analysing the access to this global search engine.

As we can see in Google statistics, IPv6 is being slowly introduced in countries like Kenya and Ethiopia, however there are situations when a connection seems non-functioning to users with IPv6 connectivity. This behaviour affects about 0.2 per cent of IPv6 users in these countries. The users can then choose what seems to be the easiest solution and switch off the IPv6 in their network, which only postpones the problem for later. In both countries the problems are most probably caused by incorrect setup and use of IPv6 in providers‘ networks. The providers may not be aware of these problems, as after switching off IPv6, IPv4 works and the users do not send an error report to their provider. In contrast to these countries‘ problems there is implementation of IPv6 in South Africa, where the problems with IPv6 connection represents 0.01 per cent only.

4. Evaluation of the IPv6 legislation effectiveness in the Czech Republic

The case of the Czech Republic demonstrates the effectiveness of the legislation (in this case a government resolution Nr. 727 adopted on 8 June 2009) oriented on IPv6 support. On the one hand, despite the valid legislative obligation there is rather a numerous group of public administration bodies disregarding the Resolution, on the other hand the web and mail servers show that for the first two categories of entities contained in the Resolution the IPv6 support is several times higher than the rest of the .cz domain.

The comparison over time (Table Nr. 3) for given public administration bodies (ministries, central state administration bodies) at web and mail servers show greater dynamics of IPv6 introduction than the rest of the Czech domain. As for the name servers, it is important to note that the majority of state institutions does not operate its own DNS server, but uses the services of an ISP, that often serves also as a domain name registrant.

Table Nr. 3: Time comparison of IPv6 implementation at public administration in the Czech Republic

	Web servers		**Name servers**		**Mail servers**	
	30.6.12	**31.12.13**	**30.6.12**	**31.12.13**	**30.6.12**	**31.12.13**
Ministries	35.7%	57,1 %	64,3 %	64,3 %	35,7 %	57,1 %
Central state administration bodies	50.0%	81,8 %	58,3 %	72,7 %	33,3 %	45,5 %
Regional authorities	14.3%	14,3 %	64,3 %	71,4 %	14,3 %	21,4 %
Municipalities with extended powers	7.3%	28,3 %	43,9 %	49,8 %	2,9 %	5,9 %
All .cz domains average	*15.1%*	*19.5%*	*51.3%*	*55.1 %*	*13.2%*	*15.2 %*

5. The advantages of IPv6 implementation and its support by public administration

Among the main reasons why governments should take interest in IPv6 deployment is ensuring the access to the Internet for all citizens and taking full advantage of the potential the World Wide Web brings. In relation to the dynamic rate of growth of new Internet users and the decreasing number of spare IPv4 address blocs this issue will be more and more topical. According to the AFRINIC data, in the African region there is still about 57 million spare addresses, however over the last 10 years the rate of allocation has grown by 1 366 per cent [8], which makes the issue of IPv4 addresses depletion more and more pressing. That is shown also by the fact that the number of AFNIC members, who are applying for IPv4 allocations (typically ISPs) has grown by 376 per cent over the same period of time.

For the Governments of the states that are in the regions lacking IPv4 addresses, such a situation can occur e.g. if there comes a big mobile phone operator or an ISP. In that case the IPv4 support represents not only a problem of a possible digital divide creation between the IPv4 and IPv6 users, that cannot access content accessible only with the old version of the IP protocol, but also a question of competitiveness and possible disadvantage that may experience any new entity wanting to enter the market.

The IPv6 implementation also brings technological advantages, such as the integration of safety solutions or mobility support, where IPv6 enables peer-to-peer communication, enabling anyone to connect with anyone else without the necessity of having an intermediary. When using the encryption it is possible to communicate directly and securely without risking the communication to be recorded at any central server. [9].

5.1 IPv6 benefits for transparency and free access to the Internet

Virtually unlimited address capacity in IPv6 protocol enables to assign a fixed address to each user. This brings about positive return to the foundations of the Internet and makes every communication clearer and more direct, thus reducing administrative efforts and operational risks by increased transparency in the transport services. In this regard it is important to bear in mind that in the public Internet only packets with public IP addresses will be routed; therefore an address translation between the address types must be established. This so called network address translation (NAT) is located at the Internet gateway of one's local network. Due to cooperation between governments, private organizations and companies sometimes multiple networks must be interconnected. Usually, at each network's edge a NAT gateway is in use. This inhibits the end-to-end view of the IP communication. At every point of the transmission the network administrators only have a clear track up to the next NAT gateway. Everything after the NAT is hidden and hard to reach – even where it should be reachable.

In marketing material of the gateway vendors, NAT evolved into a security feature. However, the security effects of NAT are a result of stateful ingress packet filtering and application layer gateways – features that are also available without address translation. The advertised hiding of local endpoint addresses behind a NAT firewall is a myth for many use cases, as for example the local IP address of a client can be read in every http-based browser session on the server side.

5.2 IPv6 benefits for development of new services

A practically unlimited address space together with the above-mentioned properties of IPv6 will enable development of new services. On this issue, IPv6 application unlocks enormous potential in Africa as the new services will have an impact not only on the area of Information Society, but also on other areas including environmental protection, protection of natural resources or facilitating communication between family members living far from each other.

Simultaneously with the dynamic development of the so-called Internet of Things (IoT) needing so far unimaginably large number of addresses, it will be possible for new services to emerge in Africa, e.g. in the area of natural resources protection. As a case in point may be new opportunities in animal protection (esp. elephants or rhinos) from rampant poachers. It will be possible to track wild animals in national parks with sensors communicating via IP protocol showing the rangers the animal's location and any deviations from his standard behaviour. IoT and the use IPv6 addresses will enable much more effective monitoring of a given area, e.g. with the help of cameras or special sensors fulfilling multiple functions–like monitoring fires or floods and their detection right when they start.

In the area of peer-to-peer communication it is especially the services of IP telephony that together with the growing penetration of smartphones in Africa will enable calls

without interception, as well as calls without paying telecommunication fees, only at the costs of connecting to the Internet. Such a service then may make it possible for many Africans to be in touch with relatives working far from home (oftentimes abroad) and at the same time to avoid possible interception and filtering communication.

5.3 IPv6 benefits in routing

The routing between governmental networks over rented lines and the improvement of security by transparent routing can be significantly supported by using a homogenous IPv6 addressing space for the national government. For a central management of domestically used governmental IP addresses, it is helpful if an institution is assigned to become a Local Internet Registry (LIR), registered with the RIPE NCC. That is the way it has been done in Germany, and it is currently under discussion in Spain. Germany set up its central LIR called "de.government" in 2009. Upon extensive requests, the RIPE NCC allocated one /26 prefix for this LIR.

5.4 Benefits for introducing the benchmarking

The case of the Czech Republic illustrates the effectiveness of legislative tools for IPv6 promotion, while a key role in monitoring the compliance with the government resolution is played by benchmarking. Besides an overall review benchmarking can determine potential problems that can occur e.g. while changing the configuration or upgrading a server and can alert to the problem in time. In the Czech Republic this allowed for timely detecting of two instances caused by the inability of the administrator to try the access via IPv6 and thus set an appropriate server response.

Deployment of benchmarking tools developed in the GEN6 project will enable to detect problems in African access networks, as indicated in statistics of the Google company.

To support the cooperation between Europe and Africa the CZ.NIC Association [10] offers free possibility to include African countries into benchmarking within the GEN6 project and to reap its benefits.

6. Conclusions

Given the near depletion of the IPv4 address blocs the new version of Internet Protocol version 6 (IPv6) represents an answer to ensure the development of information society with ever-increasing number of users and devices connecting to the Internet. The IPv6 implementation thus becomes not only a technical issue, but also is connected with social impacts and policies aspects. Insufficient IPv6 support can too soon create a new Digital Divide problem, between IPv4 users and IPv6 addresses, that will not be able to access content available only via the old version of Internet protocol. The fact that it is a current problem in Africa has been indicated by an access networks analysis, where the problems with IPv6 deployment in selected countries can result in unavailability of ‘IPv6 only content‘ and therefore to further widening of the Digital Divide. A timely remedy would enable to prevent future problems, e.g. people who switch off the IPv6 because of its current malfunction do not learn about the redress and thus the IPv6 world would remain hidden from them.

Pilot benchmarking analysing IPv6 support at the webpages of ministries and national parliaments of twelve selected African countries has shown that African governments disregard the support of the new protocol. That may cause problems especially to visitors (including future investors) who will access the pages from IPv6-only networks and for whom such pages will become inaccessible. The problem may be significant for users in the Asian region, which was the first where the IPv4 address blocs were exhausted.

IPv6 support is then connected with the question of technology neutrality and free choice of Internet protocol for end users, e.g. for security reasons.

For the reasons stated above, the issue of IPv6 support should not stay disregarded by policy and decision makers and should be taken into account when creating and implementing government policies. This is where the African countries should take advantage of their already-existing national ICT strategies and simply include IPv6 support when updating them. The Czech experience shows that among the most efficient tools are legislative ones, especially the following ones:

- An obligation to support IPv6 at least for public administration bodies, e.g. in the form of standard or government decree.
- An obligation to include IPv6 support as one of the conditions for purchase of relevant technologies (esp. network devices such as routers) and services (mainly web hosting) paid by public funds. A timely inclusion of IPv6 support into procurement may not influence the final price, on the contrary, may save on future investment connected with technologies upgrade.

A suitable tool to follow up on the fulfilment of obligations arising from the relevant legislation is a regular monitoring (benchmarking), whose effectiveness and other use can be enhanced by publishing the data gained in the form of open data.

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