CLOSING KEYNOTE REMARKS BY ALAN BARRETT, CEO, AFRINIC AT SAFNOG-3, DURBAN, SOUTH AFRICA, 4TH TO 7TH SEPTEMBER 2017.

Topic: 'The Impact of IPv4 exhaustion – The market and the need for IPv6'

Distinguished delegates,

It has been an enriching week for everyone here at SAFNOG. I have been impressed by the quality of all the sessions, and I thank the organisers for bringing together the Internet community from this sub-region, and from all over the world as well.

SAFNOG is about building a community, and cooperation in developing Internet infrastructure. These are ideals that are also at the heart of what AFRINIC stands for, as the Regional Internet Registry for Africa and the Indian Ocean region. We have therefore actively participated here this week with our capacity building sessions on Internet Number Resource Management and IPv6 deployment.

Africa has a relatively young population, and Africa's population is growing faster than that of other continents. Africa's Internet penetration is lower than that of other parts of the world, but it is also increasing rapidly. This represents a huge opportunity for Internet service providers.

I am sure that all the ISPs in this room would like to have more customers, and larger and faster networks in the future. In order to achieve that, you will need IP addresses.

The Internet has been running with IP version 4 since it was created in the 1970s. We knew that the old IPv4 did not have enough addresses for the whole world, with less than 4 billion usable addresses.

This is obviously not enough for a world with a population of about 7 billion people, and that has led to the use of address sharing technologies — Private address space and NAT.

The earliest organisations to connect to the Internet were allocated large blocks of IP addresses, then called "Class A" and "Class B" networks — in modern terminology, a "Class A" is a "/8", or about 16 million IP addresses, and a "Class B" is a "/16", or about 65 thousand addresses. By May 1992, about 38% of the Class A networks, and 45% of the Class B networks had already been allocated, and it was clear that they were running out rapidly. A document called RFC 1466 said that we should be more frugal in allocating those large blocks: An organisation that was too big for a /24 – 256 addresses – but not big enough for a /16 –

65536 addresses – would receive an intermediate amount. This seems obvious to us today, but it was novel at the time.

IPv4 allocation as of May 1992 (from RFC 1466)

	Total	Allocated	Allocated (%)
Class A	126	49	38%
Class B	16383	7354	45%
Class C	2097151	44014	2%
Total /24s	14548735	5137902	35%

Also in the early 1990s it was clear that a new Internet Protocol was needed, with a greatly expanded address space. Several competing specifications were developed. In 1994, a winner was chosen, and that developed into what we now know as IPv6. Instead of IPv4's 32 bits to address up to 4 billion hosts, IPv6 has 128 bits, conventionally divided into a 64-bit network part and a 64-bit host part. This is enough for every person to have millions of IPv6 networks, and every network to have nearly 1019 devices — that's more devices than the number of grains of sand in all the beaches and deserts of the world. In practice, most networks will have a few devices, up to a few hundred for large office or WiFi networks.

As you know, end users or typical small companies get IP addresses from their ISPs. ISPs and some companies get addresses from Regional Internet Registries such as AFRINIC — there are five RIRs serving different parts of the world. RIRs get addresses from a central registry called IANA — the Internet Assigned Numbers Authority.

RIR Service Regions map

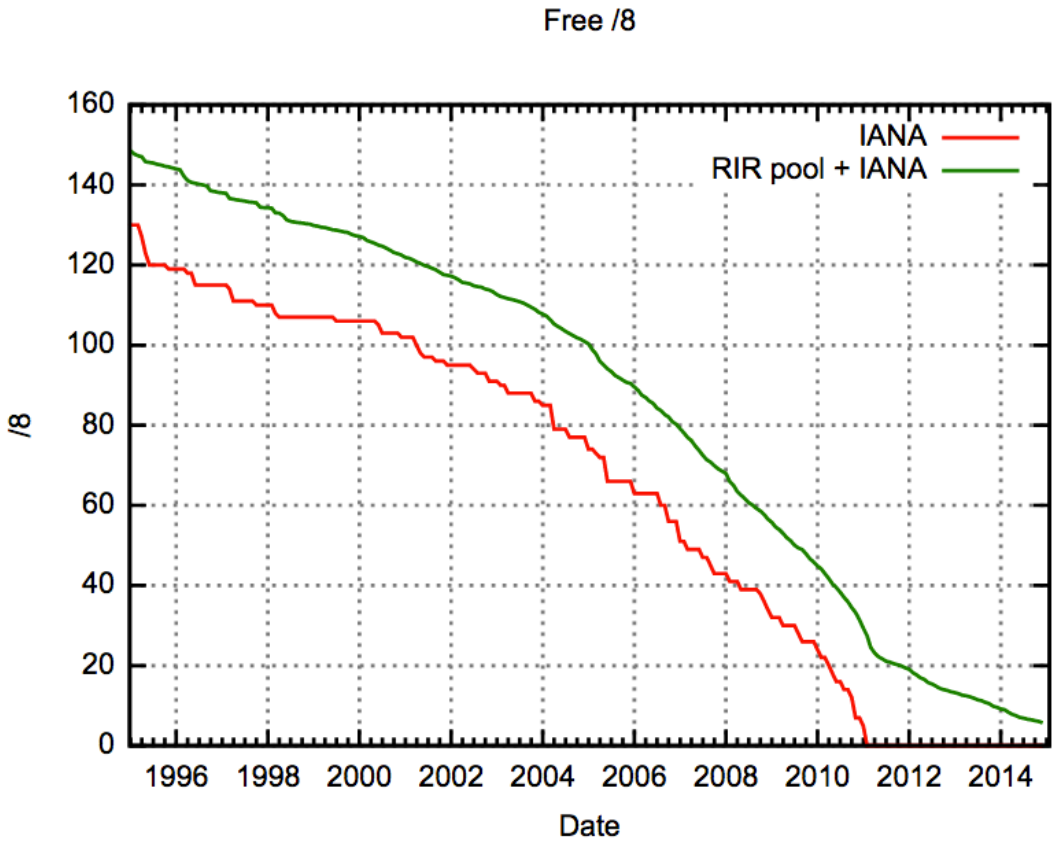
Source: NRO
https://www.nro.net/about-the-nro/regional-internet-registries/

Each of the RIRs has a policy forum, where they discuss the rules for how RIRs will allocate or assign addresses to their members. By 2008, the RIR policy forums were discussing what to do with the last few /8 blocks available in the IANA inventory. It was decided that, when only five /8s were left, then each of the five RIRs would get one final /8 from IANA.

That milestone was reached in 2011. ICANN, as the operator of the IANA function, allocated one final /8 of IPv4 addresses to each RIR in February 2011.

Here's a graph from Wikipedia showing the amount of IPv4 space available in both the IANA pool and the pools at the five RIRs, from 1995 to 2015. You can see that the IANA pool was depleted in 2011.

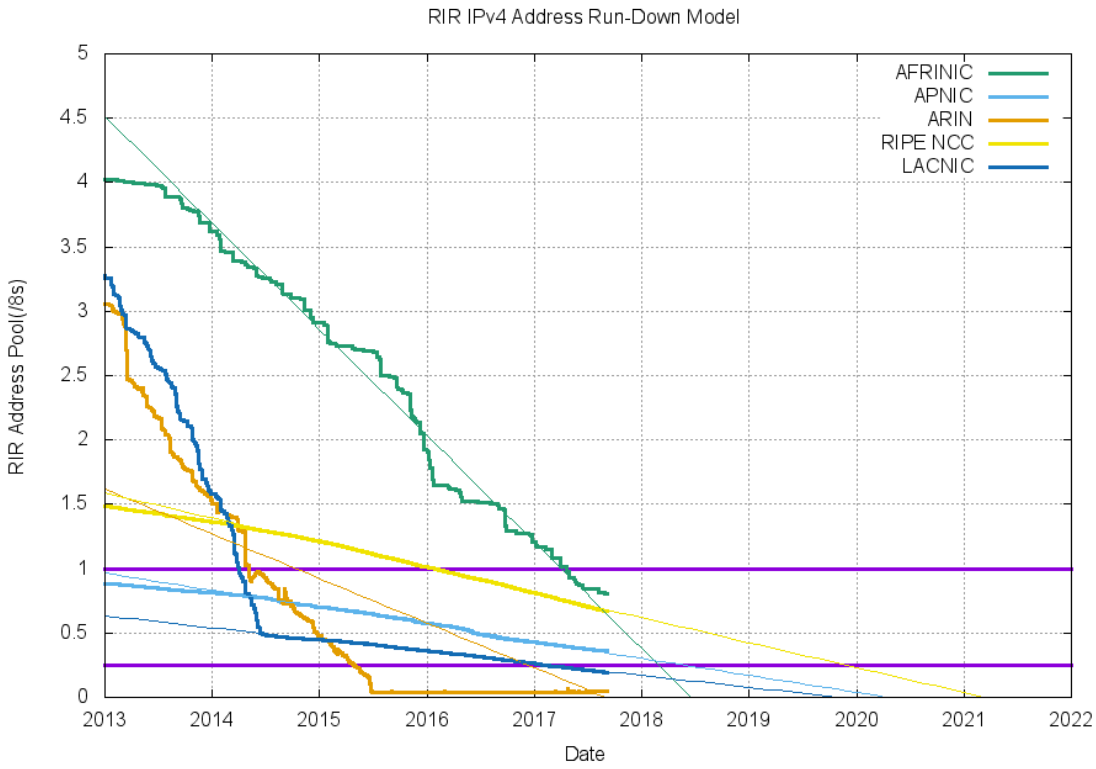
IPv4 depletion at IANA and RIRs 1995 to 2015



Source: Wikipedia
https://en.wikipedia.org/wiki/IPv4_address_exhaustion

Here's another graph, from Geoff Huston, showing the amount of IPv4 space available in each of the five RIRs from 2013 until today, including projections for the next few years. You can see that AFRINIC has the most available space today, but it probably won't last long.

IPv4 depletion at all RIRs 2013 to 2017



Source: https://ipv4.potaroo.net/

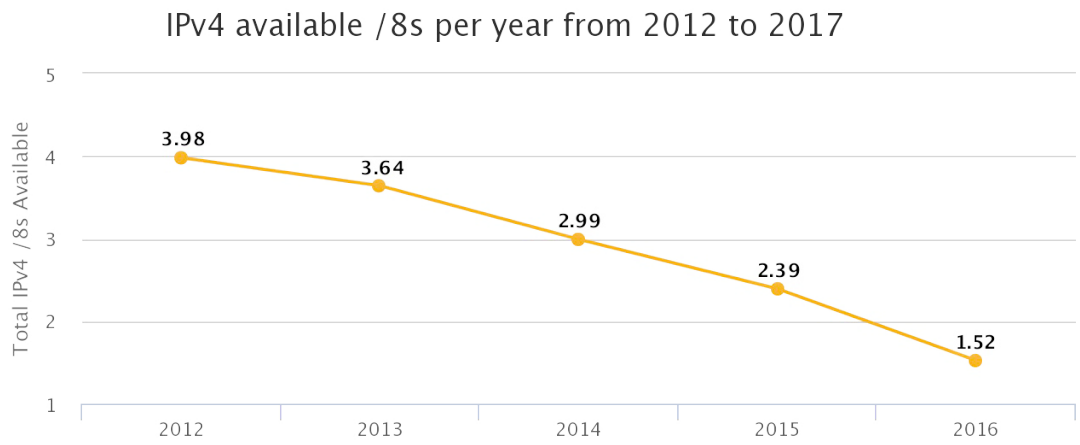
Until recently, AFRINIC has been the only Regional Internet Registry with enough IPv4 space to continue using the traditional distribution rules, but that too has changed. At the beginning of April 2017, we started allocating IPv4 addresses from the "final /8" in terms of Exhaustion Phase 1 of the Soft Landing policy that was approved in 2011.

Under the rules for Exhaustion Phase 1, you can't get more than one /13 at a time; that's about half a million addresses. You also can't get more address space until you have used 90% of your existing address space, and any usage outside Africa has to be "soley in support of connectivity back to the AfriNIC region". For example, you could connect to an exchange point outside Africa, but you could not use AFRINIC IPv4 space for a customer outside Africa.

Different RIRs have different rules. For example, in the APNIC region, you can get two /22s, totaling 2048 addresses, and then you can't come back for more. In the ARIN region, you can go onto a waiting list, and good luck getting anything at all.

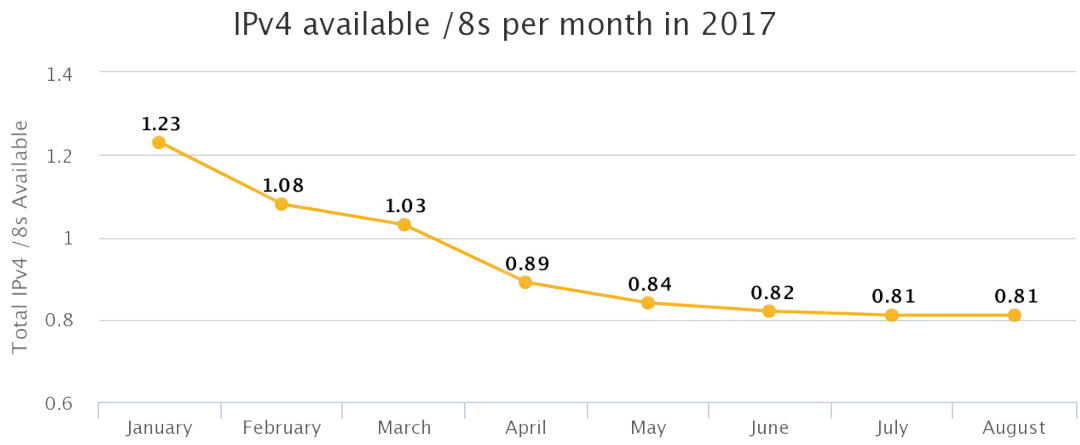
Let's zoom in on AFRINIC's IPv4 available pool for the past few years and months:

AFRINIC past 5 years



Source: AFRINIC

AFRINIC 2017



Source: AFRINIC

It's interesting that the depletion rate has slowed since AFRINIC reached the final /8 at the beginning of April 2017. We are receiving resource requests from organisations who don't meet the "90% usage" requirement, but we expect that this is only a short term situation. Within a few months, the depletion rate will probably pick up again.

Now, we know that IPv4 addresses would never have been enough for the whole world, no matter how carefully they were managed. Fortunately, we have a new protocol called IPv6 which has plenty of addresses. But IPv4 and IPv6 don't interoperate.

Oh, you can run them both at the same time on the same equipment. This is called dual-stacking. But they don't interoperate in the sense that a device with IPv4-only can't talk to a device with IPv6-only.

Today, there are many IPv4-only networks, and a few IPv6-only networks. There are also some translation schemes, like NAT64 and DNS64, to help the new IPv6-only networks talk to the old IPv4-only networks. I wish that everybody would deploy IPv6 so that we could reduce the complexity, but that will take time.

Meanwhile, IPv4 address space becomes more and more difficult to obtain.

In the AFRINIC region, the total available IPv4 pool today is about 13.5 million addresses; about 0.8 /8s.

The AFRINIC free pool won't last long; by 2018 we expect to reach "Exhaustion Phase 2", which will mean nobody can get more than a /22 – 1024 addresses – at one time.

There are discussions in the AFRINIC policy forum – the "RPD" mailing list – about a possible change to the IPv4 Soft Landing policy. There's a proposal called "Soft Landing Bis" which, if it passes, will make it even more difficult to get IPv4 addresses.

Here's a summary of the rules for AFRINIC's Exhaustion Phase 1 and Phase 2, and the proposal under discussion:

AFRINIC "Soft Landing" Policy

Exhaustion Phase 1 (when final /8 is reached -- April 2017)
- Maximum /13 at one time, no limit to number of times
- Must have used 90% of previous allocations
- Out-of-region use "solely in support of connectivity back to the AfriNIC region"

Exhaustion Phase 2 (when only a /11 is available)
- Maximum /22 at one time, no limit to number of times

"Soft Landing Bis" proposal under discussion
- Phase 1: Max /18 per 24 months
- Phase 2: Max /22 per 24 months

The policy development process is open to anybody who is interested enough to get involved in the discussions on the "RPD" mailing list. You are all invited to the AFRINIC-27 Public Policy Meeting which will be held in Lagos, Nigeria, from 27th November to 1st December later this year, but you can participate in policy discussions without attending any of Afrinic's face to face meetings.

Whether or not you get involved in the policy discussions, and whether or not there are changes to the policy, IPv4 address space supplies at all the RIRs, including AFRINIC, are running out.

So if you can't get IPv4 addresses from your RIR, what can you do?

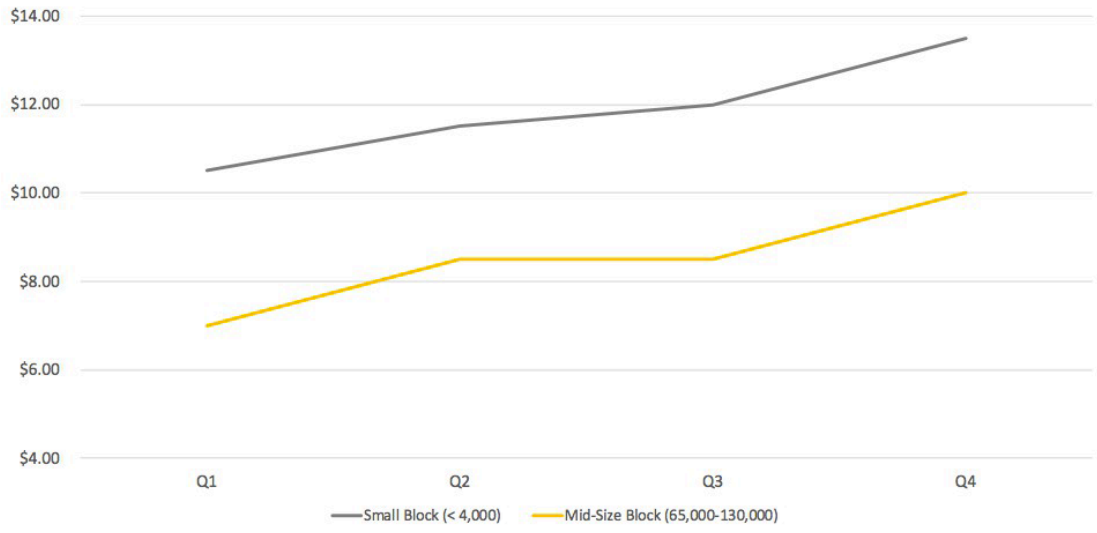
Well, you could try to make do with what you have already, using NAT to give private address space to your customers; or you could go IPv6-only, with a tiny amount of IPv4 space to let NAT64 work; or you could look to the market.

Yes, there's a market for IPv4 addresses.

All the RIRs allow some form of transfer of IPv4 addresses from one organisation to another. Some allow transfers only within their region, and others also allow transfers from an organisation in one region to an organisation in another region. AFRINIC recently passed a policy to allow in-region transfers, but the policy has not yet been implemented.

It's difficult to find pricing unless you are a buyer or seller, but figures of about $10 per IP address, or more, are mentioned. Here's are some graphs from Avenue4 LLC's 2016 State of the IPv4 Market Report, showing the prices in the ARIN region in 2016 for different block sizes.

ARIN transfer prices



Source: Avenue4
http://avenue4llc.com/wp-content/uploads/2017/03/2016-State-of-the-IPv4-Market-Report.pdf

I don't know what the market prices will be in the AFRINIC region once the transfer policy is implemented, but if it's similar to the prices in the ARIN region — $10 or more per address — then that would be a significant expense for an ISP with a need for millions of addresses.

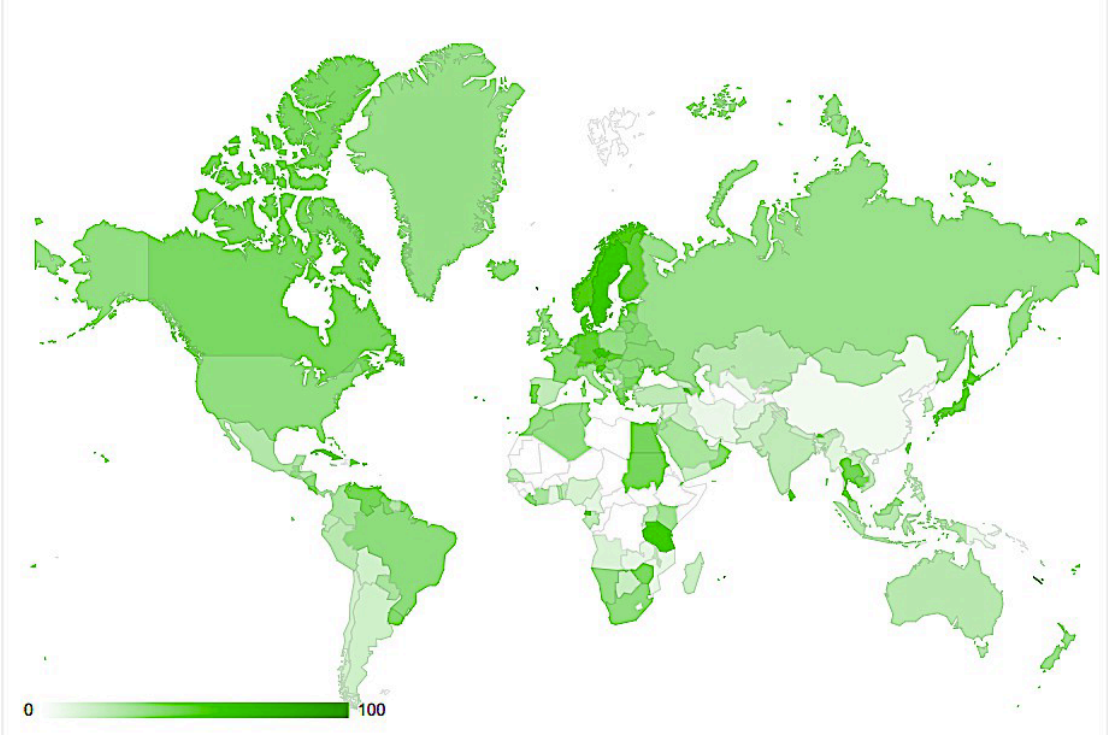
It's also difficult to estimate the market size in the AFRINIC region. There are some legacy address space holders, who received IPv4 addresses in the early 1990s before the RIRs were established, and who may have more space than they need. They might be willing to transfer some of their space, if the price were right, but the supply is rather limited.

If a future policy allows inbound transfers from other regions to the AFRINIC region, then that might increase supply, at a price. You may be able to pay to take transfer of IPv4 addresses that are currently under-utilised in other parts of the world.

Really, the only viable long-term solution is to deploy IPv6. Fortunately, that is happening, but slowly.

Here's a map showing the percentage of Ases in each country that have some IPv6 addresses. There's a lot of green on this map, but Africa is behind other regions:

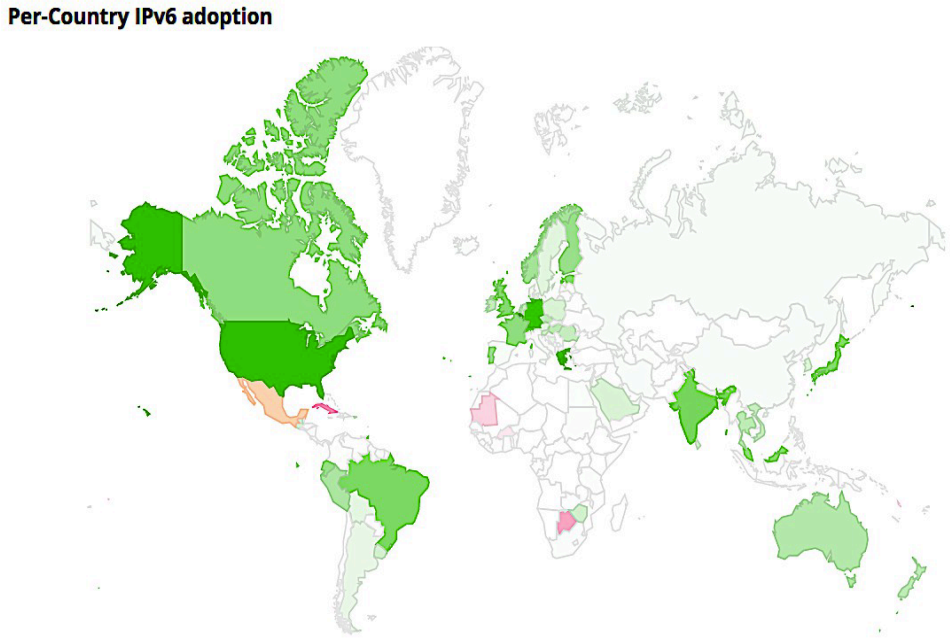
% ASs with IPv6 Allocation



Source: CISCO 6LAB

If you look at clients who actually use IPv6 in preference to IPv4, the picture is not so good:

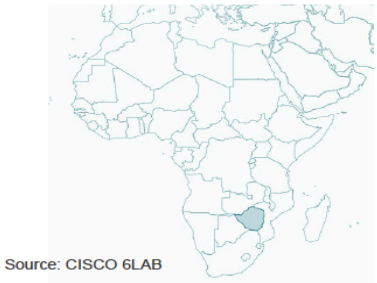
Clients using IPv6 (world)



Source: Google
https://www.google.com/intl/en/ipv6/statistics.html

In Africa, you can see a little bit of green in Zimbabwe, and some red in a few countries, which indicates that IPv6 usage is not only very low, but also experiences high latency or other problems.

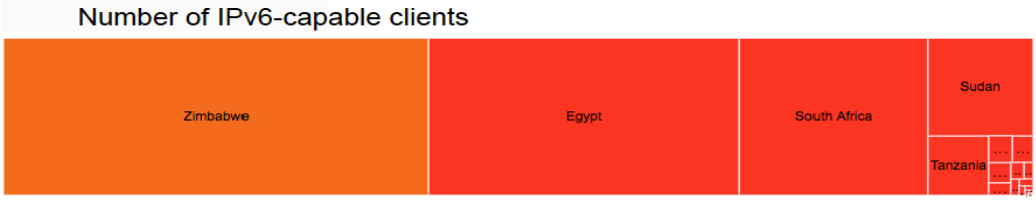
IPv6 usage % of clients (Africa)



IPv6 Usage

% of clients

Country	Google	APNIC
Zimbabwe	7.15%	9.15%
Egypt	0.57%	0.4%
South Africa	0.38%	1%
Sudan	0.34%	0%
Tanzania	0.44%	0%

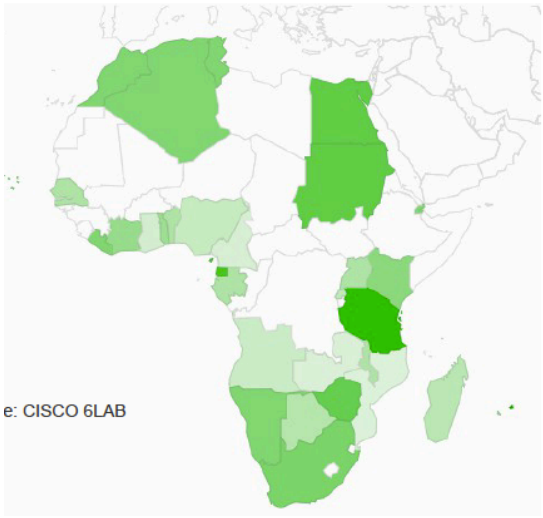


Source: CISCO 6LAB

Currently, about 41% of AFRINIC Members have some IPv6 space, and about 18% of networks in Africa are announcing an IPv6 prefix. However, only **one quarter of a per cent** of Internet users in the region are able to connect using IPv6, which is well behind the global average.

Many of organisations have IPv6 addresses but are not announcing the space in BGP. Here's a map shaded by the ratio of IPv6 prefixes announced in BGP versus the total:

Ratio of routable IPv6 prefixes (seen in BGP vs allocated)



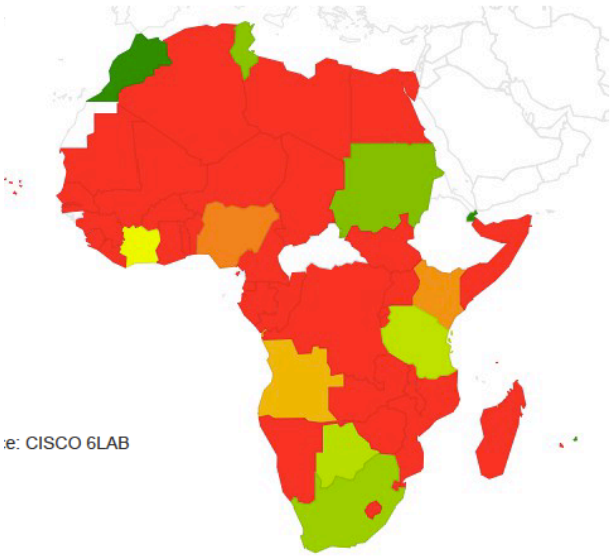
Mauritius	**68%**
Tanzania	**56%**
Equa. Guinea	**50%**
Zimbabwe	**42%**
Egypt	42%
South Africa	35%
Namibia	33%
Algeria	33%
Botswana	18%

Source: CISCO 6LAB

A big barrier to providing IPv6 service is whether or not your upstream or transit provider offers IPv6. So let's look at that:

IPv6 transit ASes

ASs offering IPv6 transit versus all transit ASs



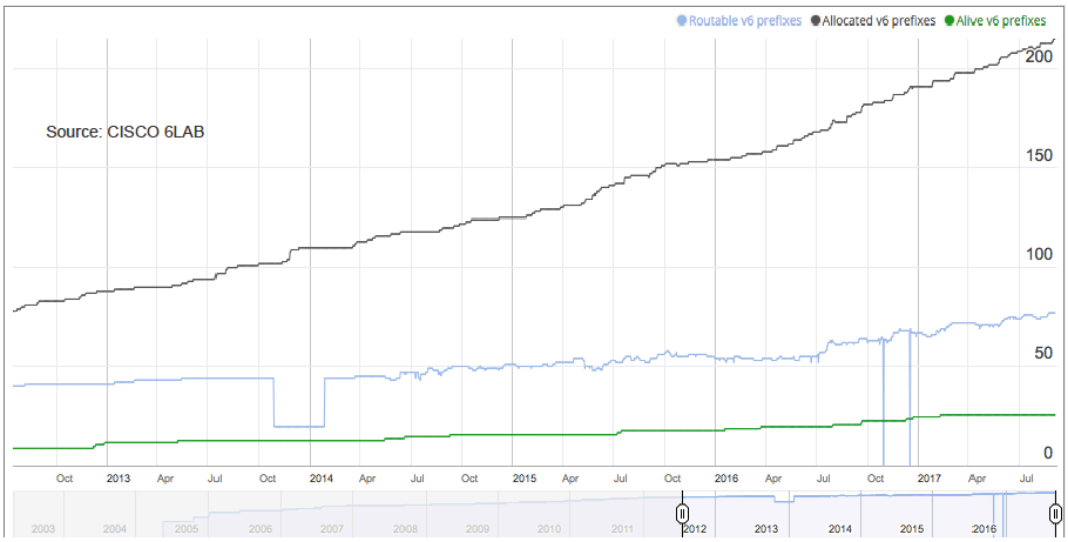
Country	Dual-stack	IPv6 Enabled
Djibouti	**100%**	**100%**
Morocco	**98%**	**98%**
Mauritius	**95%**	**96%**
Sudan	**76%**	**86%**
South Africa	70%	79%
Botswana	63%	63%
Tanzania	61%	69%
Angola	33%	64%

Source: CISCO 6LAB

A few countries are doing pretty well, but the situation in most of Africa is disappointing.

Some of the IPv6 prefixes that are seen in BGP don't really seem to be used for much. I am not sure why that is, but here's a graph of how IPv6 is taking off in South Africa:

IPv6 Uptake last 5 years (South Africa)



Source: CISCO 6LAB

The black line shows the number of IPv6 prefixes allocated.

The blue line shows prefixes announced in BGP – about one third of the allocated prefixes.

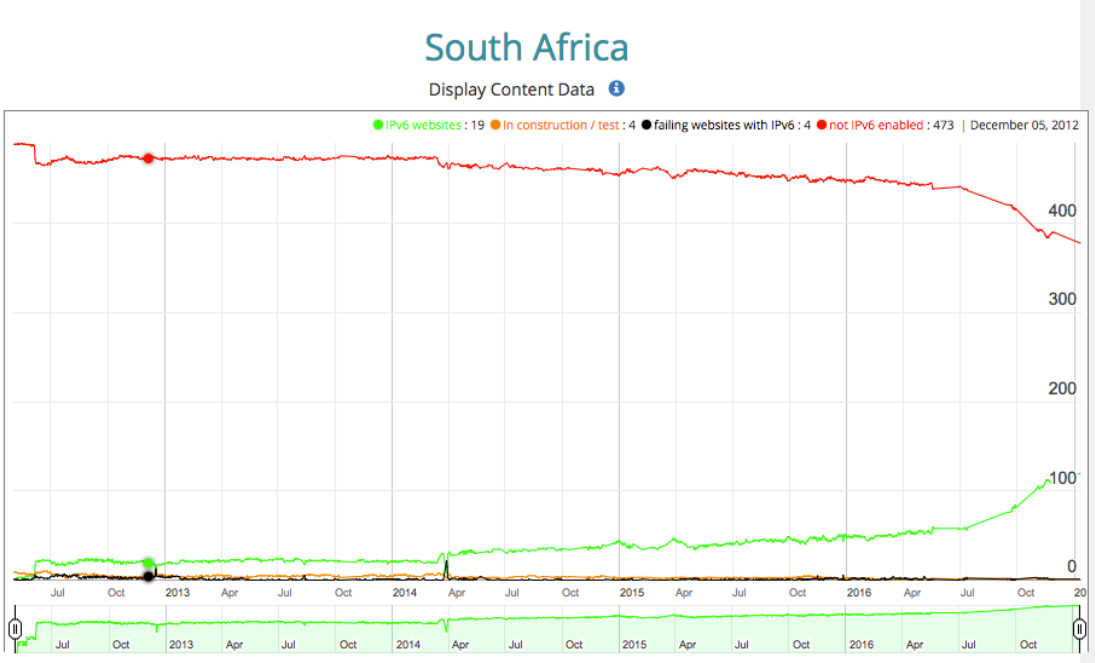
The green line shows prefixes that appear to be “alive” – they have some active devices. This low level of use is rather sad.

I know that ADSL providers in South Africa are restricted by the way the infrastructure provider works, but if you control the CPE then you could theoretically configure some kind of IPv6 tunnel, but that might not be commercially viable.

Anybody deploying new networks, such as Fibre providers, should be able to provide IPv6 as a matter of course. We heard yesterday that the equipment all supports IPv6, but the providers don’t always configure it.

However, there is some good news for South Africa. Here's a graph showing the top 500 web sites and their IPv6 status. It shows that more than 100 of the top 500 web sites in South Africa are IPv6-enabled.

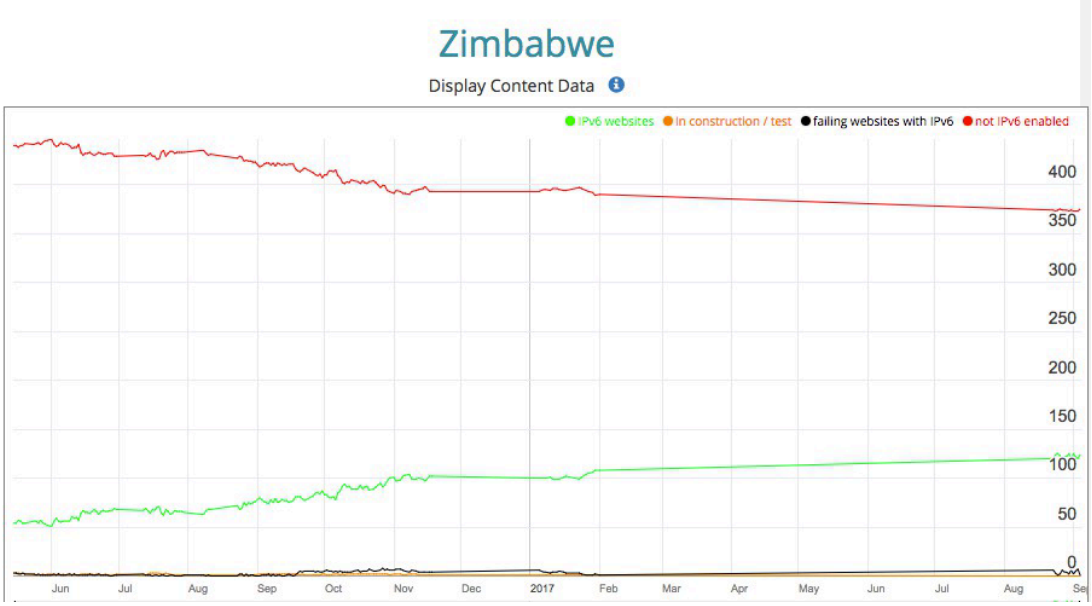
Top 500 web sites, South Africa



Source: CISCO 6LAB

Similar situations appear in some other countries, with more than 100 of the top 500 web sites being IPv6-enabled.

Top 500 web sites



Source: CISCO 6LAB

In closing, let me repeat that there is an IPv4 market in the rest of the world, and there will be a market in Africa by the end of the year. The market will move IP addresses from where they are under-utilised to where they are perceived as more valuable, but it cannot create more address space. IPv4 exhaustion is here, and it's going to hurt, so the sooner you deploy IPv6, the better for you.

Thank you for your attention.