ICANN85 Mumbai | CF – How it Works: Internet Identifiers
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SIRANUSH VARDANYAN

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language you will speak if speaking a language other than English and speak clearly at a moderate pace.

And with that, I would like to introduce you to my colleague, Champika, who is from the OCTO team, the team whom you met yesterday, the IROS, John Crane's team. And Champika is based in Australia. Yes. So, he traveled all the way from there to tell us about how Internet Identifier works. And without further ado, Champika, the floor is yours.

CHAMPIKA WIJAYATUNGA

Thank you, Siranush. And good morning, everyone. So, Siranush introduced me, so I don't need to introduce myself too much on that. So, this session is going to be on How it Works - Internet Identifiers.

Now, together with me, my colleague, Nicholas “Nico”, who was also going to be here, but then unfortunately, he could not make it due to some flight disruptions, but he will be joining remotely. So, he may also join some discussions as well, but I will be mostly presenting on site.

Okay, we're going to now discuss about the Internet Identifiers. Now, yesterday, possibly during the IANA session, you may also have got some sort of an intro into some of these Internet Identifiers that we are talking about, but we are going to actually discuss more into that now in this session. So, speaking of ICANN, I think you are already familiar with ICANN

by now, I believe. And so if you have thought about those last two ends, what you see over there, the names and numbers, right?

So, if you actually even read the bylaws of ICANN, it describes these. So, these actually, these names and numbers, what we are referring here are basically unique identifiers. So, when we say unique identifiers, you have to think that any device that connects to the internet, you know, that needs an identity or an identifier. So, that's where here, you know, we are coming from. There are a number of identifiers that we refer to.

Now, speaking of ICANN, of course, you know, ICANN coordinates these Internet Identifiers. And then, there are a lot happening around this, and then there are technologies, there are policies, and then so on. So, the whole objective of this session is to actually get to know more about these identifiers, what are these identifiers that we are talking about, and then going a bit more details into that.

Now, there are some specifics, if you read here, there is DNS, and then there is IP addresses, internet protocol numbers, then there is AS numbers, or what we call Autonomous System Numbers, and so on. You may hear these terms when we speak of Internet Identifiers.

Now, when you think of, say, the internet, the communication, the data communication aspect, when you are thinking of sending packets, so when you are sending these binary streams

from one host to another host, you know, we use a protocol. I mean, protocol is basically a set of rules, or what we call a standard.

So, the TCP IP is the protocol that we use. You may have also actually got to know about it as well. Now, in TCP IP, there are a few layers. Now, these layers are, you know, you have application layer on the top, then you have the transport layer, then you have the network, or the IP layer, and then you have the physical layer.

Now, there are different layers, and in all these layers, we have Internet Identifiers. I mean, there are certain identifiers. For example, in the physical layer, you have things like physical addresses, or MAC addresses, what we call. So, this is an identifier, basically. And then when it comes to the network layer, that's where we have these things like IP addresses, for example.

And then when you go further up, in the transport layer, we have things called protocol, I mean, protocol or the port numbers, and things like that. And then to the top of the application layer, we have things like DNS, because DNS is an application.

So, as you can see, in every of these layers, we have these identifiers. Now, there are, of course, some specifics, some focuses that we are going to have in this discussion, that's mostly around the IP addresses, the Autonomous System

Numbers, or what we call AS numbers, and then, of course, the DNS. But as you know, from ICANN context, that there is, of course, quite a lot of focus on the domain name system, the DNS.

So, we have a separate session this afternoon to talk about DNS in more detail. But we'll try to spend a bit more time, say, speaking about IP addresses and AS numbers now. Okay, speaking of the numbers.

Now, as I said, what are these numbers? So, I mentioned about IP addresses. So, IP addresses are internet protocol addresses, and then AS numbers are Autonomous System Numbers. Now, earlier, I told you that any device that needs to get connected to the internet or the network, you need these identifiers.

So, when you even think of internet, so what is internet? It's an interconnected network. So, you have lots of devices connected to various networks, and all these networks are also interconnected. So you'll see, you know, a big collection of networks around that. And so that's what we call the internet.

In terms of these identifiers, of course, when you go back to very early days of internet historical aspects, you know, there were a few computers, few nodes that were connected during very early days. You may have also heard about a network called ARPANET. So, that's pretty much, you know, the very early network of the internet. So, during these ARPANET days,

some of these hosts, some of these nodes were connected, you know, connecting some of the universities.

And then later, it became so commercial where you, you know, connected more and more devices and so on. So, these devices need some addresses. So, that's where a protocol was needed, kind of an open protocol. So, that's when the TCP IP protocol was designed. So, that was around mid-1970s or so, right? And then there were, of course, you know, some of the versions, and then IP version 4 became a standard. So, that's why we call it as a, you know, protocol, internet protocol standard, IP version 4.

Now, you may see for example, you know, this is an IPv4 address, what you see here in this slide. You'll find what we call four octets. So, why we say it's an octet? It's mainly because every of these this IP version 4 address consists of 32 bits. So, 32 bits are divided into four sort of segments.

So every segment has got eight bits in it. So, eight bits, what we call an octet. So, you have four octets in that. I mean, in data communication, all these hosts, all these devices, they communicate in ones and zeros, so what we call binary. But for humans we convert that into a decimal format. That's why you'll see something like 192.51 things like that. But in actual fact, it's a binary number, which consists of 32 bits. So, 32 bits in four segments, so every segment has got eight bits. That's

what we call an octet. So, that's an IPv4 address. Now, here, for example, you see some notation here.

This is what we call a / notation. So, in this case there is certain definition here, just in case if you want to know that. So, every of these IP address space, say in IPv4, you can divide that into two different parts.

One is what we call a network part, and the other one is called a host part. So, you can define a certain network, and then you can define number of hosts in that network. Very early days, there were things called classful addressing, but now we don't use that. Because very early days some of these big blocks were sort of delegated. Now, speaking of delegation of these IP address blocks, and also these Internet Identifiers, like AS numbers, even the domain names, and so on, I think we really have to mention about a very important name here, that is Dr. Jon Postel.

So, he was actually the one person who was actually distributing these Internet Identifiers. So, if any organization, if they needed some IP block, they had to contact Dr. Jon Postel and get these. So, he's kind of the father of the internet registry system, I would say. And so that's some historical aspect. And then later there was some entity that was needed to handle this function. So, that was when the Internet Assigned Numbers Authority, or IANA, was established.

So, you may have heard about IANA yesterday during the discussions as well. And then after that, of course there was need when the internet became more global, and then there was a need for more policies around these internet resource management, internet identifier management, and so on. So, that's where there was a need for a multi-stakeholder body, and that's when the ICANN was established back in 1998.

Now speaking from that IP address delegation perspective, now there are, of course during 1990s, also the regional internet registries also started coming in, and there are altogether now five regional internet registries in the world. We will talk about those things in a bit more detail. And then they do delegate these IP prefixes.

So, I was talking about these prefixes earlier. So, this /24 means there are 24 bits are allocated for your network prefix, and then that will leave eight bits to define your host. So, it means theoretically, you can have two raised to the power of eight number of bits, which is 256, into that particular network. And that's how the definition of that internet identifies.

Now, what you see here, the other IP address, that is IP version 6. I was talking about the IP address distribution earlier, because very early days, these classful addresses were delegated, and many of the organizations, they got some big amount of IP blocks and so on. So, there was a risk of these IP space running out. So, that is when, of course, there was need.

I mean, we needed much more better resource management policies and so on to make sure that these internet resources, Internet Identifiers are conserved and so on.

So, the regional internet registries, they have started delegating these IP address blocks on a more, kind of with guidelines and policies and so on, so that it could be better managed. And so, when it comes to the utilization of these internet resources, the other aspect was, because in case if we don't have enough IPv4 addresses, we needed some new protocol.

So, that is when the IP version 6 was designed. And during late 1990s or so, they had started distributing IP version 6 addresses as well. So, what you see here is actually an IPv6 address. Now, when you compare to IPv4, IPv6 address space is much, much larger. And theoretically, IPv4, the IP version 4, I told you earlier that you can have 32 bits. So, theoretically, you can have 2 raised to the power of 32 addresses.

So, that would give you 4.2 billion IP addresses, because if you calculate that 2 raised to the power of 32, that would get you 4.2 billion. But the thing is that if you try to put that into reality, or the perspective of real life there are currently 7 billion people in the world. So, if you have maximum out of 4 billion IP addresses, one person even can't get one IP addresses, right?

So, if you compare from that perspective, so that was when, of course, there was a need for a different version. And then when

the IPv6 started being delegated, we had to come up with, again, with proper policies and so on, so that these blocks can also be distributed accordingly.

Now, you can also see that when it comes to IPv6, there are 128 bits comparing to 32 bits in IPv4. So, if you compare the number of addresses that IPv6 can have, that's a lot. It's even if you put that number 2 raised to the power of 128, that would give you a huge amount. I mean, you can't even calculate that. It's probably there are lots of analogies given to equal this number, but then there is no way that this can be even calculated. It's a huge number. But the thing is that what you need to be, what you need to be careful is that the routing aspect, we will talk about the routing aspect a little bit later with the AS numbers.

The thing is that there is something called the routing where these IP prefixes have to be routable. So, that is also why there has to be some proper policies and proper management of these prefixes, especially when it comes to IPv6 and so on, so that it can be routable and the routers could handle these prefixes and so on.

So, anyway, I hope that you have got some intro into these IP blocks now. So, this is IPv4 addresses, these IPv6 addresses. Again, here when you say /32, that means this is a prefix where you have 32 bits in your network prefix. So, there are quite a lot of bits left for the host.

The other Internet Identifier I mentioned to you earlier, that was the AS numbers or what we call the Autonomous System Numbers. Now, what is an Autonomous System number? I don't know whether you have heard about it. Say, earlier we spoke about these networks, right? I said that, okay, there are lots of devices in a certain network. But even if you think of, say, a collection of networks with the same routing policy, now I'm using the term routing policy, what do you mean by routing policy?

So, routing policy is that when you have a certain network, how you're going to get traffic into your network, and then how you're going to get traffic out of your network. So, based on that, you can define a policy. So, this is what we call a routing policy. So, if there are some multiple networks with the same routing policy, then you can try to combine all those networks, right? Because all those networks are having the same routing policy.

And then if you combine all those networks, we can give an identifier to that collection of networks. And that identifier is called an Autonomous System Number, or what we call an AS number, simply. So, that's what we call an AS number, right? And these AS numbers are also actually delegated in the same way, just like IP addresses.

So we have IANA, and IANA delegates these AS numbers to the regional internet registries, and then regional internet

registries would delegate these AS numbers to the internet operators and so on. So, if you, say, consider an internet operator, for example, they can have all their collection of networks in their control, in their administration, and then they can have a single Autonomous System Number.

And depending on, of course, their infrastructure and so on, they may have one Autonomous System Number or multiple Autonomous System Numbers and so on. So, that's what we call an Autonomous System number. Now, comparing to IP addresses, these Autonomous System Numbers also have got two different versions. Initially, we had a version with 16 bits, or what we call a 2-byte Autonomous System number, and where we could have 2 raised to the power 16 numbers. So, 2 raised to the power 16 is 65,536.

So with 2-byte AS numbers, we could go from 0 to 65,535. But the thing is that if you think of the number of networks currently in the world today, there are lots, there are hundreds of thousands of networks. So, these 65,000 were not enough several years ago. And then that was when 4-byte AS numbers were also defined. So, that's what we call 32-bit AS numbers. So, where you could have 2 raised to the power 32 numbers.

So that, again, would give you 4.2 billion. That is why you'd see here, when you think of AS numbers it could go from 0 to 4.2 billion, right? So, that's the, of course plenty, I mean, currently,

I said it's around hundreds, 120,000 or so. So, there is plenty of AS numbers we can have from this space.

Okay, so I hope that now you've got some basic understanding of what do you mean by IP addresses, the IP version 4, the IP version 6, and then the Autonomous System Numbers.

So, going forward, okay, now how these IP or the Internet Identifiers are being distributed. Now, yesterday, you may have heard about the IANA function, and IANA would delegate these IP prefixes to what we call regional internet registries. And then regional internet registries would further delegate these prefixes to their members, the internet operators and organizations who need these prefixes.

Now, this is an example where you can see how these blocks are being delegated. Now, /8, what you see in this diagram, they are based on that definition that what I was talking about earlier, that means there are 8 bits in your network prefix. So we can have 2 raised to the power 8, /8 in IPv4 space. So, that means there are 256 /8 in your IPv4 space.

So, that's where when you see an IP address, always the first octet, you'll see it varies from 0 to 255. That's because it's a /8, right? And similarly, you'll have /8, and then you can give /16 or /20 out of that, and so on. So, you can further delegate these blocks to different levels.

So, for example, an RIR could be getting a /8, RIR could be giving a certain prefix, say a /20 to a network operator or /23 to a network operator, and then the network operator could be giving out of that /23, they could be giving a /24 to another small provider or inside customer and so on. So, that's how the delegation happens. So, it's kind of hierarchy as well, if you see the IP address distribution hierarchy.

Now, this is also, I thought maybe I'll just put a very quick snapshot to see how these Autonomous System Numbers, the interconnections you would see. In the left side, what you see is actually the visible IPv6 interconnections. So, earlier I said that there are IPv6 networks.

So, when these IPv6 networks are being announced from certain Autonomous System Numbers, you will see this kind of interconnection, say overview or a graphic, right? Whereas on your right side, what you see are the IPv4 interconnections. So, any operator, say if they get IPv4 prefixes, these prefixes are to be announced from a particular Autonomous System number.

Sometimes, I don't know, probably you may be wondering what do you mean by this announcement or what are you talking about these prefix announcements and so on. The thing is that when any operator is given a certain prefix of IP addresses to define their host within that network, these prefixes, these IP addresses have to be announced to the whole world, basically, globally, right?

It's just like if I just try to bring up some analogy here, if you want, say, in real life terms, if you live in a house, you have an address to that house, right? So, think about that address as an IP address, right? Now, if you want other people to come to your house, you have to announce your address to others. You have to give your address to the other people so that they can come to your house, maybe for a function or whatever, right?

So, in the same way, if you are an operator, if you get an IP address block from a registry, you have to tell the whole world that, okay, I have got this prefix, now others can send the traffic to me, right? So, that is what the operators, they do. So, when they get a certain prefix of IP addresses, they would announce this prefix to the whole world so that others, they can send traffic into this Autonomous System number or this AS, right?

So that is where you'll see these types of connections. And then these Autonomous Systems, they could, they're basically a collection of networks. These networks they would connect to other networks and so on, right? So, between these operators, between the operators, they have interconnections.

So you'll see, of course, there are more interconnections in IPv4 because there are much more IPv4 networks, but then in the recent times, because there are more and more operators, they are getting IPv6 networks. Now you'll see that the density of IPv6 networks, the interconnections are also increasing, right?

So, I hope that that would give you some perspective of how these interconnections happens and how these Internet Identifiers IP address prefixes need to be announced from these Autonomous System Numbers.

Okay, I think this, I mentioned to you earlier how these numbers are distributed. For this function, there are RIRs, Regional Internet Registries. So, currently there are five Regional Internet Registries in the world. So, there is IRIN, IRIN stands for American Registry for Internet Numbers. And then, so that is for North America. And then we have LACNIC, Latin American and Caribbean Network Information Center. And then we have RIPE NCC to distribute the IP addresses and AS numbers in Europe and the Middle East. And then we have AFRINIC for the African region. And then we have APNIC, which is the Asia Pacific Network Information Center for the Asia and the Pacific.

So, these are the five regional internet registries in the world. And then IANA would delegate these IP prefixes to these regional internet registries. And then the regional internet registries would actually distribute that in that respective region.

Okay, so this, you can see more distribution going into more details how these Internet Identifiers are distributed. Say, for example, yourself, if you see your phone go, if you go into your settings and you'll see an IP address, because when you're

connected, when your device is connected to the network, to the internet, your device has to get an IP address, as we discussed earlier, right?

So, you can see that address, what is it? So, the operator who is giving that address to this conference center they have given you this IP address. How did they get it? And they got it from another operator. And then that operator must have got it from the APNIC or the regional internet registry for the Asia Pacific, and then, and so on, right? So, this is how the IP address have come to your device. So, you can see that you have ICANN.

Now there is also, actually, you may have heard about this function PTI, right? So, PTI is the entity that looks after actually the ICANN also has accountability process as well. So, that is where the PTI comes in, and then IANA would distribute these blocks to the regional internet registries, and then the ISPs, and then to these different customer sites or end sites, and so on, and then finally to customer devices or end users.

Okay, when it also comes to the management of these numbers, the Internet Identifiers, there are lots of things. I told you about there are various resources involved, there are various policies involved, there are various guidelines involved, and so on.

So, it is also important that even, for example, even during these ICANN meetings, there are discussions on the policy side, I mean, the address policy side, the ASO, the address support

organization, that is the sort of interface body to this numbering community, and so on. So, there are discussions happening around that, and so on.

Now, you may also actually see some of these terminologies here, things like allocations, things like assignments all these things have a purpose. And for example, if you think of allocation, that means if a certain block is allocated, that means whoever the party receives that allocation can further distribute that IP prefix to another party. Say, for example, if an operator gets a prefix from a registry, that can be further given to another operator, small operator, for example.

So, there is a certain definition for that, and then we call it as an allocation. So, when you go into some of these policies and things like that, you'll find some little differences with this terminology, the words, and so on.

When it comes to things like assignments, when you think of IP assignments, these are blocks that gets into end sites or end networks, so we don't further assign IP blocks to other parties. So, assignments sit into the end sites or the end networks, and so on, right. So, that is what you'll see some of these terminologies you'll find here.

And also, there are various databases that are involved here as well, because these are all public resources. The Internet Identifiers are public resources. So, when it's a public resource

these things have to be registered publicly. That is why you have databases to register these resources publicly.

And so that is also why we had a protocol called WHOIS protocol before, and now there is actually something called RDAP, right. So, that's kind of another newer protocol that actually replaced WHOIS, which is more expressive. So, you can query these databases and get more information about IP prefixes, networks, and so on, right.

And another thing is also actually when we have these registrations, these Internet Identifiers are registered, and so on. It also has to be secured. And also, security is one of the very important aspects of these Internet identifiers. Later when we talk about DNS, of course there are lots of security mechanisms that we talk about things like DNS security extensions, DNSSEC, and things on. But you also have similar security mechanisms with IP prefixes as well.

If you have heard about RPKI, for example, RPKI is a mechanism where you can validate these prefixes, whether they are originating from the correct Autonomous System number. Remember earlier we spoke about the AS numbers, the autonomous systems.

So say if I'm an ISP, when I get a prefix, I have to originate this prefix from my Autonomous System, right. So, that has to be certified so that we can create some digital certificates to actually validate this. So, that's the technology we used in

RPKI. So, there are various in terms of resource management, in terms of these the numbers the Internet Identifiers, how they are managed. There are various security mechanisms, technologies, as I said there are databases and so on that comes into the picture, right.

Okay, so we kind of spoke about numbers. Let's get into a little bit of names as well. But names, I wouldn't want to go too much details because we have some discussions in the afternoon as well. But domain names are also an Internet Identifier.

I told you before because we have different layers and there are different identifiers in different layers. Now DNS sits in the application layer, top most layer, right. So, why we need DNS in the first place? Why do we need an identifier called DNS or the domains, domain name? Because all those IP addresses, what you saw before, if you remember that you saw the IPv4 addresses, you saw those IPv6 addresses, it's very hard for humans to remember.

I mean, you may remember IPv4 addresses because it's not that complicated. But when it comes to IPv6, it's very difficult for us to remember, especially because IPv6 has got 128 bits. And then you have eight fields in that. And these IPv6 addresses are defined in hexadecimals. As you know, the IPv4 addresses are defined in decimals, whereas IPv6 addresses are defined in hexadecimals.

So, it's very hard for humans to remember these numbers. So, that is why we need some mechanism to map these numbers to a form that humans can easily remember. That's where the domain names come into the picture, right? So, we can always have a mapping between these numbers and the names.

I mean, if you really think of data communication, say sending data from one host to another host, as long as you have the IP addresses, you can still do it, right? We can send the binary, the bits, bit streams from one host to another host with the IP addresses. But the thing is that, as I said earlier, it's very difficult for humans to remember that. And that is why we have this mapping called the domain names.

Now, DNS was actually defined as a sort of graph, IETF graph that was back in early 1980s. And so that's when the very early RFCs came related to the DNS. Now, with DNS, what we do is we have a certain naming convention with a proper hierarchy, and DNS is a distributed database. So, there is a proper structure with the DNS.

So, that is also what you see we have the root on top of the DNS, and then we have top-level domains, then we have second-level domains, third-level domains, and so on. So, that's how the hierarchy is. So, there is a proper naming convention.

Now, in this naming convention, you can see those early days, of course, we had these ASCII domains, right? Say, for example, in English. Again, there are some technological limitations.

Say, for example, when it comes to ASCII, we can have a limited amount of characters that can be represented. Because if you think of ASCII, in the ASCII table, we can have only two raised to the power seven symbols or the glyphs, so which means 128.

You can have all the English alphabet small a's, capital a's, and a to z, the numbers, and all that, the things what you see in your keyboard. I mean, you can fit together everything into 128, that is fine, but then when you need more than that, say, for example, if you want to have, say, for example, in India, you have so many different scripts, right?

So, you have Devanagari scripts, you have Tamil scripts, you have Telugu scripts, and so on, even in India. And then, of course there are many other languages, scripts that have been used in the world. There is Arabic, Chinese, Korean, and various other scripts, and so on. So, if you have to define all these things this 128 or ASCII is not going to be enough. So, that is why there was a need for a different encoding scheme, what we call.

So, that is where the Unicode comes in, right? And so that is where you will see the Unicode, and then, of course from the Unicode, we can actually get certain characters into the domain name. So, it is not that every character in Unicode that can be represented in domain names as well. So, this is where the label generation rules would come in, and so there is a how

it works session on the IDNs. You can listen to that in more detail later on.

So, what you see over there, those two examples, the left side, you will see an ASCII domain, whereas on the right side, what you see is what we call an IDN, or Internationalized Domain Name.

There are, again, certain guidelines when it comes to these domains as well. The top-level domain, that is actually, we can only represent the letters there. One might ask, okay, why can't we have numbers there, right? Why only letters?

The thing is that if you put some numbers there, then it will be like an IP address. If you put some numbers over there, then there's no difference with an IP address as well. The whole purpose of having domain names is to actually map these addresses to names that humans can remember, right? So, that is why in the TLDs, we have the letters.

And then for the second levels, again there are some certain guidelines. We have something called LDH rule. LDH stands for letters, digits, and hyphen. So, you can have letters, you can have digits from zero to nine, and then you can have the character hyphen, okay? But you can't use the other one, things like star, or asterisk, and exclamation mark, and things like that, you can't use it, right?

So, similar rules do apply for these internationalized domain names as well. So that is why, as I said earlier, before these things are being defined all these label generational panels they have to come up with the rules set for a particular script. So that's where over the years, many of these communities, they have been working on defining these label generation rules, actually, okay?

Okay, so I hope that you got some idea about that as well. And there are, again, some limitations of how many octets that you can have in every of those labels, and so on. So, these are all identifiers.

SIRANUSH VARDANYAN And we have a couple of questions.

CHAMPIKA WIJAYATUNGA Okay, sure. And then namespace, I told you before, the domain names it is defined in a proper structure, proper hierarchy as well. Top of this hierarchy is the root, then we have top-level domains, second-level domains, and then third-level domains, and so on, right?

And when it comes to the provisioning of DNS, you can also see that there are some relationships, actually, with different entities. Now, this is more from an administrative point of view, right, and contractual point of view as well. So, you see ICANN, and then ICANN has got registry agreements with these registry

operators when it comes to the DNS, the top-level domain registries. And then there are registrars.

Again, these registrars would have different registry agreements with the appropriate registries. And then also, when it comes to registrars, ICANN also has got registrar accreditation agreements with the registrars. And then there are resellers, because there can be multiple resellers among these different registrars, and so on. And then, ultimately, you will see, actually, the registrants. So, for example, if you want to have your own domain name, then you have to actually go to a reseller, or you go to a registrar, and then get this identifier, and get this domain name, basically, right?

And then there are certain terms and conditions that you would actually agree with your reseller and the registrar. So, there are certain agreements for that. So, that's how, actually, the relations between, when you want to get these domain names as identifiers, that's how you would actually get that from different entities around this ecosystem.

Okay, so that's from an administrative point of view. Now, from a technical point of view, there are different components that exist when it comes to the domain names. Say you have your device, so I told you earlier that your device needs to have an identity, right?

So, we spoke about IP addresses before. And then, so if you have now also, you know that there is a mapping between this

IP address and the domain name. So, the thing is that if you want to, say, browse, if you type a domain name, or if you open your mobile app, or if you want to send an email and things like that, behind the scenes, it's all the DNS queries that happen.

So you have your device, say, if you want to use a certain mobile app, for example, so that application needs to actually talk to a certain server, right? And then, to talk to that certain server, your device, your application, that needs the IP address. Because remember, I told you earlier that for data communication purposes, you need that IP address. So, the application has to get that. And so, there is something called a stub resolver running in your operating system.

And so, there are, applications are calling, communicating with the stub resolver, and then asking for that IP address. And then the stub resolver, the operating system, the sub resolver in the operating system, will have to contact what we call a recursive resolver. So, these recursive resolvers are operated by various parties, like the Internet Service Providers, the mobile service providers, there are public DNS resolver operators, and so on.

Sometimes if you are a corporate, the corporate also can run these resolvers as well. So, the clients would send a query to these recursive resolvers, and ask if I if you want to get a domain name, the IP address behind that domain name, that question is given to the recursive resolver. And then the

recursive resolver has to go out to various domain name servers. They are called authoritative name servers.

So there are lots of -- based on the DNS hierarchy, you have the root, you have top level domains, you have second level domains, and so on. So, all these different levels they have to maintain what we call authoritative name servers. Because they are authorized for a certain database, certain administrative space where they keep their data, right?

So based on that administrative space, those different servers, they can respond. So, if you want to know something about top level domains, you can go and ask the root servers. So, root servers can respond from the root servers. And then, if you want to know about the next level, you can ask the top-level domains, and so on, right? So the recursive server would go into different levels, different authoritative servers, and get the answers.

And then these answers are given to the recursive resolver. And then the recursive resolver would give these answers to the client.

So, that's how the client application gets that IP address that it has to visit. And the other thing is that this IP address will be kept in the cache in the recursive resolver. So, these recursive resolvers are also called caching servers, because cache is basically your memory. So, it's kept in the recursive resolver memory, so that next time, if the recursive resolver is getting

the same query, then it doesn't need to go and talk to all these authoritative servers. It can straight away respond from the memory itself.

So basically, the DNS response time will be much quicker, comparing to you go and talk to every other authoritative service. So, caching will improve the performance. But again, it doesn't mean that you can keep very large caches, because sometimes that can also create some errors as well, if you keep very long caches, and if you change things. So, that is why you have to, if you are a DNS administrator, and so on, they have to manage these timing parameters properly, the caching, and so on, okay?

So, I mean, this is a very quick overview that I was trying to give, but we will discuss more details about DNS later in the afternoon session.

So, I hope that gives us some time for Q&A as well. So, I hope that just to summarize what we discussed in this session, we spoke about Internet Identifiers, the ICANN role, the IANA role, and so on, and then we spoke about RIRs when it comes to the number resources, the IPv4 addresses, IPv6 addresses, we spoke about the Autonomous System Numbers, AS numbers, and then, of course, the distribution process, the management, and then the domain names, and ASCII, and then the IDNs as well.

SIRANUSH VARDANYAN

Okay. Thank you, Champika. Thank you. And yes, it's a very interesting overview of Internet Identifiers, and I'm sure we will have a couple of questions, if not many, but I will start with the question posted online from Godswill, with the rapid growth of IoT devices, how important is IPv6 for the long-term scalability of the internet?

CHAMPIKA WIJAYATUNGA

Yeah, good question, actually. Now, with IoT devices, again, one of the reasons in deciding IPv6 is also actually to make sure that everything around us gets an IP address, because with IPv4, this was not possible, because there is a practical limit of four billion, and that, I mean, that is actually a theoretical limit, but practically even much less than that, and so IPv4 can't do it.

So, from that perspective, if you think of, say, IoT devices, IPv6 is very important, because you can have lots of IPv6 addresses, and these devices can give IPv6 addresses, and so on. But, of course, there are things into consideration, because the processing, right, this is something that we have to think about, because there are things called headers.

So, many of these IoT devices, and so on, they are low-power devices. I mean, they can't consume too much power, so it has to be low-power devices. So, the processing has to be it should

be processed within a very small amount of power. So, that is why we have to make sure that the headers can be handled. There is a lot of simplification has to be brought in, and so on.

So, there are some protocols, as well, which is kind of based on IPv6, as well, but the bottom line is that IPv6 is very important, especially from IoT devices point of view, and also, the other aspect that we need to be careful is the routing aspect that I was talking earlier, because that is also why many of these, even a single network, can have so many of devices, because everything around us, think about your, even inside your car, right, so there are so many devices inside your car can have a certain address, and so, what is the size of the prefix that we should give it to a car, or what is the size of the prefix that we should give to a household, and things like that.

So, these are all based on certain policies and guidelines, and so, because currently, if you start giving very, very small prefixes to all these small IoT networks, and if you try to announce these prefixes, then the routing tables can go very, very large, and the routers will not have memory technology to handle that much of prefixes.

So, that is why, still, we have to think to make sure that proper prefixes are being delegated to these end networks, end sites, and so on, where the routers can handle those, but from addressing point of view, IPv6 is quite important from IoT.

SIRANUSH VARDANYAN

Thank you. Thank you, Champika, and thank you, Nico, for taking care of questions in the chat. Any questions here? Yes, please, Millenium. Please, go ahead.

MILLENIUM ANTHONY

Hi, thank you so much for the presentation. My name is Millenium. I'm from Tanzania, and I'm an ICANN85 fellow, but I wanted to ask something regarding a statement that you said. You mentioned that with the IPv6, there's no way that would run out of IP addresses, but I was wondering if, of course, we have names, and we have numbers, are there any threats that if coordination, like there's any challenge that happens with the coordination or allocation of IP addresses, even with IPv6, are there any things that could affect the interoperability of the Internet? Are there?

CHAMPIKA WIJAYATUNGA

Yeah, I mean, again good question. Actually, there is quite a lot of coordination in terms of these policies, especially when it comes to, if you go to some of these regional Internet registry meetings and so on, so there are quite a lot of discussions around these delegations the sizes and so on.

There are two things we have to look into, right? So, yes, from one aspect, you're giving very large blocks, so there could be lots and lots of IP addresses. You might think, okay, it's

wasteful because, say, for example that /32 that I was talking about before, so registry would give an operator a /32, right? And then operator can give, say, /48 to an end site, right?

So if you're talking about say /48, say I'm an operator, right? So, I'm an operator, I can give /48s to operators. So, how many operators I could give these /48s? So, that's /32 divided by /48, so you're talking about 2 raised to the power of 16. So, 2 raised to the power of 16 is something like 65,536. So, as an operator, I can have 65,536 customer sites that every of those customer sites can have /48s.

Now, if you take a single customer site, say Siranush is one of the end sites, a customer site, so Siranush gets a /48, and Siranush could give subnets of /64s. So, how many subnets a Siranush can get? That's, again, 2 raised to the power of 16, yes, 65,536 subnets she could have in her end site, in her customer site.

And every subnet is a /64. So, how many IP addresses in that? That's 2 raised to the power of 64. So, 2 raised to the power of 64 is a huge, huge number. Earlier I told you 2 raised to the power of 32, that's the theoretical limit of IPv4. So, that's 4 billion. 2 raised to the power of 32 is 4 billion. And 2 raised to the power of 33 is 8 billion. It doubles up. And 34 becomes 16 billion. You can see that every time it doubles up.

So, we are not talking 30s. We are not talking 40s. We are not talking 50s. We are talking 60s, 2 raised to the power of 60. So,

that's a single subnet inside her customer site. So, this is why you may see it as, okay, that's a lot of IP addresses, IPv6 addresses that's been sort of wasteful. But the thing is, the reality, again it comes back to that question before there are lots of devices could be around us.

Maybe another 20 years' time, there could be everything around us could be IP enabled devices. We don't know that. But for this time, at this point of time, more important is more than the addresses, right? More important thing is actually the routability. Because if we start giving very small, small, small prefixes to different end sites and different subnets and things like that, then the routers will not be able to handle that kind of routing table, that kind of prefixes in the routing table.

So, you have to balance this act as well. So, that is why, again there are lots of policies out there, lots of guidelines out there. So, during number communities, RIRs, and so on. So, they do discuss these things. And then there are regional policies, there are global policies as well. And so, the delegations are made based on that in IPv4 as well as in IPv6.

SIRANUSH VARDANYAN Thank you, Champika. Ilham, I see your hand raised. Yes, please go ahead.

ILHAM SUTOYO

Thanks. Good morning, everyone. It's Ilham speaking. I'm with NextGen. So, I understand that there's like IPv4 transfer market, right? So, it comes to my understanding that IPv4 is getting more rare and rare. That's why there's like IPv6, if I'm not mistaken.

Correct me if I'm wrong. So, I'm just wondering for RIRs, are they only focusing on distribution process and operators for distributing the address blocks to the resellers? Or the body also have talked on making like a policy to make sure and ensure that there's like a fairness and accessibility of getting IPv4 in the market for like a new and smaller operators. Because like it's getting a bit more-rare.

And I just want to know whether like internet service provider or like university companies and et cetera, they could get a more fairness and accessibility to still getting the IPv4. And yeah, I just want to know your thought on that one. Thank you.

CHAMPIKA WIJAYATUNGA

Yeah. So now when it comes to the IP address distributions, regional internet registries, they do this process. And then I told you before that there are lots of policies and guidelines are in place. How just like exactly what you said every organization they have to have some access whoever joining new.

So, say, for example, you start a new company and then you want to get IPv4 block. Is there a provision to get that? Yes,

because that is why if you go into say the regional internet registry policies, say currently in Asia Pacific region, we have APNIC. So, in APNIC, if you are a new member, you can get /23. So, that's actually two /24 or 512 IP addresses from the internet registry and also actually that is the maximum size as well.

So, none of the other operators, they can't. And if you have already got IP block, the maximum amount of IP addresses that you can get is a /23 at this point of time, based on the current policy. But in the past, it was different before. Long time ago, it was you could get any amount of IP blocks, right?

And then at certain times, this was reduced. But currently, it is /23. And still, they have plenty of these prefixes left for new members, new organizations to come and get their prefixes. Because even if you think of say, in a single /8, there are plenty of /24. So, there are plenty of millions of /24s and 23s and so on. So, there are lots of IP prefixes, you can if there is a need, you can still go to an RIR and then get those prefixes. But then for the other prefixes, you also mentioned about the IP address transfers and so on. So, there are different policies, even you can do inter-regional internet registry, inter-RIR transfers as well. But of course, the RIR has to be involved in this process.

And so, if you don't have enough resources into your network, you could actually go based on these different transfer policies and so on, you can get the prefixes as well. And also, there are IPv4 address brokers and so on. So, they're all actually,

everyone is in the policy framework as well. So, they do based on the guidelines that are being set with the number community.

So, there are various ways that you can participate in this process and get your resources.

SIRANUSH VARDANYAN: Thank you, Champika. Unfortunately, we are out of time. But Champika, I will request you to stay during the break here, because I know there are a couple of people who want to talk to you. And I would like to thank you for being here at our early session.

With that, I would like to close this session by congratulating everyone with Happy International Women's Day and see you at 10:30. Thank you. The meeting is adjourned.

CHAMPIKA WIJAYATUNGA: Thank you very much.

[END OF TRANSCRIPTION]