
SAN JUAN – How It Works: Internet Networking
Monday, March 12, 2018 – 15:15 to 16:45 AST
ICANN61 | San Juan, Puerto Rico

UNKNOWN SPEAKER: Good afternoon, ICANN 61, March 12th. How it Works; Internet Networking.

CATHY PETERSEN: Good afternoon and welcome to How It Works on Internet Networking. We have Alain Durand from the office of the Chief Technology Officer at ICANN presenting. Thank you for your patience by the way. Alain?

ALAIN DURAND: Good afternoon. First off, I apologize for the delay; I was called last minute in a meeting and tried to come out as quickly as I could. Today we are going to talk about some of the fundamental technologies in the Internet; naming, addressing, and routing. And a number of you may already know all about this, and you're not going to learn much more, but it might be an opportunity to ask questions and if you have always wondered what was happening under the hood on the Internet, well hopefully we may answer some of those questions.

Note: The following is the output resulting from transcribing an audio file into a word/text document. Although the transcription is largely accurate, in some cases may be incomplete or inaccurate due to inaudible passages and grammatical corrections. It is posted as an aid to the original audio file, but should not be treated as an authoritative record.

So, there are lots of seats up front if you would like to move closer, please do. I would like to make this interactive, so if you have questions, please interrupt me, ask your question any time; don't wait until the end, okay? So, next slide.

I will start by a little refresher on the OSI model, it's always interesting to talk about some of the concept around networking. Not necessarily to be bound by them, but to use them as a framework, and then we will use that to start the discussion on naming, addressing, and routing. So, next slide please.

Alright, so I call this networking by number, the same as we talk about painting by numbers. You know, we have a box that's called number 2 and you have to put yellow in there, and box number 3 you put green in there, etcetera. So, that's what we're trying to do as a basic here. The OSI model as defined 7 layers of networking, and we are talking about the layers 0-9, so we are extending this to the left, and extending this to the right. We quickly understand why. So, next?

Let's start from the beginning; when we are talking about networking, there are two fundamental types of technologies that we are using, and they have different properties, a different sort of trade-off. So, we have wired technologies like wired or

copper, or we have wireless technologies; things like cellular or WIFI, WiMAX, ZigBee, and a bunch of others.

So, wired technology, copper fiber, you can get really, really fast. There are fibers now that can do 100 terabytes of multiple of 100 terabytes per second. It can be quite a lot of bandwidth on those things. It's interesting in cities, because you bring fiber to a building, and if there are maybe 100 tenants in the building, then you have 100 people that can actually use the fiber. It could be quite cost effective this way. If you try to bring fiber in a rural environment, it's a lot more expensive, because now you have to bring your fiber to every single house, so it's much more expensive.

Also, when you try to bring a fiber somewhere, you can have it dangling on posts like telephone wires, but most of the time you don't want to do that because it's a little bit too brittle, fragile, and you want to have a fiber underground, so you need to dig a trench. So, sometimes you need to get authorizations, you know, to dig a trench, and that process can take a while. So, if you have already places where you have conduit and you can simply get your fiber for that conduit, it makes it much easier. For example, a number of years ago in some countries, the railway companies had all kinds of conduits that were going

along tracks, and that was a perfect place to start putting fibers because you don't have to dig a trench.

Wireless is the exact opposite side of tradeoff; the bandwidth is limited, so depending on which technology, more or less, but bandwidth is going to be shared by all the people that are local to this antenna. So, for example, if you have 3G or 4G network, and let's say that you have maybe up to 10 megabytes, or it could be 10 megabytes but shared by maybe 100 people, so if you have 10 megabytes shared by 100 people, that's 100 kilobytes per second per person if it's shared equally. If it's not, then there might be some imbalance.

And, you don't know how many people are actually going to be connected to the same cell tower. This is a decision that's made by the service provider by putting how many antennas, how much spectrum have they decided to put in specific locations. So, when you are a cell phone provider, wireless provider, you have to decide how you are going to use your spectrum; do you want to spread it a lot and have a lot of customers on the same tower, but using the bandwidth per customer, or do you want to put more spectrum and essentially have more bandwidth to your customers?

You don't have to dig a trench, but you have put antennas somewhere, so in some cities like in the picture here on the

right, if you put an antenna on top of a historical building, that may create problems; people don't like these type of things because they think it's ugly, and you might not get the authorization to put the antenna there. In suburban area, that's actually a similar problem.

I used to live in Philadelphia, or around Philadelphia in suburban Philadelphia, and the cell coverage was extraordinarily poor. Why? Because a resident in my neighborhood thought that the cellular antennas were ugly and did not give the authorization to put the antennas there, so there was very, very weak cellular coverage. So, it was one of the wealthiest areas, and paradoxically it was one of the places where the cell phone coverage was the worst.

This is a problem that happens all the time. In some places, people have come up with some creative stories, like they disguise an antenna as a tree, and they paint it green, and they put like fake leaves and fake branches. I have seen one giant coconut tree, or palm tree, I'm not quite sure what one it was, but it was like 100 meters tall. There's no such thing as a 100-meter-tall palm tree; it was just an antenna but made to look like a palm tree. So, those are some of the things that people do to deal with those issues. Next slide.

So, let's talk a bit more about fibers; so, if I set a fiber between, let's say, here and Cathy, who's going to be assisting me today, fiber is a piece of glass. So, I can send light through the glass, and our light is going to follow the glass and not get out and if I send light at one extremity, the same light will be received on the other end. So, that's relatively easy; I can send things and Cathy on the other side can receive it. It's something that is point to point. Only two people can talk on the fiber; the receiver, and the sender. That is nice, but when you make the investment to put a fiber somewhere, if only 2 people can talk at the same time, that's not exactly cost efficient, right? So, I'd like to use it in a better way. So, the way to use it is to use colors; so instead of using white light, we are going to use colors. So, we are going to play a little game here. Could you please tell me, what is your favorite color?

UNKNOWN SPEAKER: Green.

ALAIN DURAND: Great. Next person, could you please tell me what is your favorite color?

UNKNOWN SPEAKER: Green.

ALAIN DURAND: Green also, okay.

UNKNOWN SPEAKER: Cream.

ALAIN DURAND: Cream, okay, thank you. And what is your favorite color?

UNKNOWN SPEAKER: Red.

ALAIN DURAND: Red, okay. What is your favorite color, Christopher?

CHRISTOPHER: Mauve.

ALAIN DURAND: Mauve, okay. You guys have very fancy taste. So, if you want to talk to somebody, let's say to Cathy, and you two decide that you are going to use cream, that will be fine. You use green, and

if you find a partner over there, but agree to use green, that's okay. If your partner receives something that is cream, he says, "Okay, not for me." Right? Don't care. But green, yes. So, it's like turning on a radio; like if you have a walkie talkie, and you have different channels from 1-10, if you choose channel 1, you choose channel 2, things are fine, okay?

If you choose a color that's a little bit too close, for example, cream maybe a little bit yellow, a little bit red, that can create problems, so we have to make sure that there is enough difference between the wavelength to make this work. So, that will essentially enable us to share a fiber among multiple parties. But, the fiber still goes from one point to the next one.

So, let's assume that I would like to get a fiber from my office to here in San Juan, Puerto Rico. My office is in Washington, DC. And, I would like to have this for this ICANN meeting. I'm certainly not going to ask for a ship to lay a new fiber to come here; that's going to cost a fortune, that's going to take forever. I have to use things that already exist. But what are the odds that there's already a fiber that goes straight from my office all the way to here? None.

But, there might be a fiber that goes from my office, in Washington DC, to some kind of a central office in Washington, but there might be another fiber that goes from there to a

central office in Miami, and there might be a fiber that goes from Miami to a central office here in Puerto Rico in San Juan, and another fiber that goes from that central office in San Juan to the exhibition hall here. What I'm going to do here is to patch them all together and create what we call a, "Fiber path." I'm going to stitch them.

Now, you are using green, maybe between here and the central office in San Juan, maybe you will be the only one using green, but most likely there will be somebody using green in between San Juan and Miami already; it's kind of a popular color. So, we cannot use green all the way. But that's okay; what we are going to do is, each element of the fiber path will have to agree. So, when we stitch them we make convert; so, we may start from green from here to the office in San Juan, and then we will convert to blue from San Juan to Miami where we'll convert to red from Miami to Washington and convert to purple from Washington to my office. All I need to know is that for each end of those little segments in the path, we all agree. And, in the end, you will talk green, I will receive purple, and that's fine as long as we agree on that.

So, one of the first things that comes here is this notion of agreement. If we all agree on how it's going to work, it's going to work. If we disagree, and I put random stuff and you listen to

random stuff, well, nothing will work. So, that's one of the fundamental things on the Internet; this entire system works because people decide to cooperate.

So, I was saying that you can have fiber, now multiple hundreds of gigabytes per second, thus have a faster one. There are some smaller speeds available, typically in a data center you would find 1 gigabyte per second, or 10 gigabytes or 25, now on many servers you find 40. Very often when you have 40, it's actually 4x10; so, there are 4 parts of 10 gigabytes that are patched together to make 40. So, if you want to have 400 for example, you would take 4x100. 2x100, 4x100 is...2x, or 4x anything is fairly common; when you go to 5x10, 6x, 7x, 10x something, it becomes really hard and really, really expensive, that's why you need the next generation of technology. So, when we went from 10 gigs to 100 gigs, the very first 100 gigs is actually 10, 10 gigs put together. But it was extremely expensive until the technology caught up and then a standard came with 400 native. Now we can take 100 native and patch it together to 200 native, or 400 native.

The problem is that it takes longer and longer and longer every time we define a new generation of fiber technology. So, standardization process is pushing the physics a little bit far

these days, and it's more expensive and takes longer. So, next slide.

So, when we have all those fiber paths together we start to build a network. And when we put all the networks together, that's when we have the Internet. So, the Internet spelled with a capital "I" for a simple reason; is that it's a network of network, that's really what it is. It's not just one network; it's a network of networks. And why we do that is that we want to separate the networks; if I have minor talk, and thinks in minor talk, you have your network, you want to receive traffic from me only for things that matter to you. If I have a lot of internal traffic, you don't want to see. There is no reason why you should pay for the bandwidth to carry traffic that is not for you. So, we want to segregate things. Say; this is mine, this is yours, only give me what is yours. So that's what IP is all about, is making sure that your network is not the same as my network, but we can exchange traffic.

So, this is done at layer 3 by a protocol that's called IP. IP in that sense does not mean Intellectual Property, okay? It means Internet Protocol. I want to talk about Intellectual Property, actually the proper phrase is Intellectual Property Rights. IP just means Internet Protocol.

So, there are two versions of the Internet Protocol that are in use today; the one that most of you are using is called IP version 4. It was defined in the late 70's, started really in the early 80's and is still going on. There is a maximum of 4 billion addresses on this, and the addresses are distributed by the original internet registries to service providers. There are no more new addresses available. We have distributed them all; that doesn't mean that the protocol stopped working, it means that if you're new and you need some more addresses, you need to be a little creative. Maybe get them from somebody who had many in the beginning and is not using them, there's a market for that. Or, there's another protocol, IP Version 6 that was defined about 20 years ago and that is starting to roll out. At this moment the two are not compatible, so that caused some problems. Next slide.

Once you have a network you can start a communication. So, we are going to play a little game. Let's say I want to send some traffic to Cathy. First, I need to make sure that she can listen to me, she can receive my traffic. And I also need to make sure that I can listen to her, and that the connection is going to be reliable. So, if I only send one message to Cathy, I send one message, and that's all that happens, what do I do about her being able to listen to me? Nothing; absolutely nothing.

Now, if I send a message, she responds to me, because she responded to me, she said, “Ack,” that means acknowledgement, then I know that she has heard me, okay? So, I know that I can send something to her, she can hear it. Now, does she know that I can hear her? No, she doesn’t; I need to respond back to her, “Ack,” and then she will hear that one. If she hears my, “Ack,” message, now she knows that I have actually received an acknowledgement, and now both of us know that each of us can hear the other one. This is called a TCP three-way handshake. TCP is the Transport Control Protocol, that’s the protocol that’s the most used on the Internet, and three-way handshake because I send my message, “Ack,” 1, 2, 3. Once you have done that, we know that we can communicate.

So, now we can send data, we can send traffic. And I’m going to send traffic. Message 1, “Ack.” So I sent a message, she responded, message has been received. Message 2, “Ack,” message 3, “Ack,” message 4...nothing. What does it mean? Well it means that she has not received my message, right? She has not responded to it. And why could it be that she has not received my message, do you have any idea? Make a guess, yeah?

UNKNOWN SPEAKER: That’s a PACQET loss.

ALAIN DURAND: A PACQET loss, why do we have PACQET loss?

UNKNOWN SPEAKER: Sometimes due to the problem on the transmission path, sometimes if the speed of sending the PACQET is high more than the receiver can acknowledge, then there may be a PACQET loss.

ALAIN DURAND: Those are interesting comments, thank you very much.

CHRISTINA HAKOPIAN: It means that connection—my name is Christina, I am a Fellow from Armenia—it means that the connection is lost at that moment.

ALAIN DURAND: Now, let me ask; which connection?

CHRISTINA HAKOPIAN: Internet connection?

ALAIN DURAND:

So, when we talk about Internet and IP, that's the difference between telephone and network; there's actually no connection. It's called a connection-less environment, it's datagram environment. So, there might be a connection when actually I establish a circuit for my dial-up modem to the Internet, that one can break, and you are totally correct; it could be a blockage of my dial-up connection, but there is no such thing as an Internet really connection per se, so your comment is actually spot on. You have PACQET loss; the PACQET has been lost. The question is; what circumstances can create a loss of PACQET?

So, in the old days, when we had like big, thick wires, they were yellow, and we had connectors that were clamping onto the wires, we called them Vampires; Vampire Connector. They were loose connections, and loose electrical connections means sometimes things can shake, shake and move, and there is a like buzz and electricity doesn't go through, PACQET doesn't go through, PACQET is lost. Or, it could be a wireless antenna sending traffic and when there is a bird, a big bird that flies just in front of the antennas, boom, zap, and PACQET is dropped, okay?

Those things don't really happen much these days; rarely. The number one cause of PACQET loss is when there is too much traffic. So, there might be a router somewhere that received a

bunch of connections, let's say we have 10 thousand subscribers connected to this router, each of them has a contract that's guaranteed, let's say, 50 megabytes per second. 50 megabytes per second, and you have like a 100 of them, that's 500 megabytes, that's 5 gigabytes per second, right? It might be that there is only a 1 gigabyte per second pipe from that router to the rest of the Internet. And, over a subscription of 5, that's not a lot actually; most of the time it's much, much higher than that. If the 100 subscribers are talking at a slightly different time, that's okay.

But, if they are talking at the exact same time, well I have 5 times more traffic than I can manage. So, what is the router going to do? It can put it in the queue, but the queue is going to fill up fairly quickly, so the best thing is actually to drop a PACQET. So, I will have about 80% of the PACQET that will be dropped, and that is most likely what just happened in the connection with Cathy.

So, what do I do now if I know that Cathy has not received my PACQET?

UNKNOWN SPEAKER: You have to send it again.

ALAIN DURAND: Yes, that’s exactly right; I have to send it again.

CATHY PETERSEN: Ack.

ALAIN DURAND: Now she has received it, okay? So, I know that there is congestion most likely. I know that she can actually receive my PACQET from time to time, but not when they were sending them very fast, to your point, I was sending too fast. What should I do, any idea?

UNKNOWN SPEAKER: You have to wait for her response.

ALAIN DURAND: Yes, I have to wait for a response, but essentially it means I have to slow down; I was too fast. So, instead of saying, “PACQET 1, ack, PACQET 2, ack, PACQET 3, ack,” I have to go slower. I’m going say, “Paaaaaacqeeeeet 1. Ack.” Paaaaacqet 2. Ack. There we go; if I go slower, there is a higher likelihood that the PACQET will go. And, if I do paaaaaacqeeeeet 5, I have to go even slower like, “P-A-C-Q-E-T 6.” Ack. Now it worked. So that is called, “Backoff.” And, I’m usually going to backoff to alpha

speed. If I have to back off several times, that may be slowing quite down. And then, I am going to start going faster a little bit at a time until I find what is the maximum speed, okay?

So, that's an algorithm created by somebody called Van Jacobson many, many, many years ago called Exponential Backoff, and it's used all the time. That's the way people are polite on the Internet; they don't simply talk, talk, talk, talk. They will talk, if there is collision, there is PACQET drops, there is congestion, then you stop talking and you let other people talk. It's called being polite.

So, there's another protocol on the Internet that's called UDP. That's a little bit less polite, or to be specific; it's not polite. It simply says, "I send a PACQET, and I don't care if it goes through, I don't care if it's received, I don't care what people do with it, and I'm just going to send PACQETS." It's a little bit problematic first off because well, you can send quite a lot of traffic and there is no flow control; nobody is telling you if the PACQET are going or not, if the PACQETS are dropped, so at the application layer, people should actually do this same type of a go even, but most of the time they don't, so it's just a lot of traffic. But there is another reason why it's problematic these days; when we established this connection with Cathy, she remembered me.

So, she has to keep a contact about the communication we are having. If she is talking to 1000 people at the same time, you know, she has to keep 1000 contacts. If she is talking to a million customers at the same time, she has to keep a million contacts; that's a certain price. For UDP, send a PACQET, there will be a response, it goes through or not, it doesn't matter; she is not going to remember anything. So, one hand, this is very efficient, on the other hand it's not polite and it can be abused.

If there is some protocol for example where you send a simple question in maybe one or two bytes, and the answer is going to be a long message, maybe 1000 bytes, okay? Now, let's say I'm a bad guy, I put on my hat; I'm a bad guy. And, I want to create a DDoS attack. And let's say that I have only maybe a 10 megabytes path. The maximum I could do is 10 megabytes worth of damage, right? No, I can use a relay, a mirror of some other UDP servers, and I'm going to fake my address. I'm going to create a fake address, send the PACQET out there, and let's say this is one of the servers that doesn't keep track of anything, okay, and immediately sends back the answer. Let's say that the answer is 1000 times bigger.

Now, if I hit that thing with 10 megabytes, at the end, they are 10 gigabytes; I have multiplied my attack by a factor of 1000. This is what we are seeing today. And by today, I mean, today, in the

last maybe week or so there is a new attack called, “Memcached D,” this is exactly what is happening, and the traffic is multiplied sometimes by a factor of 50,000. That’s why those protocols have a bad reputation these days.

Alright, now we have done all about transport, next one. So, session, most of this stuff is to transport video. Video is the highest bandwidth thing that we can move on the Internet. We can have like single quality video, SD video, it’s like 1 or 2 megabytes per second, Hi Def video is about 20 megabytes per second, 4K maybe double that, 8K double again, Virtual Reality maybe double again more or less, but that’s what consumes the most bandwidth. So, having a session layer that explains what the encoding of all of this video is, is something useful. Next?

Sometimes you carry your data, and you need to structure the data. I apologize for the font being displayed wrong here, but you need to explain what this is about. So, this is an example of a menu, so you describe your menu and things that can happen when you click on something, all the actions that take place. In the good old days it was a binary format, this was called ASN1; fairly common in the telephoning networks, and when in the mid 90’s came something called SGML and a derivative of that called XML, and you may have heard about the Web, that actually using that format, it was something to describe what we are going to

present to you. So, there will be some characters in bold, some flashing, some underlined, and this visit at the top of the page, bottom of a page, center, all of that.

Now, the new format that the new kids are using is called JSON. And there's a lot of text, dictionary is very easy to extend, so it's much faster to develop a new application using things like that, that's why all the stuff that works now on iCloud, on those platforms are using structures like this. But none of this matters; really, honestly, none of this matters. What really matters is the next slide, please.

My kids, when they come visit me, surf the web, watch YouTube, go on Facebook, that's what matters to them. If you are a service provider and you try to build a network, those are your customers, right? The parents are paying, but those are your customers. So, you are to make sure that they are happy; if they like the service, you are in business. If they don't; you're not. Very, very simple. Next slide.

That's where we start to add more layers to the USI model. I was saying, if the customers are happy, meaning they keep paying you. If they don't pay you, you are not in business, if you're not in business, you're not part of the internet anymore. So, sometimes we talk about free services, but there is no such thing as really a free service. Free service means somebody else is

paying for it; it can be paid through advertisement, it can be paid through other people who have an interest in you watching their product, in other words; if you don't pay, it means that you are the service. And that's okay, as long as you are aware of it. But, regardless of a paid service or indirectly paid service for commercial, there is somewhere some flow of money that sustains this service. So, sometimes we forget about this. Next one?

Layer 9 is why we are this week. Political means how a community gets together to make decisions. What is a process? So, historically, you have empires, kingdoms, political parties, democracies, the process that we use here at ICANN is multi-stakeholder process. Where different people from different walks of life, different stakes in this get together and try to discuss and come to some conclusion, so that's why we are here today.

So, this is the introduction, so we can go now to the meat of the tutorial. How much time do I have left? Oh, okay. Next.

Alright, if you forget everything that I have said so far, that's okay. There are 3 things I would like you to remember today, and we are going to get to the first one. Naming; this whole story started a few years ago. I was in a meeting somewhere, and I had a really, really bad toothache. It was really, really,

really hurting, and I needed to take care of that because I couldn't work, couldn't do anything. So, I need to find a dentist. Next slide.

When I wanted to find a dentist, I went to see my friend and colleague Cathy, and I asked her, "Cathy, you've been living here before right? So, you must know a dentist, who is your dentist?"

CATHY PETERSEN: Dr. Pina Colada.

ALAIN DURAND: I need find Dr. Pina Colada, maybe he will have some beverage that I can use that will take care of my toothache. So, she gave me the name of a dentist, right? So, what's a name? So, my favorite exercise is to go to a dictionary and look at the name, but I think I know what it is, but I'm not quite sure really, and to have a precise definition. So, a name is a word by which a person, an animal, a place is known, addressed, or referred to. So, there are two concepts here; a person is addressed, or a person is referred to. Like, "Cathy, what is your dentist's name?" When I say that, I talk to Cathy, okay? And then, the dentist's name is?

CATHY PETERSEN: Dr. Pina Colada.

ALAIN DURAND: We are talking about Dr. Pina Colada. You see, in once case it's a joint connection, on the other we are talking about, that is a referral. Okay, two usages. So, that's the first thing I want you to remember. If I know your name, I know who you are, okay? I know your name, I know who you are. I'm sure you can all remember that. Next slide.

So, we just talked about that; a name is a handle, a name is not just to have a communication, but we can talk about somebody. So, we can have a conversation, for example, "Okay, this Dr. Pina Colada, is he a sweet guy or is it just a fun guy?"

CATHY PETERSEN: A fun guy. He's a good guy.

ALAIN DURAND: He's a good guy, alright. So, we have a conversation about somebody, right? So, next slide.

And sometimes names can be ambiguous, so when I was in school, in grade school, my name is Alain, Alain in French; I used to live in France, it was a fairly common name, my parents were

not very creative, right? So, sometimes there were like 2, 3, 4, one year there was 6 Alain's in the same classroom. And we had one teacher, she was a little old, and she was getting sometimes a little cranky, I'm sure we can relate to that, and when she was unhappy, she would say the name of somebody, "Please go to the blackboard." We had a blackboard at the time, not a whiteboard. So, she would say, "Alain, go to the blackboard."

And there were 6 of us looking at each other and say, "Which one?" And that would make her mad, because nobody would go to the blackboard. She would say, "Alain, go to the blackboard!" And, at some point she would go, "Oh, Alain Durand, go to the blackboard." So, I will go, and they will have a sigh of relief; not me. Okay, so actually qualify the name that you can have a unique identity, so that's very important. Next.

But, a name is not enough to communicate. I mean, I know that I need to find Dr. Pina Colada, but I have no clue where he is. So how will I find him? That's easy; I go back to my trusted source, "Cathy, could you find in your archive, your rolodex, what is the address of Dr. Pina Colada?"

CATHY PETERSEN: His address is 125 Root Canal Road, DC.

ALAIN DURAND: Thank you. So, I need to go to Root Canal Road. Did you notice what she did? She went to her rolodex, and actually looked up the name and found the address; that's exactly what we call the DNS. That's exactly the same thing; it's called, "Name resolution." You input a key, you get a value; that's what a DNS is. Next slide.

Alright, so I know I need to find this Dr. Pina Colada, 125 Root Canal Road. Next slide.

Alright, what's an address? So, same thing; going back to the dictionary. Address is; the particulars of a place where someone lives. Alright, if I know your name, I know where you are; second thing I want you to remember, okay? What was the first thing?

CHRISTINA HAKOPIAN: Christina.

ALAIN DURAND: What was the first thing I want you to remember?

CHRISTINA HAKOPIAN: The name.

ALAIN DURAND: If I know your name, I know who you are. Second thing is?

UNKNOWN SPEAKER: The address.

ALAIN DURAND: Yes, if I know your address?

UNKNOWN SPEAKER: I know where you are.

ALAIN DURAND: Remember those movies, “I know where you are?” Same thing. That’s not too difficult what I’m asking you today. So, next.

Alright, so addresses; so, this picture here is a little house in Washington where I live. I don’t live in that house, but a lot of people want to live there. And it’s not very big actually, I’ve been inside, it takes like 10 minutes to go through it. The address is 1600 Pennsylvania Avenue Northwest Washington, District of Columbia, 20500-003, USA. So, that’s the full postal address. You see there is a structure; you have to look at it from the right to the left, or from the end to the beginning. And when you do that, the granularity increased, so you start wide and then you go very specific.

So, USA, DC is not a state, so District of Columbia, that's one of the few things that are in the US that's not a state by purpose. When we created the capitol of the United States, they decided that not a single state should be favored, so they created this entity special for that. So, Washington is the name of a city inside of a district, there is only one city, but that's okay. NW is for Northwest because there are 4 quadrants; Northwest, Southwest, Northeast, Southeast. Pennsylvania Avenue is the name of a street. 1600 is the number. You used to be able to drive through that street; not anymore. Security reasons, or so we are told.

So, when you have addresses, in this case there is a geographical structure, right? It's not always the case. So, in the US we have this notion of toll-free numbers; you can dial the number, you don't have to pay, the other side pays. So, when you dial those numbers like 1-800-something, somebody is going to pick up the phone; you have no idea where. Could be in the US, could be in India, very often it is, or it could be anywhere on the planet. We have no clue by simply looking at the number where the person is; there's no geographical attachment to it. Same thing with the cell phone numbers; my cell phone number starts with 703, which is an area code for Northern Virginia, right next to Washington where I live. But right now, I am in Puerto Rico, so

looking at my phone number tells you nothing about where I am.

IP addresses; if you look at an IP address, there is nothing embedded in an IP address that tells you where you are, which continent you are, which country, however, people have done some very complex, expensive, and long studies trying to reverse engineer how the addresses, where are located, and it's called Geolocation, and some are paying services that can Geolocate you all the way down to a block within a street, and by inputting an IP address to the system, they can do this reverse map and says, "Oh, you live in Washington, the city of Handan, in that street, in that spot on the street."

Some of those things are fairly accurate, some are not. You cannot rely 100% on those. Sometimes you will find an address, you Geolocate the address, and they will tell you you are in Germany. Ah, no. The address belongs to a German provider, but that German providers are subsidiaries all over Europe and are using the address block, one place or another, it changes every day, and you have no idea what it actually is in usage in Czechoslovakia or in Belgium, so you have to be taking this information with a little bit of a grain of salt.

How is this used? It's used a lot by the content industry. For example, Netflix; Netflix has different agreements in different

countries for distribution of movies, so if you are a US customer, you have a right to watch certain movies, if you are a customer somewhere else you may have a different set of rights. We have a question here, please?

UNKNOWN SPEAKER: This actually made me think of another concept; so, you speak of Geolocation, but when you speak about certain services being available in only in one country or one region, then you can also end up talking about Geoblocking. Of course, on the case of Netflix that you said, these are certain agreements, perhaps that they online service provider has just a certain catalog with services available there, but for instance, there are some other cases, but again, now we're talking about content so you may say, "ICANN doesn't have to do this necessarily," but there are cases in which you could be a customer that tries to purchase a certain online service, and you, just because you are Geolocated somewhere else, you cannot do that anymore because it was only available in a country.

ALAIN DURAND: This is actually fairly common, even inside of the US. For example, there are broadcasting rights for sporting events, and if a sporting event happened, let's say, in Washington, DC. You

may have a right to watch it online anywhere in the US, but in Washington DC. So, if they geolocate you close to where the event is, they will say, “No,” because they want you to go to a stadium. It’s a tool; how the tool is used is up to whoever is using the tool. Sometimes they use it for good, sometimes they use it for profit, sometimes they use it for other purposes. It’s a tool. All those techniques can be used multiple different ways. Next.

Alright, so remember there was 6 Alain’s, well the same thing with addresses, right? So, I have this reoccurring joke with my children, so they live in France, but they come to visit me in America, in Washington. And sometimes I tell them when they are here for a week, “Let’s go and have lunch in Paris.” They start laughing, because we are not going to take the Concord to go to Paris, because the Concord is not flying anymore, and still it takes a couple of hours, so we cannot have lunch in Paris, France. But, there is a small city in Virginia that’s called Paris, it’s actually a 20-minute drive from where I live. It’s a very small village, maybe like 100 people living there more or less, that’s it. So, when you say simply, “Paris,” in France everybody knows you mean Paris, France, but in the US, there are 20 cities which names are Paris. You have to be careful; so, an address is the same thing. If it’s not fully qualified, there may be conflict, right? So, next slide.

Alright, same thing as names that we can use to talk to somebody or to talk about somebody, we can do the same thing with addresses. So, I can use an address to go, for example, write an address on a postcard, ship a postcard, or I can talk about an address. So, Cathy, this Root Canal Road, is it in an okay neighborhood? I mean, should I be careful? Should I take a taxi to go there, or can I just walk, it's not very far.

CATHY PETERSEN: It's in a safe neighborhood.

ALAIN DURAND: Can I walk there?

CATHY PETERSEN: Yes, you can.

ALAIN DURAND: Thank you. So, we can talk about an address; we can have a conversation. For example, for IP addresses, we can have a conversation; has this address been used by spammers? Is this a lot of malware that is associated with this address? Is it an address that is hosting the web server? Does this address

belong to a known service provider? When was it allocated? We can have a conversation about an address. So, next.

Alright, got an address, that's great, but I still don't know how to go to Root Canal Road, right? So, let's make a little detour; I talked about postcards, right? I was in Katmandu last week. If I wanted to send a postcard from Katmandu to this address; 1600 Pennsylvania Avenue, Northwest Washington, DC, USA, I can, and I'm sure the postcard will arrive there. Not sure if somebody will read it over there, but that's a different story. The postcard will arrive. What is responsible for making the postcard to from Katmandu, Nepal, to Washington, DC, USA?

UNKNOWN SPEAKER: The post office.

ALAIN DURAND: Which one?

UNKNOWN SPEAKER: Located from where you are sending your message.

ALAIN DURAND: Alright, so I give my postcard, I put it in the mailbox, the local post office in Katmandu takes it, and they have to send it to the

US, how do they do that? Do you have any idea how they do that? So, you could say, “They put it in the plane from Katmandu to US.” But, there’s no such thing; I have tried it, there is no direct flight from Katmandu to the US, right? So, you cannot put it in a plane.

UNKNOWN SPEAKER: I will send it to another country, from there that country to the United States.

ALAIN DURAND: Which country?

UNKNOWN SPEAKER: I don’t know. The one that has a connection with the United States and has connection with my location.

ALAIN DURAND: Great, that’s exactly what is happening. So, the postcard is probably going to go to New Deli, in India, and I do know for a fact that there is a flight from New Deli, to Washington DC operated by Air India. I didn’t take that flight, but I know there is one. There is another way to go, which is to take a flight operated by Lufthansa to Frankfurt, and then connect in

Frankfurt to Washington. So, the post office in New Deli has the choice; they can send it through the plane directly to Washington, or they can send it to Frankfurt. Which one are they going to use?

UNKNOWN SPEAKER: The one with the least cost.

ALAIN DURAND: The one with the least cost, okay. Do you have another suggestion?

UNKNOWN SPEAKER: The cheapest one.

ALAIN DURAND: The cheapest one, that's the same suggestion. Another suggestion? I get my gymnastics today.

UNKNOWN SPEAKER: We can say either least distance, or least number of transit points.

ALAIN DURAND:

Yeah, so the actual answer is; it depends. Like many times, it depends. Well, the first thing it depends on is how much you paid. What kind of stamp did you put on your postcard; an expensive stamp, or like the cheapest thing? If it is the cheapest stamp, they will do exactly what you said; the cheapest cost, right?

Cheapest doesn't mean direct, it maybe that there is a contract with Lufthansa that's much less expensive than the contract with India and they simply ship it to Lufthansa, right? That's possible, we don't know. But, if I put an expensive stamp, and I said, "Please make it go as fast as possible," example is FedEx overnight, they will make it go, regardless of cost, to the fastest one, right? So, both algorithms are actually possible.

So, it works! Let me give you an example; a year ago I went to Vietnam. I went to Hanoi, and I went to a place called the Hanoi Hilton. If you know what it was, it was a prison in Vietnam for people that had been captured during the war against Americans. And there was a very famous person called John McCain that was held in that prison for the longest time. John McCain received packages while he was in prison in Vietnam. I don't think there was an agreement between Vietnam and the US to transfer packages, right? How did it work? It worked because there was a third-party who had agreements with both

the US and Vietnam, it actually went through Russia. It was a cold war, but not a hot war, right?

So, you send packages to Russia, and then actually they will find their way to Vietnam. This entire thing worked because there was collaboration between the various post offices. And the second time I'm bringing this concept; this whole Internet thing is the same, it only works because we have collaborations. Without that, it will just collapse. So, next.

Routing; how do I go to 125 Root Canal Road? Before we go there, I asked you to remember 2 things, right? Number 1? If I know your name...

UNKNOWN SPEAKER: I know who you are.

ALAIN DURAND: Second one; if I know your address...

UNKNOWN SPEAKER: I know where you are.

ALAIN DURAND: Now the third one; next slide.

A route. Dictionary; a route, or root, depending if you are British English, is a way or course taken from getting from point A to point B. Like, just go there, and there and there, with directions, right? So, if I have a route to you, I know where to go; that's the third thing I want you to remember today. Let's start again. If I know your name, I know who you are. If I know your address, I know where you are, and if I have a route for you, I know how to get to you, okay? Forget everything else, forget my jokes, but remember those 3 things. Next?

Alright, let's do a little bit of routing. So, this is a network, network diagram, I am the source, I want to go to the destination. I'm on the left, I want to go to the right. So, think of it as, "I'm in a new city and I have a car and I want to drive from point A to point B." Think of it in the era before the GPS, alright? How do you drive from point A to point B in a new city? Well, you follow the directions, you follow the signs. You go to the intersection and there is a sign, for example in Paris, Eiffel Tower, go to the left. Okay, and then you follow the signs until you arrive to the Eiffel Tower. Easy, right?

But somebody had to put in place those signs on all those poles at all the intersections before you start driving; they don't just show up magically at the time you turn your key on in your car; somebody has to put those in place. So, it's the same thing on

the Internet; we need to create those routes and at every single intersection we need to put post signs saying, “If you want to go to this network, take the left, if you want to go to that other network, take the fiber on port number 2,” okay, so that is what we are going to build.

So, when we talk about a Routing Table, what it means is a series of post signs that says, “To go to this network, use this interface, to go to that other network, use that other interface, that’s all it is.” So, how do we do that? Now I’m going to need the laser pointer. We don’t have the laser pointer? I’m disappointed. Ah, I’ll do without. Anybody has a laser pointer here? Alright.

So, look at this diagram; we are going to build the path reverse from the destination back to me. So, the destination is connected to a service provider, has a contract with a service provider. The contract says, “When you get traffic for me, send it to me on this connection,” okay? So, that’s the job of a service provider to send the PACQET there. It’s also the job of a service provider to tell all his friends, service providers, “I have this customer, if you want to send traffic to this customer, send it to me.”

So, that’s the node, that’s to the right, that’s going to tell the other service provider, “I know how to reach this customer,

that’s my customer. If you have traffic for it, send it to me.” Now, if you have a second orange dot, a little bit lower, if you want to send traffic to this customer, you say, “Okay, I need to send it to the ISP that’s just above me.” But you’re also going to tell your friends, your service provider friends, that you know how to get there. So that’s a game of, ‘I know somebody, who knows somebody, how to get there.’ The first guy says, “I know you.” Second guy says, “I know somebody who knows this customer.” Third guy will say, “I know somebody who knows somebody, who knows this customer.” There’s a lot of trust here, right? Remember what I said earlier; this entire thing works because of cooperation. If there were no cooperation between the service providers, it will just collapse. So, at some point, all those announcements about, “I know how to get there,” or, “I know somebody who knows somebody etcetera, how to get there,” we reach the source. Next slide?

So, when all the traffic sign posts have been put in place, then I can simply send my traffic, so I can turn the key on, start the engine, drive the car. Well, how do I do that? Well, I’m going to send the traffic to the router that’s nearest to me, that has told me, “I know how to get to this customer.” Do I trust that person? Yes. Why? Most probably because I have a contract with that person; that’s my service provider, I have a contract with, they told me that they will take care of my traffic. Okay, what are we

going to do with it? We most probably don't have a connection directly with the destination, but they know somebody in the middle. Do they trust that person? Yes. Am I going to trust that person indirectly? Yes, because I have no choice.

So, again, this is this collaboration; I'm sending this to somebody who claims that he knows how to get there. That person sent it to another person that also claims that it is somewhat closer to the destination. And hope by hope, this is going to arrive to the service provider that services this destination, and the PAQET will get there. Once again, it's collaboration. There was collaboration on the previous slide to build the sign post, now there is collaboration to move the traffic; these are two critical collaborations on the Internet to make this work. Next?

Now we have arrived. Let me introduce you to Dr. Pina Colada. Question?

HARRY CHAPMAN:

Thank you, Harry Chapman from New Zealand. Is there a mechanism for punishing players who don't collaborate, or stopping them from sending directions?

ALAIN DURAND:

There is no such thing as the network police; it works essentially because everybody believes it works as is. If one service provider started to go rogue, his reputation will go down the drain very quickly, and what will happen, all the other service providers will say, “This guy from New Zealand is not reliable. We are not going to send any traffic there.” And, they all talk to each other, right? And they will simply blackhole your traffic, and when you have no connection to anybody, in that case you will have an incentive to correct whatever problem there was to join the party again. That’s how it works.

Now, can this be abused? Yes. There was a very famous incident, when was it, like 5, 10 years ago, in Pakistan when you had somebody from, I don’t know exactly what was the rationale or how did it happen, but all of the sudden announced a route for YouTube in Pakistan, and it was not a YouTube site, so all of the traffic originally went to Pakistan instead of going to Google services. It was quickly corrected, because people realized that the traffic was going to the wrong place, so collaboration amongst service providers, they changed that, a couple of hours later the problem was fixed. It was fixed because of this collaboration, not because some kind of police had said, “You have to change it.”

Alright, so that's the end of my talk, but on the end of a session, if you have questions, now is the time. Question?

CATHY PETERSEN: A reminder; please give your name and your affiliation if you have one, thank you.

CHRISTINA HAKOPIAN: My name is Christina Hakopian, I am Fellow of ICANN 61, I'm from Armenia. So, my question is; there services in Internet which hide your IP, which is hiding your IP, I mean hide services. So, what does it mean, how are they working?

ALAIN DURAND: Okay, so hiding IP's; so usually those things are called VPN; Virtual Private Network, and it's somehow related to the point we made earlier about Geolocation, right? If you are to look up your IP address, then I know where you are. The second thing you remember from my talk today. So, what people do is they want to pretend they are in another place, and they have an agreement with somebody in that place, and they are going to send their traffic to that place and there it will essentially bounce and apparently originate from that point.

So, you can think of it as a relay; you send the traffic to a relay, and the relay sends the traffic. How do you do that? When you take your final traffic and you encapsulate it into traffic that goes to the relay, it's called a Tunnel. Those techniques have been created for enterprises, so you are in the Internet, and you want to be part of a corporate network, so what you do is you send the traffic to a gateway of the corporation, and it's encrypted most of the time, so nobody else can see it, and it drives in the corporate network as if you were actually physically in the corporate network. That's another case of a technology that can be used for one use case, but the exact same technology can be used for another use case. So, does it really hide your IP address? At first sight, yes. Only at first site. Next question?

ANDERSON KGOMOTSO: My name is Anderson Kgomotso, I am a Fellow from Botswana. I wanted to know whether the material use here, even know addressing a technical question is very simple, whether it's available publicly, especially for people who'd want to use it for community outreach, or teaching people basically in a community about Internet, whether it's available for people to use?

ALAIN DURAND: Thank you. Cathy, will the slide be available?

CATHY PETERSEN: The slides are already available in the public schedule under the session description. We are also going to be adding in a few days the link to the recording, as well as the transcripts.

ALAIN DURAND: Thank you. The slides, eye level by design, because not everybody is deeply technical, but it's an important topic that needs to be understood by the wider community, so I've tried to up-level the message a bit. Any more questions?

YOHANI RANASINGHE: This is Yohani, ICANN Fellow from Sri Lanka. I would like to know the options available, you said if I want to send or route something faster, in our context we can use FedEx, like that in routing, what other options we can use to send something faster?

ALAIN DURAND: That's a very good question, thank you. On the global Internet, you don't have much of an option for that. Now, your service provider can do it. For example; the most used service on the

Internet are from Facebook and Google, right? So, some service providers have a direct agreement with Facebook and Google, where they will host a Facebook cache or a Google cache within their infrastructure, and if they are a service provider that is located in multiple countries, or in the big countries in multiple cities, they will have a cache close to the customers, so that way the fast route, the FedEx equivalent will be for the customers through that cache, instead of going through all the Internet, all the way back to California.

Now, do you know it as a customer, if your service provider has those caches or not? And the answer is, you kind of know; it's not advertised like this, but when you use the Internet you can see if it goes fast to Facebook or if it takes forever. And, that's a competitive advantage, so sometimes you will have a choice between 3 service providers in place, and you try one, it goes slowly, you try the other one, it goes fast, maybe the one that goes fast is a little bit more expensive every month, but that's your choice then as a customer to either go with the one that is less expensive but slower, or the one that's more expensive but faster. Next question?

CHYLOE HEALY:

Hello, my name is Chyloe Healy, I'm the Global Indigenous Ambassador from Canada. So, within Canada we have service

providers, but First Nations Communities don't have the same access to the internet. I'm just curious if there's anything in check for service providers to provide equity, like equal opportunity?

ALAIN DURAND:

That's a difficult question. There is no network police I mentioned earlier. There is also no network government that is going to say, "You must deploy there," right? Some governments, will infringe on jurisdictions have mandated like this, for example, I know that in the States, service providers have state-level regulations, and they have to provide service to some of those communities, or they have to provide service at a lower price point for underserved communities, but that's part of a legal framework. But, there is no such thing for global Internet.

Now, there are technologies that make this easier to do than other technologies. For example; we have seen a lot of uptake on the Internet when wireless technologies started to become much more attractive and financially possible. In many countries, if you look at the deployment of wireless versus wired, you will see just a few persons of wired, and 90-something % of wireless, and that has really enabled the outreach of the Internet to communities that are not just in cities, because you can serve

a much broader area that way. So, if you think of a combination of those two approaches may help in some of those places.

PAUL BLAKER:

Hi, I'm Paul Blaker from the UK government. In the International Telecommunication Union, we hear from some countries, such as Russia for example, that there should be a right for sovereign states to know what data is being routed over networks in their territory. Is that possible, how is it possible, and what would the impact be?

ALAIN DURAND:

Some of it is certainly possible, the question is what the cost of that thing will be. If you look at the way the Internet is deployed today, it doesn't flow according to country boundaries. So, if you want to enforce country boundaries, you will have to redo quite a lot; you will have to change the locations of fibers, change some connection of exchange points, that's not something that can be done instantly.

Also, when things are in the Cloud now, it's not always easy to know where it is, and actually it is by design and you could argue if it's a bug or a feature. It's certainly a feature when you think about, I am travelling, like I mentioned I was in Nepal last week, I want to address my content, and the fact that I can find a local

cache that is somewhere maybe in India or in Japan instead of going all the way back to the US, means I have faster access to my content, so that's a feature. If you are concerned about country boundaries, that may be a bug.

So, I will somewhat relate this to the previous arguments about some of those technologies about Geolocations, Tunneling and others; techniques exist, and they can be used for one purpose or another. If you want to achieve a certain outcome, you may have to put more money on the table to actually go do it. Now, one question that's of interest is; does this make things more reliable, or does this make things more brittle? I would argue that the current Internet is relatively reliable, if you want to change that and enforce some control points, it is unclear if it will remain as reliable, so that's one thing to watch. It may or may not. I'm trying to dance around the answer to your question I realize, but I'm not sure I can answer any further than that. Any other questions?

HARRY CHAPMAN:

Harry Chapman, New Zealand government again. Thanks for your answer previously. We've heard a lot recently about the concept of Net Neutrality and it makes sense at a conceptual level that perhaps, you know, you've got different classes of postage, and you send some packages faster, which arrive at the

user at a different speed, but I've also heard from more technical perspectives that in reality, Internet service providers just kind of send PACQETS and don't really know when they'll arrive, and it's all kind of random and a giant mess, so if you could comment on whether violations of Net Neutrality you think are technically possible, or whether it is just kind of a random process that is difficult to control and understand the outcomes of?

ALAIN DURAND:

It's another one I have to dance around. So, at one hand, when you are a service provider, you have traffic to move. Your goal is to get rid of the traffic as quickly as you can. Your goal also is to give a good service to your customers. So those things could be sometimes at odds, right? How you manage your network or how you do so according to the local regulation is always an interesting challenge. Those are not really topics that ICANN really deals with directly; this is not related to ICANN's mission, so I'm afraid I would have a really hard time to go much further into this. Another question?

UNKNOWN SPEAKER:

My name is [inaudible]. I'm from here, from Puerto Rico. I can do the question in Spanish? [AUDIO BREAK]

Is ICANN going to change the new KSK, they are using the old key and the new key, they haven't rolled it over yet because they don't know if all ISP's have both keys. If they roll over to the new key, there will be some ISP's who won't be able to use the system because they are using the old key, what is ICANN doing to know which ISP's have the new one and the old one and which ones will have access to Internet when the rollover takes place?

ALAIN DURAND:

No hablo Espanol, so I cannot answer -- so there is a process that has been designed by ICANN of a timetable and a way forward that is going to be open for public consultation, and ICANN will follow whatever recommendations will come from the public consultation on this, Jaron, do you want to add something?

JARON:

My name is Jaron, I'm the Vice President for Asia, working for ICANN. So, regarding your question, the short answer actually is that because the Internet is rolled out in such a way that anyone who wants to set up their own network, they can. So, actually this exercise of the KSK rollover is very challenging for us, because we actually do not know exactly who is running a

DNSSEC resolver, so what we need help is, is to bring the message out to everybody.

So, a lot of the communications is rolled out in the regions, so, for example, in the Asia region, I do a lot of work to make sure that we can reach out to ISP's and network operators to let them know about the KSK rollover, and to tell them what they need to do. So, our own efforts are not enough, and I think working with you and the wider community is exactly what we need to tell the community that, "Can you help us spread the message, let your ISP's know in the local communities the network communities in your country, in your region, to know about the KSK rollover, that if they have deployed DNSSEC, they need to make sure that their system is updated. Then, that way we can ensure that nobody when the KSK rollover happens, the Internet doesn't break. So, that's the best answer I think we can give you. Thank you.

CATHY PETERSEN: I'm sorry, Alain, we have reached the end of our session, so we won't be able to accept any more questions.

ALAIN DURAND: Well, I am very happy to have all those questions, and especially from a lot of Fellows and from somebody from Puerto Rico, I

think it was really great. Thank you all for your participation, and there are three things I want you to remember; I know your name...

UNKNOWN SPEAKER: I know who you are.

ALAIN DURAND: I know your address...

CATHY PETERSEN: I know where you are.

ALAIN DURAND: And I know a route to you...

UNKNOWN SPEAKER: I know how to reach you.

ALAIN DURAND: Thank you all very much.

CATHY PETERSEN: Thank you everybody. Up next, we will have our How it Works on DNS Fundamentals. This is meant as a refresher on basic DNS, and it will include what it is, how it operates, and differences between a Registrant, Registrar, and Registry. We will be starting this session in 15 minutes at 5:00, and you have --

[END OF TRANSCRIPTION]