ICANN Start, Episode 5: What Does IPv6 Mean?

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Scott: Imagine you're at a technology conference, and they planned for 500 attendees, but 800 showed up. The local area network for the conference planned only 500 network addresses. So what happens? The first people to arrive get an address for their laptops, and their smart-phones, and maybe even their e-readers. The last people who show up can't connect at all, because there are no more network addresses.

Something similar to that could happen to the Internet itself, because of the depletion of something we call IPv4. To inform us about the problem, and the answer (known as IPv6), today we meet with Leo Vegoda, Manager of Number Resources for ICANN. When will the Internet run out of addresses? And what happens then? I'm Scott Pinzon. Those topics and much more are all ahead on this special expanded episode of *ICANN Start*.

[Music Intro]: Welcome to *ICANN Start*. This is the show about one issue, five questions:

- What is it?
- Why does it matter?
- Who does it affect?
- Who's going to fix it?
- What can I do about it?

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Scott: Thanks for being here today, Leo.

Leo: Well, thank you very much, Scott.

Scott: Just to kick things off, can you explain to us, as a foundation, what is an IP address?

Leo: IP addresses are the numeric identifiers that computers use when they talk to each other. So while we use names, for instance, www.ICANN.org to identify ICANN's website, the computers themselves don't actually talk to the name, they talk the number that sits behind that name. Those numbers in IPv4, the fourth version of the Internet protocol, look like this: 192.0.2.53. And in IPv6, they're written in

hexadecimal, and IPv6 is the sixth version of the Internet protocol. That's the new version that we'll hopefully be moving to in the next few years.

Scott: New is a relative term here, right? IPv4 is from about when?

Leo: IPv4 is from the early 1980s. So, we've pretty much had thirty years of it. IPv6 was finished as an initial protocol specification in 1996 and it started being allocated in 1999. So, we've had it around for just over ten years as a real networking protocol that people can use.

Scott: What is the problem with IPv4 that made people think there needs to be an IPv6?

Leo: IPv4 is a finite space. It has a bit more than four billion addresses. There are more than four billion people on the planet. Lots of those people want to have more than one device that has network connectivity. That's why we need the new version of the Internet protocol with the bigger address space.

IPv6 has a 128-bit address space, which is 340 undecillion addresses, which is such a big number that I don't really understand what it means myself in my head. It's just such a big number. Whereas IPv4 with its 4 billion addresses is a 32-bit address space. So there's a massive difference in the size between the two.

Scott: One of the things we like to ask in our audio briefings after "What is it?" is, "Why does it matter?" Why do we need IPv6? If it's so great, how come it's not already established after this many years?

Leo: I think the main reason that people haven't been implementing IPv6 on a wide-scale so far, is because up until now we've had IPv4 and it works. If it ain't broke, don't fix it. People knew that at some point IPv4 would be full, and we would need something else like IPv6. But until that happens why take on the extra cost of implementing IPv6?

Scott: So when we say that IPv4 space is nearly depleted, we're not going to be all out of addresses tomorrow, right?

Leo: No, no, you can look at it like this. There are 4 billion addresses and that's all of the addresses in the address space. And some of those are reserved for special purposes. But overall, we have less than ten percent of that address space unallocated. And that's in our pool that we manage. And the Regional Internet Registries, or RIRs, also distribute IP addresses. We distribute addresses to them, and they distribute it within their regions, which are roughly continental in scope.

And each of those Regional Internet Registries has a pool that they distribute from because they need to hold some stock to make sure that they can fulfill the requests that they receive. They distribute addresses to ISPs and enterprise networks and so on. Those ISPs and enterprise networks also have a small amount of stock so they can fulfill requests from their customers or enterprise network operators from new sites that they start up when they open a new sales office or some remote location or whatever it is.
So we are not going to run out of addresses instantly. But the pool that we manage, the central top level pool of addresses, is likely to be fully allocated in about eighteen months time.

Scott: Wow! That's fast, by protocol standards.

Leo: I guess so; yes.

Scott: And what needs to happen then? Can we just start using IPv4 and IPv6 and now we have this big combined addressing system across the Internet? Or what happens?

Leo: We can use IPv4 and IPv6 on the same network as in the same bits of fiber or copper. But the devices that are IPv4 only can't speak to the devices that are IPv6 only, and vice versa. If they are going to speak to each other they would need some kind of translation system sitting in the middle.

Because IPv4 and IPv6 are different sizes, that means the IPv6 network can be much, much bigger. So eventually you won't be able to have IPv4 and IPv6 networks having the same layout. It's going to be too difficult because there won't be enough IPv4 addresses to match the number of addresses in the IPv6 network.

Scott: Yes, and I can see that since the IPv6 addresses are so much larger, you might just have a different type of device and a different way of shoving packets around on the network.

Leo: Most of the existing systems that we are using today actually support IPv6 already. So the laptops that you and I have in front of us support IPv6 and have done for quite some years. The devices are pretty much capable of it. Because you've got to remember that those machines that we were using 30 years ago were capable of IPv4, and IPv6 isn't dramatically different on the network from IPv6. So if the kind of computers that were running thirty years ago could run IPv4, then pretty much any cell phone (or probably pocket calculator) could run IPv6 today, if you really wanted to.

Scott: So then really, the main motivator to get over to IPv6 is just to have that additional address space, I take it?

Leo: The real motivator is to let the Internet grow, both in the scope of the Internet and the fact that we want people who don't have any network connection at all at the moment, to be able to connect to the Internet so their lives can be improved. But also, by allowing growth that doesn't require intermediation devices like application layer gateways, we can have a network that can have much more innovation.

Scott: Let's back up a second. Can you define for us what an application layer gateway is in this context?

Leo: Right. An application layer gateway is a special kind of device or piece of software that sits between the IPv4 and the IPv6 network, and it takes something like an email from IPv4 and it spits it out as an email over IPv6. Or it could be a request from a web page. Or it could be a Voice Over IP call, or something like that.

They will make sure that you can have a basic level of services that are interoperable on both IPv4 and IPv6 networks. So that means your email and web and news and Voice Over IP and stuff like that should just work. But it's sitting there and it understands the application and it's translating the protocol that the application is running over.

Scott: So I take it the need for application layer gateways is primarily to help people migrate from IPv4 to IPv6?

Leo: Yes, the application layer gateways are going to be necessary during that period where you need to run IPv4 and IPv6 side-by-side. In many ways they're useful. But the problem with an application layer gateway is that the application layer gateway needs to understand the application before it can do this translation.

Which means that when you buy a device, say a home router, if you don't have support for a new protocol in that device, you won't be able to download a piece of software on your laptop and have it run if you are on IPv6 and the other users are on IPv4. Unless you update the device's firmware or operating system. So you end up with a freeze on innovation.

You've lost all sorts of opportunity and we don't know what you would be losing by not having that innovation. Over the longer term, you want innovation in the

number of services that you have. You want all those new things that we don't have yet, but when we find out about them, we're going to wonder how we ever survived without them. You only need those gateways during the initial adoption. Once IPv6 is widespread you don't need those gateways.

Scott: Okay.

Leo: And you can have innovation. What happens is because you got all that innovation, which is presumably happening on the IPv6 network, it acts as an encouragement to people who are on the legacy IPv4 network to then adopt IPv6. So you have a virtuous cycle there.

Scott: Okay. Well it cannot be a dead simple thing to change a lot of the Internet addresses from Version 4 to Version 6. In this effort to migrate to a new addressing system, who does that affect?

Leo: Well, it shouldn't have any great affect on end-users. It will probably have most impact on Internet service providers and enterprise network operators. ISPs need to make changes like getting blocks of addresses, which is a very simple process. Configuring their networks so that they support IPv6 addressing, which is relatively simple on a network basis where you're just making sure the routers and your switches have support for IPv6, and then providing IPv6 service to customers and depending on the kind of customer that can be easy or difficult.

In some situations it is very simple because you've got a customer who is connecting over something very fast, you know, Ethernet and you can just connect them very easily. If you've got customers connecting over dial-up and DSL, sometimes it will require a little bit more change.

Scott: We've talked about this from the end-user perspective and we've talked about ISP's, but if someone is listening to this, the odds are they might be a network administrator. So how difficult would it be for a person to take their local or their business network and migrate it to IPv6?

Leo: I think that you could put those network administrators into three camps. If you've got a very small network and your service requirements are equivalent to residential users, you can buy commercial off-the-shelf services for e-mail, web-hosting, stuff like that. You could pretty much ignore the protocol that your network is delivered over. You are buying a complete service from your service provider; they will have to go through all this effort, not you.

If you work for a very large enterprise, you probably have a team of network administrators and they have a network testing lab, and they have a technology refresh cycle. And they will be going through their regular technology refresh cycle which is budgeted for, and planned. They'll be making sure that when they buy new routers and buy new switches, and buy new servers, and buy new software, that it all has support for IPv6, because they have the resources to plan for that and implement it slowly as they go and do everything else that they do. It's something they have to do, but it's not a massive effort.

I think, if you're caught between those two camps, it could be more difficult. You might have a network that is sufficiently large that you can't buy commercial, off-the-shelf solutions. But, on the other hand, not have the resources to have a regular technology refresh cycle and not have -

Scott: A large IT team.

Leo: Exactly, yeah, so if you're in between those two camps, that is probably where you will have businesses that have problems. They need to hassle their service providers and make sure their managers understand what they need to do. And it's one of those things where people need to do as much planning as they can, just so they can minimize the eventual impact.

Scott: Right. And how would this affect registries and registrars?

Leo: For registries and registrars in the ICANN system, the three key things are to make sure that IPv6 glue registration is supported in the DNS. And when you have a DNS name – like, for instance, NS.example.org could be the name server for example.org. If you want to find out about anything in example.org, you go and ask NS.example.org

Scott: I'm with you so far.

Leo: But you can only get to NS.example.org if you know the IP address of NS.example.org

Scott: Okay.

Leo: But you can't get that IP address without asking NS.example.org.

Scott: Catch-22.

Leo: You're in a Catch-22. So what you need is you need glue, and that's basically a hint that comes from the higher-level name server. In this case, it would presumably be the name server for the .org zone, saying NS.example.org is at this IP address. Registries and registrars need to make sure that they can at least support IPv6 glue registration so that they aren't on the critical path for custom organizations that are deploying IPv6. Then it works. Similarly, they should be supporting DNS and provisioning functionality over IPv6. For provisioning, what we're talking about is basically the fulfillment of customer orders.

So a customer needs to connect to the registry or the registrar in order to tell them, "Hey, I want this thing done." And for some registries and registrars, they use the EPP protocol. And that would mean running that protocol over IPv6. Others use web-pages with some kind of management on the web-page and that would be providing that web-page over IPv6.

And the other thing is public facing servers, like web servers, mail servers. If you find that your servers aren't available over IPv6, then anyone who's only connected over IPv6 and has poor IPv4 connectivity through some kind of translation service, would have a hard time accessing your services. So you would want to make your services available over IPv6, so that you can be available to those potential customers.

Scott: Makes sense. So we have this situation where we're running out of IPv4 addresses. The world has not really headed pell-mell in bulk to IPv6, so who's supposed to fix this awkward situation?

Leo: Basically we all are. We all have our own role. We don't all have to do everything, but ICANN has a role. ICANN provides the IANA functions. Part of those functions is allocating blocks of addresses to the Regional Internet Registries. We've done that. We've allocated each of the Regional Internet Registries an equal size block of addresses.

Those blocks are big enough to provide the minimum-sized allocations to one million Internet service providers, so each of those continental-sized Regional Internet Registries could have a million Internet service providers in their region, from this first block.

And of course, there's plenty more where that came from because IPv6 is very big. The other groups are-- for instance, the Internet service providers and content providers, and they need to deploy IPv6 support for their own networks and for end-users, and that is happening to some extent.

Scott: You're talking present tense about the RIRs, right? You're saying that the 5 RIRs already each have a block of IPv6 addresses now that they could distribute to a million ISPs in each continent?

Leo: Yes, the Regional Internet Registries have had IPv6 addresses since 1999. And they have been distributing them to ISPs pretty much since day one. They can all hand out IPv6 addresses today. They have been making it progressively easier for Internet service providers and other network operators to get IPv6 addresses.

Scott: So, if they've already been doing this for a while, are there some examples where they've allocated IPv6 addresses and everything's working great?

Leo: Well I suppose the examples that pop straight to mind are, for instance, Free in France, which has pioneered IPv6 deployment with a special transition technology called 6RD, or 6 Rapid Deployment. They have got significant numbers of customers, hundreds of thousands, using IPv6 already.

Scott: And isn't Comcast doing some stuff in the United States with IPv6?

Leo: That's right. They announced recently that they've started IPv6 trials. And I believe that if you're an existing Comcast customer you can contact them and ask to be included in the trials that they're operating.

But it's not just the Internet service providers. The content providers, and the people who provide the stuff that our eyes look at, also need to support IPv6. And one of the leaders in that has been Google. They have been providing their maps and email and search and videos over IPv6, and they've been showing that it works quite nicely.

Scott: Okay, just to bring it all down to individual Internet users who might be listening to this. You're saying that they probably won't have any big problem with this?

Leo: They shouldn't have. As a user of IPv6, you just plug in your computer and most of the time you just don't really notice that it's there, in the same way that you don't really notice that IPv4 is there. You just open web pages, send email--

Scott: Just start connecting.

Leo: Yes, exactly.

Scott: For some of these ISPs, would they have to upgrade some of the equipment in the domestic user's home, though?

Leo: That's right, in some cases that will have to happen. For instance, if you get Internet over cable connection, then in order to get IPv6, you will be getting a new home modem of some kind.

What happened is, the cable operators worked together to develop standards. And they developed a standard, which allowed customers to get much faster access and ISPs to get much better network management. And while they were putting that together, they included IPv6 support in it. When you sign up for the faster, better Internet service, you get IPv6 with it.

Scott: Where do we stand now? We've talked about places that are migrating to it. It's only a small percentage of all the Internet's traffic right now, so how would you categorize where we stand with IPv6?

Leo: Well it won't be happening overnight. We expect to allocate the last 5 IPv4 blocks to the RIRs by sometime in 2012. The RIRs will probably have space then for a few months, maybe to a year after that; and then everyone's running on reserves. After that, it will be down to each individual network operator and how much address space they have left in their stock, which will vary. And then we're running on empty.

At that point, it's really time to start implementing IPv6 in a concerted effort. It's quite well supported in the Internet's core infrastructure. IPv6 support is there in the root DNS, it's there with many top-level domains, being reachable over IPv6 and most of the Internet exchange points allow ISPs to exchange IPv6 traffic.

Scott: Okay, what is an Internet exchange point?

Leo: An Internet exchange point is a network where ISPs meet each other and they exchange traffic, so they all connect to the same piece of network equipment. By doing that, they save money, because they don't have to buy separate lines to every single ISP in the city. Instead, they buy one line to the Internet exchange point, then they all connect to that same switch and they just send traffic over that Internet exchange point. So it's a very cost efficient way of connecting to a large number of ISPs and other network operators.

Scott: And you're saying those already support IPv6?

Leo: Yes, most of them do.

Scott: So you're describing a scenario as soon as 2012, where we cannot officially allocate any more IPv4 address space. Can you speculate for us a little bit, what effect on the market might that have, at that time?

Leo: So at the point that IPv4 is fully allocated, the IPv6 is not universally implemented. There will be a period where IPv4 and IPv6 need to interoperate. And that means if you are a new market entrant and you don't have much IPv4, you can maybe get an address that you can run some translation on, you will have a hard time. You'll need your IPv6 so that you can run your network and you'll need to run a translation service of some kind.

If you need more than that one address that you can get from your ISP, you may be able to get a transfer of addresses from a network that has a surplus. In some cases, a network changes the way that it works and so it, for instance, may decide that it's printers no longer need IP addresses, and that frees up some addresses. It can then say, "Well, we've freed up these addresses, and we might be able to transfer them to you."

And the Regional Internet Registries have been developing policies to support this kind of transfer between different organizations, so there might be a possibility of getting a slightly larger block of addresses through a transfer. And also, the Regional Internet Registries have developed some policies for their last block of address space, so that they make it go as far as possible.

Where they've approved these policies, they've said, "We'll give out slightly smaller blocks, but everyone gets one block." That should provide some support for new market entrants for some time, during that period where IPv4 and IPv6 need to co-exist.

Scott: All right. If persons listen to all this and they're still interested to know more, what are some resources you would recommend for learning about IPv6 and the migration and all these issues?

Leo: I think from a policy perspective, people could look at their own Regional Internet Registry as a good resource. And you can find all the Regional Internet Registries through the Number Resource Organization website, which is at www.nro.net.

If you are interested in the technology and the implementation, then National Network Operators Groups and IPv6 Forums are good places to look at. And

because there are so many of them, I would suggest using a search engine and typing in the name of your country and “IPv6 Forum,” or “IPv6 Task Force,” or “Network Operator Group,” and seeing what happens.

Scott: Excellent. Leo Vegoda, it’s been a delight having you here. Thanks so much for sharing your impressive depth of knowledge with us.

Leo: Thank you very much, Scott.

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To let us know what you think of *ICANN Start*, email your comments, questions, and suggestions to start@ICANN.org.

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