IPV6 DEPLOYMENT STATUS, THE SITUATION IN AFRICA AND WAY OUT

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ABSTRACT

The number of internet connected devices is increasing terrifically, with each device assigned a unique Internet Protocol (IP) address at a time. Hence the expected problem of IPv4 address exhaustion in the near future called for a better and permanent solution, which is switching to IPv6. Adoption and deployment of IPv6 recorded a fast growth rate globally, though the slow growth rate recorded in Africa was suspected to be due to the poor capacity building and the level of the IPv6 awareness campaign in the region. It was concluded that the developmental strategies created to help in the deployment of IPv6, such as the global awareness campaign, was confirmed effective. Also the World IPv6 day provides a 24 hours experiment to uncover the challenges of the transition to IPv6 and to develop measures to resolve them.

KEYWORDS: *Internet, IPv4, IPv6, RIRs, AfriNIC, ISP.*

I. INTRODUCTION

Today, most electronic devices such as mobile phones, Personal Digital Assistants (PDAs), PCs, Internet telephones, etc use in homes and other places, rely on the internet technology for their various services. The internet connected devices use the internet protocol (IP) address to communicate over the network with each device assigned a unique IP address. This means that, for any device to communicate through the internet, it must be assigned an IP address. Most private and business application services (online transactions), including social activities such as Facebook, Twitter, Yahoo, etc., depend on the IP address for their functions. Thence, the tremendous growth rate in the number of internet connected devices and high dependence on the internet for human daily activities have caused the expected exhaustion of the long-time used IPv4 addresses.

The two versions of IP currently in use; Internet Protocol Version Four (IPv4) and Internet Protocol Version Six (IPv6), with the IPv6 adopted proactively to solve the expected problem of the first and widely used version (IPv4) exhaustion in the future. The Number Recourse Organization (NRO), made up of five regional internet registries (RIRs) was set up to work together at global and regional levels to promote the transition from IPv4 to IPv6 and layout strategies to manage the distribution of the remaining unallocated IPv4 address pool [2].

The objective of this paper is to examine the possible solutions towards the transition challenges, focusing on the situation in Africa which reveals the situation in most other developing nations or regions in the world. This will lead to a thorough look at the global experiment and awareness campaign on the world IPv6 day, which was setup to uncover the transition problems and develop strategies to resolve them.

The analysis carried out in this work will be limited to the African IPv6 deployment from 1984 to 2011 to justify the IPv6 promotion campaign realized through this 24-hour global experiment carried out every year.

Section two discussed the internet protocol (IP) versions; Internet Protocol version four (IPv4) and Internet Protocol version six (IPv6). The regional internet registries (RIRs) and their functions are also

presented. Section three discussed the transition from IPv4 to IPv6 the importance of the transition and the trend. Section four presents the results of the deployment statues of IPv6 in Africa, the situation in most of the countries in the region and the measure to improve the situation. Section five presents the conclusions and recommendations.

II. OVERVIEW

Internet Protocol is a set of technical rules that define how computers communicate over a network [6]. There are currently two versions [6]: IP version 4 (IPv4) and IP version 6 (IPv6). IPv4 was the first version of Internet Protocol to be widely used and still accounts for most of today's Internet traffic. There are just over 4 billion IPv4 addresses. While that is a lot of IP addresses, it is not enough to last forever. IPv6 is a newer numbering system to replace IPv4. It was deployed in 1999 and provides far more IP addresses [6], which are expected to meet the need in the future. All internet connected devices and websites have an IP address so that the internet's servers know where to send information to. When a website's address (or URL) is typed into a browser, the system needs to convert it into an IP address so that it knows which computer to connect to [9]. To do this, the system uses the internet's equivalent of a phonebook, known as the Domain Name System (DNS). At the moment, the vast majority of IP addresses in the DNS resolve to IPv4 - the current standard for addresses. So even if you have an IPv6-enabled machine that is connected to an IPv6-enabled network, you will still be connected to another computer or website using IPv4. Some websites have been set up to use IPv6, but generally you need to type in a special web address (such as http://ipv6.sanger.ac.uk, or http://ipv6.google.com) to connect using the new protocol [9].
A global experiment and awareness campaign on the World IPv6 day has been set up to uncover the transition problems and develop strategies to resolve them. Google, Facebook, Yahoo, Akamai, and Limelight Networks will be some of the organizations offering their content over IPv6 for a 24-hour 'test flight' [1] [14]. The goal is to motivate organizations-Internet-service providers, hardware makers, operating-system vendors and web companies-to prepare their services for IPv6, ensuring a successful transition as IPv4 addresses run out [14]. On World IPv6 day, the Sanger Institute, along with more than 300 organisations, advertise both IPv4 and IPv6 addresses in the DNS [9]. This will allow users with IPv6-enabled devices to connect via IPv6 without need to use the special address. IPv4 and IPv6 will coexist on the Internet for many years [7]. Users without IPv6 connectivity will continue to access the sites using IPv4 as normal [9] for the moment but with little or increasing restriction in the future. In comparison (Table 1) the major difference between IPv4 and IPv6 is the number of IP addresses. Although there are slightly more than 4 billion IPv4 addresses, there are more than 16 billion-billion IPv6 addresses [6].

Table 1: Comparing IPv6 and IPv4 [6]

	Internet Protocol version 4 (IPv4)	Internet Protocol version 6 (IPv6)
Deployed	1981	1999
Address size	32-bit number	128-bit number
Address format	Dotted decimal notation:192.168.0.202	Hexadecimal notation:3FFE:0400:2807:8AC9::/64
Number of addresses	2^32	2^128

2.1. Regional Internet Registries

Regional Internet Registries (RIRs) are independent, not-for-profit membership organizations that support the infrastructure of the Internet through technical coordination [2]. There are five RIRs in the world today (Figure 1). Currently, the Internet Assigned Numbers Association (IANA) allocates blocks of IP addresses and ASNs, known collectively as Internet number resources, to the RIRs, who then distribute them to their members within their own specific service regions. RIR members include Internet Service Providers (ISPs), telecommunications organizations, large corporations, governments, academic institutions, and industry stakeholders, including end users. The RIR model of open, transparent participation has proven successful at responding to the rapidly changing Internet environment. Each RIR holds one to two open meetings per year, as well as facilitating online

discussion by the community, to allow the open exchange of ideas from the technical community, the business sector, civil society, and government regulators.
The five RIRs are [2]:
AFRINIC - Africa region
APNIC - Asia and Pacific region
ARIN - Canada, many Caribbean and North Atlantic islands, and the United States
LACNIC - Latin America and parts of the Caribbean
RIPE NCC - Europe, Parts of Asia and the Middle East

Fig. 1: The RIRs and the general areas of responsibility (courtesy of NOR) [5]

Each RIR performs a range of critical functions including [2]:

- The reliable and stable allocation of Internet number resources (IPv4, IPv6 and AS Number resources)
- The responsible storage and maintenance of this registration data.
- The provision of an open, publicly accessible database where this data can be accessed.
- RIRs also provide a range of technical and coordination services for the Internet community.

2.2. IPv4 Current Status

The IPv4 address space is a 32 bit field. There are 4,294,967,296 unique values, considered in this context as a sequence of 256 "/8s", where each "/8" corresponds to 16,777,216 unique address values. In adding up these special purposes use address reservations there are the equivalent of 35.078 /8 address blocks in this category [11]. This is composed of 16 /8 blocks reserved for use in multicast scenarios, 16 /8 blocks reserved for some unspecified future use, 1 /8 block (0.0.0.0/8) for local identification, a single /8 block reserved for loopback (127.0.0.0/8), and a /8 block reserved for private use (10.0.0.0/8). Smaller address blocks are also reserved for other special uses. The remaining 220.922 /8 address blocks are available for use in the public IPv4 Internet. IANA holds a pool of unallocated addresses, while the remainder has already been allocated by IANA for further downstream assignment by the RIRs [11]. The current status of the total IPv4 address space is indicated in figure 2.

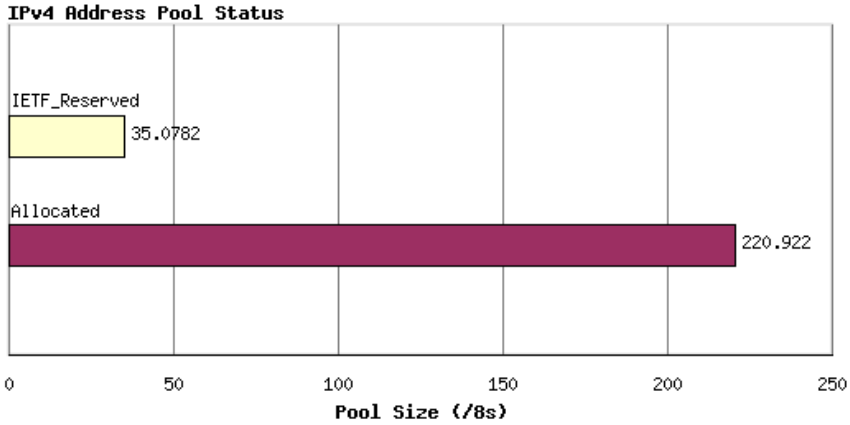

Fig. 2: Address Pool Status [11]

The current RIR address status (Table 2) which shows the present situation in the various RIRs based on the amount of the assigned addresses and the remaining addresses.

Table 2: The current RIRs address status

RIR	Assigned Addresses (/8s)	Remaining Addresses (/8s)
AFRINIC	8.5854	4.4107
APNIC	53.7944	1.2055
ARIN	77.9392	5.9865
LACNIC	15.3909	4.6091
RIPE NCC	45.2077	3.7923

Stephen Groat, et al [18] testified the eminence of the migration from IPv4 to IPv6 addresses. They argued that current methods of IPv6 address assignment, both stateful and stateless, use static identifiers that allow geotemporal tracking of users, monitoring and correlation of traffic over multiple sessions, and targeting for system-specific cyber-attacks. Susan Trulove [19] from Virginia Tech discussed the need for the IPv6 to replace the 20-year-old internet protocol version 4. Mark Tink [20] discussed the readiness for effects of IPv4 exhaustion, the dual-stack IP deployment on May 2007 and the transition from IPv4 to IPv6 addresses in Africa. John Loughney [21] carried out research on IPv4 allocation pool exhaustion and the switch to IPv6 addresses. He concluded that IPv4 addresses will run out, but there sre going to be some dynamic issues which affect this. According to him, public IPv4 addresses may be needed for transition, so earlier usage of IPv6 can help. Silvia Hagen [22] in a brief study about IPv6 discovered that Asia especially Korea, China, Japan and India have embraced IPv6.She further argued that USA and Europe are planning for IPv6 deployment but nothing was found describing what Africa has done to prepare for IPv6 deployment.

III. THE TRANSITION

The internet is fast running out of addresses [9], [23]. By the end of the year it is thought that almost all the available addresses for computers, smartphones and websites will have been exhausted [9]. The best solution to ensure that the web can grow to its full potential is to change the way the system reads websites' addresses by moving to the next generation of addresses, known as IPv6. However, this system has never been used at a global scale and potential problems need to be uncovered before it can become the internet's new standard. The leading internet providers and websites collaborated in a 24-hour global experiment - World IPv6 day. The goal of this day is to tackle this pressing issue and drive forward the change needed ensure the continued delivery of full and free access to data and resources to the research community via the web [9].

On Wednesday 8 June, more than 300 organizations, institutions, companies and governments under went a trial experiment of the future language of the internet: World IPv6 day. From 1am Nigerian time to 1am (Nigeria time) on Thursday morning, alongside Facebook, Google, Cisco, Yahoo, Sony, universities and many US Government departments, some institutions such as the Sanger Institute opened its websites to visitors using two methods of delivery [9]: the current standard of IPv4 and the future standard of IPv6.

This change is needed because IPv4 is about to run out of addresses [23] for all the websites, computers, smartphones and internet-enabled devices that are coming on stream. In fact, the last major batch of available IPv4 addresses (about 80 million of them) was given out in a ceremony on 3 February 2011 [9], [15] [24]. It is expected that all these addresses will have been taken by September 2011 [9].

The move to IPv6 is facing challenges. Although the new addressing system was designed in the 1990s and its technical foundations are now well established, not everyone is using currently equipment that can handle IPv6. It is estimated that roughly 0.05% of internet users will not be able to connect to websites that offer both IPv6 and IPv4 (a system known as 'dual stacking') [9]. IPv4 and IPv6 will coexist on the Internet for decades, creating the need for additional transition mechanisms because the dual-stack model won't solve all of the emerging problems for network operators [25].

To uncover any problems that might occur with a switch to IPv6, and to create an event to drive forward the change, the Internet Society is coordinating a global experiment. The society - a charity dedicated to ensuring the open development, evolution and use of the internet - is using this day-long

event, to create a common focus to bring together all stakeholders in the internet to resolve any issues [9]: from governments and universities, to internet service providers, operating system suppliers and hardware manufacturers.

3.1. IPv6 Deployment Trend

Globally, the rate of the IPv6 deployment is growing super-linearly [17] (Figure 3) showing the response towards the adoption of the future promising technology.

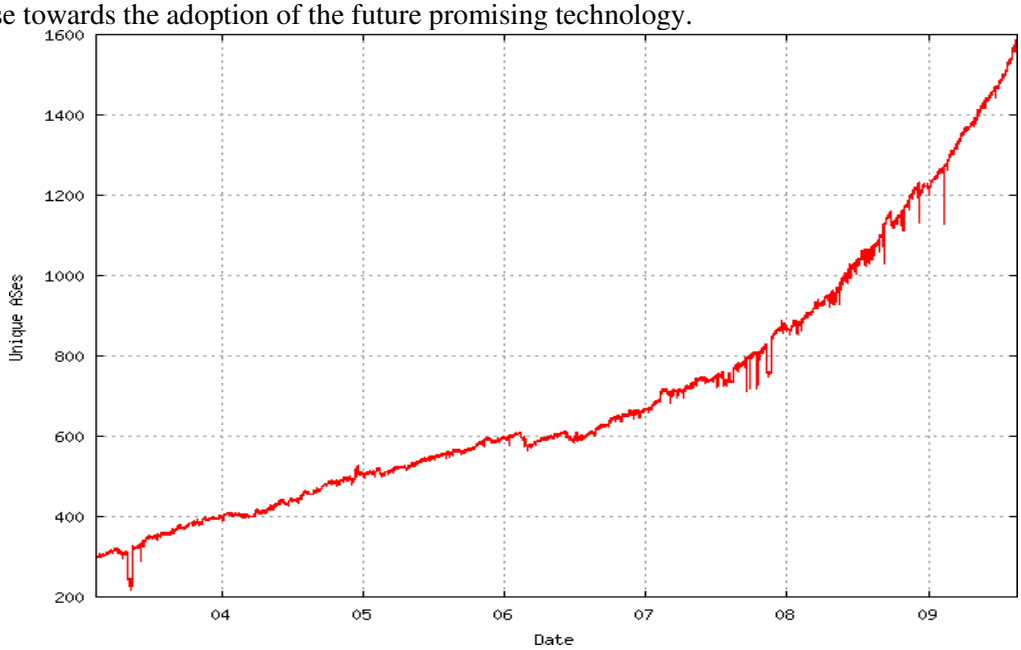

Fig. 3: IPv6 deployment growth [17]

The NRO announced that the rate of new entrants into the IPv6 routing system has increased by approximately 300 percent over the past two years. This growth has been attributed to the active promotion of IPv6 by the five RIRs and their communities [2].

IV. RESULTS AND DISCUSSION

The IPv6 adoption and deployment status in Africa was drawn from 1984 to 2011 as shown in figure 4. The results were based on the latest information on IPv6 Addresses allocated in the AfriNIC region [4]. The deployment which was further categorized into countries (Figure 5) in the region also revealed the poor rate of IPv6 deployment, recorded in most the countries.

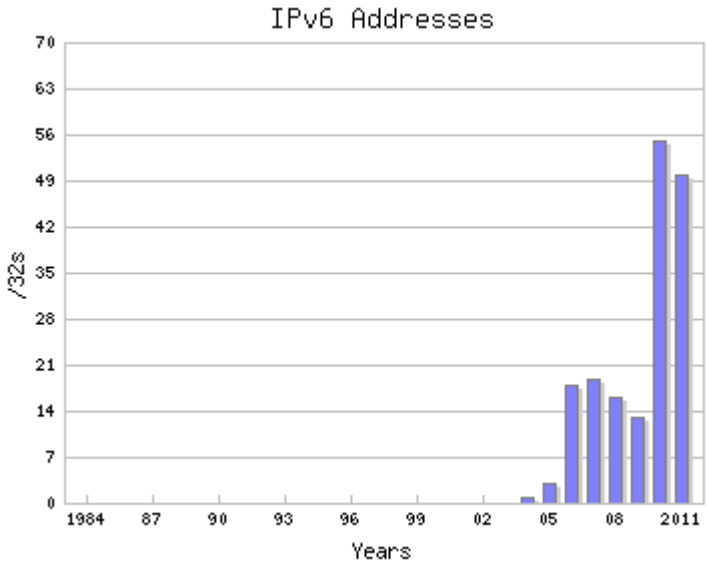

Fig.4: IPv6 Addresses (Yearly) [4]

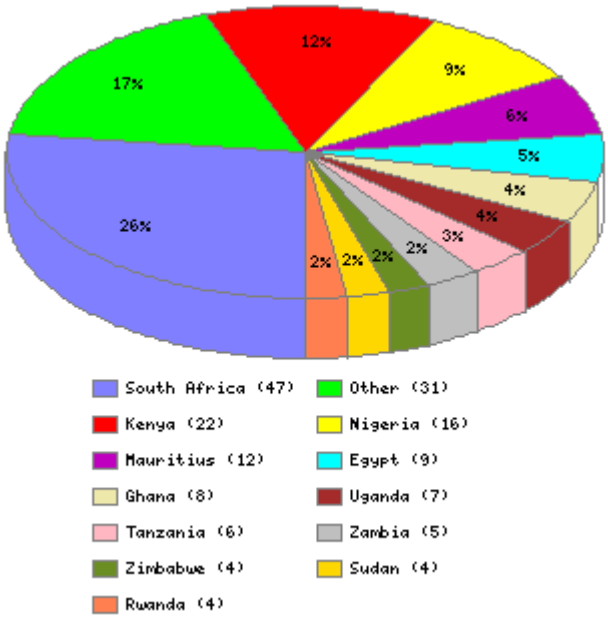

Fig.5: IPv6 Address by Country [4]

Note that "Other" refers to all countries that have less than 2% of the total.

South Africa recorded the highest percentage of the IPv6 address allocation followed by Kenya and Nigeria with 26%, 12% and 9% respectively (Figure 5). According to the result, twelve countries in Africa recorded 2% and above of the IPv6 address allocation and the remaining greater number of countries recorded less than 2% of the allocation indicating little or no awareness of the future internet communication technology in most countries in Africa.

The poor IPv6 adoption in Africa as reflected in the results was attributed to the following:

- People are not aware of additional benefits IPv6 should bring in their lives; thereby, nothing is motivating them especially in the dynamic sustenance towards IPv6. The main cause is the fact that there is no active e-strategy program in the different government/ political policy agenda.
- The continent on its entirety lacks the general IPv6 consciousness-raising campaign for total capacity building programs. Many organizations including AFRINIC tried to initiate some capacity building programs upon IPv6 for the attention of mainly some technical bodies such as the Internet Service Providers (ISPs). Since then, not sure those things are going ahead at the expected speed. It should not be strategic to begin the consciousness-raising campaign focusing on those specific bodies.
- Many ISPs in Africa are not yet aware on the technical/business benefits of IPv6. Some of the ISPs in Africans are still relying on the simple seem fact that since IPv4 is working well presently, it is not cost-effective should they change or remove it.

4.1. The Consequences of Delay in Ipv6 Deployment

Without a dual-stacked network or deployed protocol translation services, an individual user gaining Internet access for the first time from an IPv6-only ISP may not be able to access the Web sites or mail servers for organizations that operate IPv4-only networks [8]. There are implications to not adopting IPv6. These implications become evident as wide-scale deployment of IPv6 accelerates. Not adopting IPv6 may cause the following types of issues for the various types of Internet users [8]:

Individual Users: Individual users may not be able to view Web sites and communicate with certain destinations. Many individuals use the Internet to communicate with distant friends and family, research medical issues, and participate in group discussions among other things.

Enterprise Organizations: Enterprise organizations and corporations may not be able to communicate with certain critical government resources, clients, and potential customers. E-mail is a critical form of communication for most enterprise organizations today and their Web sites are vitally important resources for them to communicate with the public.

Governments: Governments may lose their ability to see and communicate with the "whole Internet." Access to information is critical for governments. There also may be an inability for citizens and other Internet users to access information about the government and communicate over the Internet with government agencies.

Service Providers: Organizations that provide services over the Internet may experience customer and/or revenue losses if they do not update their offerings to include IPv6. Customers will expect to be able to communicate with everyone else on the Internet and may seek out other ways to do that if their current service provider is not capable.

4.2. The Way-out

In other to facilitate the rate of IPv6 deployment, the various levels of governance (government, academic/ business organizations, etc) in African countries should in their day-to-day policy making include as an agenda, active e-strategy programs to help not only in the imperative deployment of IPv6 but also in other Information and Communication Technology (ICT) facility development. AFRINIC and other related organizations in Africa should be expected to develop some capacity building programs upon IPv6 awareness campaign for the general populace, thereby motivating the people and enlightening them about the technical/ business benefits derived from switching to IPv6.

V. CONCLUSION AND RECOMMENDATION

The Internet Protocol Version 6 (IPv6) had been adopted globally to solve the future problem of Internet Protocol Version 4 (IPv4) exhaustion. The IPv4 was the first Internet protocol version to be used widely and still dominating today's internet traffic. The global rate of IPv6 deployment accelerated due to the total adoption of the technology in most developed regions of the world. The African situation was revealed to be different as reflected by the poor results of IPv6 deployment rate recorded in most countries of the region by AfriNIC over some past years.

The various development strategies stipulated to aid the deployment of IPv6 such as the global awareness campaign of the World IPv6 day, general capacity building set up by the RIRs, and many more, have been confirmed effective with the recent IPv6 deployment improvement recorded globally even in Africa.

It was recommended that the business sector should start to support IPv6 by hosting content on IPv6-enabled websites, ensuring accessibility to IPv6 users. Software and hardware vendors should implement IPv6 support in their products urgently, to ensure they are available at production standard when needed. Governments should learn more about IPv6 transition issues in order to support IPv6 deployment efforts in their countries. IPv6 requirements in government procurement policies are critical at this time. Finally, civil society, including organizations and end users, should request IPv6 services from their ISPs and vendors, to build demand and ensure competitive availability of IPv6 services in coming years.

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