
COPENHAGEN – How It Works: Internet Networking
Monday, March 13, 2017 – 11:00 to 12:30 CET
ICANN58 | Copenhagen, Denmark

UNIDENTIFIED MALE: This is the ICANN58 How It Works: Internet Networking session.
March 13th 2017, 11:00 to 12:30, Hall B3.

STEVE CONTE: Everyone walking in, there are still seats at the table. We are a very informal presentation. We encourage dialog and, look, there's microphones at the table so that would help in facilitate-the-dialog part. Please, there's also power. You can come here and charge your phone, tablets, devices, pacemaker, whatever. We're going to get started in just a minute.

Okay, we'll go ahead and get started. We still do have a couple of seats up here available. It's got a beautiful view of our presentation here. I see there's some cheap seats in the back. Good, no one's in the cheap seats.

I'm Steve Conte. I'm Director of Programs for the Office of the CTO. We do a How It Works tutorial series foundational knowledge on some of the technology that takes place that is relevant to the ICANN mission in ICANN.

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Today we have—we're kind of mixed around today. We're starting with our Internet Networking with Alain Durand. We're going to be following that with a session at 1:45 in this—I think the entire day is in this room. 1:45 will be on DNS abuse. We have Carlos Alvarez from the Security, Stability and Resiliency Team from ICANN.

At 3:15 today, we have members of the Root Server System Advisory Committee, the RSSAC, coming in to talk about root server system. That's a super interesting one. I highly recommend that one. And then directly against the public forum, if you're anti-public speaking and you want to just come to a place to stay and sit, I'll be doing the DNS Fundamentals Tutorial at 5:00 today.

In the meantime, we're going to start out with you're here to see Alain so I will get off the mic. A little bit of housekeeping. If you have a question, we encourage dialog, we encourage discussion on this so throughout the presentation if you have a question or a comment, those with the mic just go on and raise your hand. Alain will recognize that there's a question or comment and you can use the mics. Anyone out there, we only have the one mic so raise your hand and Alain will come out and bring the microphone to you.

We encourage the questions or dialog to be on the microphone because we do have remote participation and we are recording the event as well so we want to make sure that everyone, even if you're not physically in the room, can engage and be part of the dialog.

So with that, I'm going to pass it along to Alain Durand and enjoy.

ALAIN DURAND:

Good morning. My name is Alain Durand. I'm French-American and over there it's much easier if you call me Alain. Everybody can understand so that's how I go by so if you have a question, please don't hesitate.

I would really like this to be interactive. It's much more interesting, at least to me, so I encourage questions.

The genesis of this tutorial was when I came to ICANN, people told me, "Oh, you're going to ICANN, a place where IP means Intellectual Property." And I come from a technical background. I've been in IETF for 20-something years and I've done a lot of technical things where IP means Internet Protocol so there's kind of a mismatch here.

This is a very introductory level tutorial but explaining really what this IP stuff is all about. It's not meant to go really deep

into the technology. There are other tutorials during the day that do that. This one is really foundation. We're going to talk about naming, addressing, and routing. And as I said, it's a one-on-one level so really level-setting thing. Because I've observed in many discussions that actually in the technical community, people confuse what a name and address and a route is and those are very, very different things so I'm trying to illustrate that a little bit.

The agenda for today: we are first going to talk about the 7 layer of the OSI model. Everybody has heard about that. Actually, I'm going to introduce 10 layers so it will be interesting to look at those. That's what I will use to go into naming, addressing, and routing and we'll try to follow an example on this.

So let's start with Networking by Numbers. Layers from one to nine actually start at zero. Let's start at zero. Zero is the physical stuff. When you want to do a network, you need to connect devices and there are fundamentally two ways to connect devices. One way is to use wired like either copper lines or fiber lines or wireless with some antenna somewhere.

And those two are fundamentally different. They have different properties and even from a consumer perspective, they're different. This is really good in a highly dense populated area. You can put fiber, a lot of bandwidth, really nice. The problem is

that you have to dig a trench to get to this fiber. Sometimes it's easy because somebody has already done that or you're piggybacking on some kind of water work in the streets and the sidewalks are already open and you can do this. Sometimes it's difficult, it's expensive, capital expensive.

In suburban areas, this is a little bit difficult because houses are fairly sparse and if you want to pass a number of houses, you really have to do a lot of work. If you go into a rural area, this is even more expensive. If you go into countries that don't have really a good infrastructure in place already, that may be cost prohibitive. But the advantage is that you can get a lot of bandwidth. You can get gigabyte per second for people who have a home that is connected to this type of infrastructure directly.

Wireless, on the opposite, is so much simpler to deploy. All you have to do is you put up an antenna and always then you cover a fairly large population. How large? Well, it depends. If you're in an urban environment, you may have to have an antenna every so often building. If you're in a rural area, you may have one antenna and that will cover miles and miles of territory.

The problem with antennas is most of the time they're ugly so in a neighborhood like where I used to live outside of Washington D.C., people just don't like those antennas. They think it's really

ugly so they push back and as a result, in those communities that sometimes are affluent communities, you have very, very poor coverage on wireless. It's kind of a paradox but it's because people don't want to see this. So if you put this on top of an historical building, that's also problematic in the city, right? So it's not that obvious.

Now we have different standards of wireless that have evolved over time like 1G. People remember just to carry maybe a suitcase to have your cellphone with you. 2G, it was a little bit smaller. 3G, 4G and now people are talking about 5G. The bandwidth has increased each time but it's still far behind fiber. That's something important to think about when you build networks.

I'm going to talk more about the wire line because that's my background. I used to work for a very large cable provider in America, Comcast, for those who know it so I'm somehow in a better position to talk about this thing.

When we lay out fibers, well, a fiber is this thing that is very thin. It's a little bit thicker than air. It's wrapped into some plastics about 1 mm thick and you can run these for miles and miles to hundreds of miles. It's point-to-point, so if I want to have a communication between here and center of the city, I can have a fiber like this and I'm going to send communication. But if I send

light on this fiber, I'm the only one sending light and I can receive it. There's only one communication there. If I want to share the fiber with somebody else then there's a bit of an issue here. The way it's done is by sending light at different wavelength, different color. So, for example, what's your favorite color?

UNIDENTIFIED MALE: Red.

ALAIN DURAND: Red. Thank you. What's your favorite color?

UNIDENTIFIED FEMALE: Yellow.

ALAIN DURAND: Perfect. Mine is blue. If the three of us want to send data over the same fiber, if you send it in red, you send it in yellow, and I send it in blue, it just works, right? So we can now share the fiber. Now depending on how sensitive laser beams receiver and senders are, then we can have different shades of red and different shades of blue and different shades of yellow but that way we can actually share a fiber, it's not only used by one person.

That's a real value of networking. It's not one person talking. It's many communications being enabled. But this is still point-to-point so assume that we would like to connect to this building our fiber that goes all the way to say my office in Washington D.C. That's a pretty long fiber and are we going to have this fiber installed just for this particular meeting, all the way from Washington D.C., over the ocean and here? Well, that's not exactly practical so people do not really do that.

What we do is to create a fiber path. We're going to re-use different fibers that have been laid out by other people and connect them together and at each junction point, there's going to be a conversion. So maybe from here to central office here in Copenhagen, we can use like red, yellow, and blue but my fiber has to go to D.C. and between the central office here and let's say an ocean station in London, there's a fiber, okay, I'm going to use it. There's some bandwidth available there but somebody's already using yellow. Well, I have to change. Maybe I have to change to blue.

So somebody has to maintain this mapping between—that's me, I'm blue here and I was yellow there, or yours was blue there and turns into some green. Yours was red and may turn into some purple. And every time we go from one league to another, we may change colors.

From a communicative perspective, it just doesn't matter because what you want is to send data. It happens that red and blue are your favorite colors but at the end of the day it really doesn't matter. What you want is to send fast data.

So by putting all those bits of fiber, we create this fiber path and that's what we call the Layer 2. Layer 1 was just one fiber, Layer 0 was when we dug the trench, Layer 2 is for now we have a fiber path.

So what speed can we use in fiber? Well, what is really common now is to use 10 gigabyte per second. We call this 10 gigabyte Ethernet. One gigE is extraordinarily common. You can see that even in houses in some places where there's service providers that connect you directly to the home. 10 gigE is very common for enterprises. 25 gigE and 40 gigE are standards that you're seeing a lot in data centers. 100 gigE is something that we see for service providers for links connecting call routers or service providers or in-between service providers.

But honestly when I was back in Comcast in 2008, we already had 100 gigE. Now 10 years later almost, we need more than that. So places where there are multiple links at 100 gigE that are simply stitched together so if you have four of them, it creates 400 gigE. With IEEE is walking on standardizing 400 gigE and going to the next level to [inaudible] Ethernet.

But one thing that has happened between the Ethernet as we used to know it in the '80s or '90s or even earlier, it was a shared media. The very first Ethernet was a big yellow cable, we call it a thick cable, and if you wanted to attach the network, we had some plugs we called vampire plugs and we just hooked them to the cable and then we had connectivity and it was shared with everybody.

Unfortunately, what happened is that those cables were not long enough so we had to patch them together and sometimes somebody was unscrewing things up and then there was loss of connectivity and you had to send somebody though all the different buildings and all the different rooms and in the attic to figure out where it was disconnected. It was a bit of a mess.

When we started to have 100 megabytes per second and when really we moved to gigabyte per second, we so much changed the model. Instead of having multiple people sharing the exact same media, we moved into topology where there was one link from you to a switch or hub and it's a point-to-point communication we've had instead of having everybody sharing something. So if one of those links fails, you only your connection to the hub. You're not impacting the other people.

The other interest it has is when you have a shared media like this big thick Ethernet, if somebody is talking all the time, there's

no room for anybody else to talk. So there was put a call called CDMA. It was essentially Carrier Sends... I cannot remember the rest of the acronym but essentially you were listening to the cable and if nobody was talking you say, “Ha ha. That’s my turn.” And you were starting to transmit. But somebody may be doing the exact same thing at the same time so the two of you will be colliding and then you have to detect that there’s a collision and you had to stop talking and wait a little bit and start talking again.

But it was great. It worked back in the ‘80s but it’s not exactly efficient because you spend most of your time waiting. And if somebody is talking all the time, it just like political debates, somebody talks all the time, you can get your message [inaudible].

So with those technologies where you have a fiber dedicated to you or wire connected dedicated to you so you can talk whenever you want, it can get much faster this way. That’s how we have been able to go to much higher speed.

Let’s move on. Networking. The world is not flat, something we discovered probably around, I would say, mid 1990s. Copernicus said that long time ago but in the networking world, that’s when we really discovered that.

Some people tried to create networks where everybody will see everybody else from a logical perspective, not just from a fiber perspective and all the fibers would be connected and create this huge, wonderful network. But it created problems. There's this notion of podcast domain and it's when you send a packet in the network, you can say, "This packet is for me to Steve." You can ask Steve, "Did you receive my packet?"

STEVE CONTE: Ack.

ALAIN DURAND: Thank you. Or I can say this packet is for everybody because I'm talking over the microphone it's very loud and you all can hear me, right? When you send a packet to everybody and everybody is about 10 people or 50 people or 100 people, it works. If you have a million people, it's really, really bad.

So when I started working in academia in the university, we had one of those networks where we still were broadcasting to everybody and something weird really happened. We wanted to do backups of all the computers and we said we're going to start the backup after 5:00 p.m. when everybody leaves their office and hopefully we will end the backup before 8:00 in the morning

when people come back, right? It sounded like a smart thing to do.

And we did that and at 8:00 in the morning when everybody was coming back, the backup system was still trying to do something and it was far from being finished and according to our calculation, it should have been finished long, long ago. So we said, “Okay, we need to explore this.”

So we put a probe into the network to figure out what is happening. It turns out that the maximum bandwidth usage on the network was after 5:00 p.m. even if we didn’t turn on the backup system. After 5:00 p.m. everybody is out at home especially in academia. So what was wrong?

Well, we realized by experimenting and measuring things that it was back in the late ‘90s when we had X terminal, for those who remember those things, and people had a screen saver and this screen saver was running over the network and everybody was running his own screen saver and the message was broadcasted to everybody else. So as soon as everybody was leaving the university, then all of a sudden there was no bandwidth available, the network was really, really busy. That’s so stupid, right?

So how did we solve this problem? Well, we told people, “Don’t run your screensaver,” and we also in the background said we’re

going to segment the network so that what was broadcast message are not going to reach an entire campus but they will be only limited to one floor or one building so we're going to segment the network. And this is really what routing is there for, to say you can do what you want in your local part of a network. If you want to do the broadcast things, fine but don't mess with the other people, okay?

So this isolation is created by routing and this is done at this Layer 3 that we call IP for Internet Protocol. Again, this is not Intellectual Property. Next.

Once we have this network, now we really want to send data and there's not just one application that's running on a computer. When you have a laptop here, how many applications are running on your laptop at the same time now? How many applications are open? 12? Yes, it's about that. Steve, how many applications are running on your laptop?

STEVE CONTE: Three.

ALAIN DURAND: Three? Yes, so it's more than one, that's the point. So if you want to communicate and those 12 applications have to work or maybe 3 applications over 100s that are running on a server, you

need to somehow de-multiplex, meaning that for the same IP address, identify the end point, you need to be able to send multiple communication.

For that we use what's called box number. It's like the same as when you go to a building, there are ten different floors and you can say I want to go to floor number nine because that's where HR is, if I have an HR issue. I want to go to floor number three. That's where engineering is, that's where my office might be.

There are two protocols on the Internet. One is called UDP (User Datagram Protocol) and the other one is TCP or Transmission Control Protocol.

Let's talk about PDP first. Let's say I want to have a communication with Steve here, this is how UDP works. Steve, "Here's a bunch of data," and I walk away. Do I know if he has received the data? No. That's not great. So if I really want to make sure he has received the data, what I will have to do is send him another question, "Steve, did you receive my data?" And he may not respond so I don't know. This doesn't guarantee anything, that's the point. UDP is just about I send the data and I walk away.

TCP on the contrary is about trying to have a communication protocol, meaning essentially like a code of conduct between Steve and me but sending data. So I'm going to take my

message, I'm chopping it into relatively small blocks like maximum size of 1,500 bytes most of the time and I'm sending the first packet. "Steve, here is my first packet."

STEVE CONTE: Ack.

ALAIN DURAND: I've just received something from Steve. He has received my first packet. What do I know now? I know that he's alive – that's a good thing, because if he were not there was no need for me to send packets, right? The second thing I know is that he can hear me. But does Steve know that I can hear that he's alive? Not yet. He has sent something back to me but he doesn't know if I've received it. I have sent something to him. I know he can receive it. He sent something back to me but he still doesn't know if I've received it so I need to acknowledge also the fact that I've received his acknowledgement, so ack.

Now what we have done is in TCP link we call it a three-way handshake. Thank you, Steve. Now I can start to send data and I'm going to start sending data relatively fast in different packets; packet number 1, packet number 2, packet number 3, packet number 4,

STEVE CONTE: Ack, ack.

ALAIN DURAND: He sent me two acks. I've sent four packets. What does it mean?
Two are missing. I'm going to wait a little bit, maybe one more.

STEVE CONTE: Ack.

ALAIN DURAND: Okay, so three ack. The thing is I don't know which one has
been received, right? So actually in his ack he has to tell me
something a little more. So let's start again. I'm going to send
number one, two, three, four.

STEVE CONTE: Ack 1, Ack 2, Ack 4.

ALAIN DURAND: Now I know that the third one has been missing so what I can do
is to wait a little bit and send packet number 3.

STEVE CONTE: Ack 3.

ALAIN DURAND:

Here we go. Now I know the four packets went through. I can also use it differently. Question is why did my packet number 3 not go through while the others did? Well, there are two things that could happen. One is somebody cut a fiber and reconnected later. That can happen.

One of the research institutes that I was working at, it was in the outskirts of Paris in Versai and there were rabbits. The thing about rabbits is that they like to dig holes and chew on anything, especially wires and fibers so sometimes a rabbit will arrive and—it's a true story—and they will just chew on the fiber and for a minute or two there, nothing, absolutely nothing will go through.

Back [inaudible] have exactly the same problem. They want to dig a trench and all the time they eat a fiber. But the back [inaudible] you know because you will see it outside of a window. A rabbit, maybe not. So that's one possibility but there was no rabbit there.

So what could happen is the second case is that there's congestion in the network so there might be some routers in between me and Steve and they're busy sending other people's traffic. So they've allowed packet 1 and 2 to go through, packet 3, well, there was something else, they dropped it, and packet 4 went through.

So if there's congestion, it might simply mean that I was trying to send traffic too fast so I have to slow down. So I'm going to take this as an indication that I need to slow down so now I'm going to send the rest of the traffic 5, 6.

STEVE CONTE: Ack 5.

ALAIN DURAND: 7

STEVE CONTE: Ack 6

ALAIN DURAND: 8

STEVE CONTE: Ack 7, ack 8.

ALAIN DURAND: Now I know that if I go at that pace, routers in the middle are capable of forwarding my traffic without dropping it. So it's much better for me to slow down and make sure that everything

goes through rather than rushing away and I have to repeat myself many times.

Now I can try to go a little faster. 8, 9, 10,

STEVE CONTE: Ack 9, ack 10.

ALAIN DURAND: That's good. I can go a little faster: 11, 12, 13.

STEVE CONTE: Ack 11, ack 13.

ALAIN DURAND: Uh-uh, that time I went too fast so I need to back down, okay? So that's called the TCP exponential back-off and then linear regain. When I first detected that there was a packet loss, I had to severely slow down and then I tried to increase slowly my traffic.

Does it make sense? If you have a question, please feel free to ask.

So when do you use one protocol over the other? You could say well, it's much better to use TCP. You have all this protocol stuff that we have [bandwidth] but there is a little bit of overhead.

And sometimes I actually do not care that all of the packets go through. If I trust a file, yes, I do care that Steve gets everything. The integrity of a file is really important. But if it's a voice communication and let's say I want to say to Steve I will be late tomorrow, and I said, "I will be tomo—mm—I will be—mm—late—mm" That's garbage for him, right? He cannot in his brain reconstruct all this. A computer can do that for a file but a human cannot really do that. It's just really too difficult. It's much better if I say or if receives something like, "I will be—mm—tomorrow." Maybe he can reconstruct what was missing. Or if I simply say, "I will be late—mm—tomorrow," he knows that I have a meeting tomorrow with him so his brain can reconstruct this.

So for all those real-time communication protocol, it's actually better to drop some of the traffic rather than to try to send everything in one [order]. That's why real-time protocol most of the time use this UDP stuff.

Next, Upper Layer. There's something called session layer which is about describing for real-time traffic what this is going to be like. Say, "Oh, we're going to stream a movie. This is the encoding for the movie. This is the bandwidth that I'm expecting to get for the movie." I don't have a TCP protocol to help us to adjust a bandwidth but I can maybe try to send some messages to the routers and expect them to say, "Okay, we want you to

have this bandwidth to go through.” This is really useful for all those multimedia real-time stuff.

On top of that, something that is used more for any type of data is the presentation layer. If I send just a file and it’s just a text file of my expense report that I sent to Kathy and she needs to approve them, well, she knows that’s an expense report, she knows what it looks like. But sometimes those have much more complex things that I’m going to send and it has to be structure. There are different ways to explain the structure of a document that’s going to be sent over the Internet.

It could be things like some fixed width field. So for example, I’m going to say byte from 0 to 100, this is this, from byte from 101 to 200, this is this, from 301 to 400, this is that, and that’s what people have done for a while. It’s not necessarily the best representation of data.

For many, many years was a protocol called ASN1. It’s actually not a protocol, it’s an encoding. It was a binary encoding so what you saw on the network was not text but really binary and you needed to add a program called compiler to take what you wanted to send, compile it into this binary form, send it, and on the other side decompile it so that you could actually read it.

It was quite efficient. The problem was it was somewhat too efficient and if you're trying to debug the network, all you see is this compiled stuff and you don't understand anything.

So folks went back to text and the first one that came was XML. So if you browse a Web, what comes back from the HTTP protocol is an XML document. XML is for Extended Markup Language. When you have a document but you also have tags that say this has to be bold character, this has to be big characters, this has to be that color, there is a background picture behind it, there's an embedded logo somewhere there. All this is described as meta data at the same time of the file in XML.

XML was in the '90s. Well cool kids now using something called JSON. It's text also. There's an example here. This is used for things called—you may have heard—rest API when you have a database of complex structures you want to interact with them and you want to say, "Give me, for example, the fifth element of this data set," or, "I want to configure this particular widget somewhere." This is what is used there.

What it looks like is this. It's text and it's structured text so here this is describing a menu. So this would be a webpage that may have a menu in it and in a menu there are different elements that could be ID, value, pop-up, and each of them have different

parameters. You can associate functions to that. Once you get into it it's really nice. It has more of a programmatic approach to it rather than XML which is just a description.

So this is now in many places you will see JSON but everything that has been discussed so far is completely useless for most of the people who want to use the Internet. My kids all they want to do is to get on their iPad, watch a movie on YouTube, do some stuff on Snapchat, maybe go to Facebook. That's what they care about. At the end of the day, all these machinery serve this and we need to remember that. If you cannot enable voice application, there's no point.

When I started networking, there were many application layer protocols. Today seeing that we have essentially one which is HTTP, the one for the web and everything has been now coded over HTTP. Why? Because it's simpler and it works, because there are multiple boxes in the middle of a network. We call them middle boxes, nut boxes, firewall and all this stuff. Instead of creating some special link coding to explain to those middle boxes what they should or should not do something, they know how to handle web traffic so any of our applications now masquerading over web traffic use HTTP.

HTTPS is the same thing with security embedded [for] SSL, Secure Socket Layer but that's what we're trying to achieve here.

But if a service provider was to provide this but break the bank, we'd not go very far. And as a user, that will not be good because he would go bankrupt and then we don't have service any more

So sometimes there's a tussle where users say, "Oh, I want free," and service providers say, "Well, you have to pay because if you don't pay I cannot build it." So there's this tussle to reconcile but the point I'm making here is even when it's free, you're paying for it, one way or another maybe through ads, maybe through sponsorship, maybe through something else. There's always a flow of money somewhere. You just need to be aware of that.

And once we have understood this financial layer, there's a political layer. In all the discussion in between different countries and between different constitutes and all those happening in many places, ICANN is one of them. That's where we are today in this galaxy to get everybody together to talk about how we're going to work together. That's the most important thing.

So that's my introduction to my introduction. Any questions so far? No? Okay, I'll move on.

So a couple days ago, I was in Vietnam and I had a problem with one of my teeth so I went to Steve and I said, "Steve, my tooth is really, really hurting. This is quite bad. I know nobody here. Do you know anybody dentist around?"

STEVE CONTE: I do actually. I used to use Dr. Toberg but he's a sellout so I went to Dr. Carlsberg instead.

ALAIN DURAND: Dr. Carlsberg, okay.

STEVE CONTE: Yes.

ALAIN DURAND: I think I need to find Dr. Carlsberg. You just gave me a name. What's a name? Let's look up a dictionary. I always love to look at dictionaries and using dictionaries because what you find is piles of wisdom. What's a name? It's a word or set of words by which a person, an animal, a place or a thing is known, addressed or referred to. Example, my name is [person] and the name of the dentist, Carlsberg, right?

That's the first thing I would like you to remember today. Forget about my ten layers, it doesn't matter. Please remember that. If I know your name, I know who you are. I know that Dr. Carlsberg is a person that can help me with my tooth. I could talk to Dr. Carlsberg the same way I can talk to Steve. Steve, we have this conversation, right? What we're also doing is talking about Dr.

Carlsberg. So you see that two [holes remains]. Can I have a conversation and—what's your name?

DAVID: David.

ALAIN DURAND: David. Thank you, David. Thank you for coming today. I really appreciate it. I hope this is interesting. So we just had this conversation but David, what is the name of your neighbor?

DAVID: Julie.

ALAIN DURAND: Oh, now we talk about Julie. You see? Names can help us to do those two things and that's really important. So we can relate to somebody by simply exchanging the name. We can pass about a name to somebody else as a referral. You're talking about Julie. Steve was mentioning or giving me the referral as a dentist to Dr. Carlsberg. That's what is really interesting about names. They're handled for that but names have scopes.

I told you my first name is Alain. In my family there's only one Alain but when I was a kid in school, Alain was a fairly common name. There were always six or seven kids in my classroom that

had the name Alain so imagine when the teacher was saying, “Alain, go to the blackboard,” and sometimes it was like we had done something wrong. The seven of us were looking at each other saying, “Which one?” and none of us went there. And when the teacher got really mad, “Alain, go to the blackboard,” and we were in trouble but none of us knew which one had to go to the blackboard. And then after a while she would say, “Alain Durand, go to the blackboard,” and I knew it was me that was really in trouble, the others were safe, but she had to qualify the name. Simply saying Alain is not enough, okay? This combination of the first name and the last name is what makes it.

So my tooth really hurts. I know that Dr. Carlsberg in town can help me. I need to find him. So Steve, can you look up in your address book and tell me where I can find this Dr. Carlsberg.

STEVE CONTE: Dr. Carlsberg is at 125, Root Canal Road. If you’d Googled that, you would know.

ALAIN DURAND: So Steve just mentioned that many ways to actually do a mapping between a name and an address, right? We can go for his rolodex but he doesn’t have one any more. We can go for his

address book in his computer or he'll tell me to just go Google it. It doesn't matter which way you use. At the end of the day, what matters is that I've made an association with Dr. Carlsberg and 125 Root Canal Road. That's really what is at stake here, okay?

So in DNS terms this is called DNS resolution but you could use other protocols same way that we could use the rolodex, the address book or Google. There are many ways to do this.

All right, I know that the dentist is 125 Root Canal Road. That's the address so let's try to dig a little bit there. Back to the dictionary, an address is the particulars of a place where someone lives or an organization is situated. 125 Root Canal Road. So I know this address, I know where Dr. Carlsberg is.

Remember first thing I want you to remember if I know your name, I know who you are. If I know your address, I know where you are, second thing. There will be only three so don't worry.

So I know where Dr. Carlsberg is. Let's look about addresses and different types of addresses. As I mentioned earlier, I work in Washington D.C. and right next to our offices there's this little house over there. It's painted white and the address is 1600 Pennsylvania Avenue, Northwest Washington D.C. 20500-003 USA. Every four years, people compete to live in there.

If I look at this address versus structure, you have to look at it from the right to the left. USA is the country. This is a zip code, this could be typically the state, Washington D.C., District of Columbia is not exactly a state but it's almost like one. Washington is the name of the city. Northwest is because Washington is divided into four quadrants, Northwest, Southwest, Northeast, Southeast, and Pennsylvania Avenue is the name of the street, 1600 is the number on the street. So there's the structure.

But not every address has a structure like this. For example, in the U.S. there's a phone system. If you dial a number that starts with 1-800, it's a toll free number, meaning you don't pay for the communication. Somebody else is paying for it. When I dial a number like this, I have no idea if the person who is picking up the phone is in the same city, the same state, even the same country. Sometimes they're in India, right? So by simply looking at the address, I have no clue where geographically it is. That's a flat address example.

Cell phones. My cell phone number starts with 1, 703, the area code for Washington D.C. and the other digits. You could say, "Oh, it's a 703 number, it's a Washington number. Well, I just happened to be in Copenhagen this week. I was in Vietnam the week before. Looking at this number doesn't tell you much about where I am really. There's a layer of indirection but later is

used by the phone company to send the communication to my cell phone.

IP addresses. If you look at an IP address, for example, what's the IP address on your Mac, Steve? Yes, let's look it up.

STEVE CONTE: My v4 address is 10.196.196.111

ALAIN DURAND: Okay. If I look up 10 dot something, I know it's a private address. I have no idea where in the world it is. But to look at a global IP address, if you go to—what's my IP?

STEVE DURAND: My public address is 192.0.47.236.

ALAIN DURAND: All right. If I look at this 192.0.something, that's all I see, 192.0.something. I don't know where it is. Addresses are located by the RIR, regional Internet registry so I could look up in the RIR database, figure out was this address allocated by an RIR in North America (ARIN), by RIPE in Europe, APNIC in Asia Pacific, LACNIC in Latin America and Caribbean, or AfriNIC in Africa. I could have continent-wide geography but sometimes address moves around.

So there are database that have been built by people who sell it as a service that can map your IP address almost all the way down to the street number. Sometimes they're accurate, sometimes they're not. And depending on which country the address is, that may be more or less accurate. But it's a service that people have built. They spent a lot of resources to go and build this database. Simply by looking at the number, you don't know. It's not the same as postal address.

STEVE CONTE:

Alain, just for an example on that, because we're in the ICANN meeting space IP addressing, when I look that IP address up, it says I'm in DC.icann.org so it's a misrepresentation based on the point of because this is reusable space that we move around the world during our conferences.

ALAIN DURAN:

Perfect. Thank you, Steve. So that points that even you may pay a lot of money to your database that will do geo location to know where you are but daytime they may or may not be true.

All right, I was talking about my first name at name surfing scopes but addresses too also have scopes. For example, if you're in Washington D.C. and you ask a taxi driver to take you to

1600 Pennsylvania Avenue, they know. They know that's the white house. They know where to go.

If you live here in Copenhagen and you want to go to Paris, you know that you can take the train, drive or go to the airport. It's about an hour, an hour and a half flight to Paris, France "City of Light," everything. Sometimes my children visit me in Washington—we live in France, I live there—and we joke, "Oh, let's go to Paris so in the afternoon we'll be back for dinner," because there's a little town in Virginia called Paris and there are actually 29 cities in the U.S. that are called Paris. There's one that was made famous in a movie called Paris Texas. So if you simply say we go to Paris, it's not enough. You have to give the scope of this, Paris, France or Paris, Virginia, wherever you like.

The same way that I was talking about names, we can have a conversation. Hey, Steve, how are you doing today?

STEVE DURAND:

I'm fine, thanks. How are you?

ALAIN DURAND:

My tooth is really, really hurting. I hope that we can find Dr. Carlsberg. So we have this conversation here. We can talk about the address also. Steve, this address, 125 Root Canal Road, is it

in a good neighborhood? Is it far from here, can I walk, do I have to take a taxi?

STEVE CONTE: It's pretty far from here but it is a good neighborhood.

ALAIN DURAND: So you recommend a taxi.

STEVE CONTE: Don't walk. It'll take you a while.

ALAIN DURAND: Okay, thank you. So we had this conversation about the address, okay? So that's what is really interesting. All those things we can't have a direct communication or we can talk about something.

All right, now it's time to go to 125 Root Canal Road. It's not in D.C. It's in Copenhagen. I have the address but that's simply not enough. I have to get there. How do I get there?

Back to my example of a little white house in Washington, let's say that you wanted to send a postcard to the current tenant of the white house? Well, get your postcard, you write down the address, 1600 Pennsylvania Avenue, Northwest, Washington

D.C., 20500 U.S.A. From anywhere in the world the postcard will arrive there. Why? Because here in Copenhagen, the Danish post office has some kind of agreement with the U.S. post office. It works because there is a mechanic underneath.

Sometimes it's an indirect connection. It could be that a Danish post office doesn't have a connection with the U.S. but everything is sent to London, for example, and then in London there's an exchange.

I saw a real example of that last week when I was in Vietnam. I went to Hanoi, to the infamous Hilton Hanoi and they're showing us pictures of American prisoners of war who were receiving packages during the war from their family. And I was wondering, "How is that possible?" Countries are at war. How is it even possible that post office can go through.

Well, the answer was it went through Russia. The Americans and the Russians were not at war. The Russians and the enemies were not at war so there was a special address you could send things through Russia and it will actually go there. It might be inspected in the way but that's a different story. The package actually went there so it went for a special [hop].

So it was this kind of collaboration that made it work and the Internet is no different. There is not necessarily a joint connection between here in this building and my office in

Washington D.C. but if I can get cooperation from a number of service providers in between, I can have a communication working.

Let's go into this in more details. What I need is essentially a route to tell me you have to go there first and there first and there second there, etc.

So let's look at the dictionary again one last time. A route or if you're British English, the route is a noun. It's a way or course taken in getting from a starting point to a destination so all the different steps that I have to go from point A to point B.

So remember third thing. Number one, I know your name, I know who you are. Number two, I know your address, I know where you are. Number three, I know a route for you, I know how to get to you. Those are three different things. You can forget everything else today but remember those three things.

So how do you do that? Well, let's say that you wanted to drive from here to Paris. You're going to follow the signs on the road. The signs on the road have been put in place way before you started your journey, maybe years ago, right? In the Internet that's the same thing. We are not going to wait for you to send traffic to calculate your routes. Those routes have been put in place before. How? They're put in place in the reverse direction – from the destination back to the source.

The destination here is going to have a connection to service provider and tell the service provider, “Please forward me all the traffic that is for me,” which is very simple. Service provider here is going to tell his neighbors, “If you want to send traffic to, let’s say, Steve, please send it to me because I’m Steve’s service provider.” So those two guys who are directly connected to Steve’s service provider know how to reach Steve because they know a guy who is Steve’s service provider who knows Steve.

Now let’s say that I’m further down the chain. I’m a service provider now that knows a service provider that knows a service provider that Steve is connected to. Now when the second service provider announced to all his neighbors that he knows how to reach Steve, this one also knows how to reach Steve. So this game is all about I know someone who knows someone who knows how to reach Steve and you can make this chain as deep as you want or as short as you want. Like you want to buy something, I know somebody who knows how to get that, right? Same story, exact same story.

The point I’m stressing here, this is a cooperative system. It only works because there is a cooperation of all the service providers that have agreed to faithfully propagate the announcements and not mess around with them. So when you send the packet you just reverse this. I’m resource. I don’t know anything about this. All I know is my service provider so I’m going to send the

packet to my service provider and I'm going to trust that my service provider is going to do the right thing. If I don't trust my service provider to do the right thing, I might as well resign my contract and go to somebody else. My service provider is going to say, "I've heard from that guy over here that they know how to get to Steve. I'm going to send them a traffic and is it going to arrive or not? Not my problem. I've heard from somebody that they know how to deal with it. Okay, I'll send the traffic." It's called hot potato routing. I don't what to deal with traffic. I know somebody else who knows how to do that.

This guy here, same thing, he has heard from this one but he's somehow closer to the destination. So all right, pass it along. I'm not going to keep it. All the way to Steve's service provider, we'll be very happy to send a package to Steve because he has a contract with Steve. Remember about Layer 8, financial? It all works because Steve has a contract. That's the only reason.

Sometimes there is money exchanged between those guys. Sometimes there is not. It depends on the agreements but overall it works because this is a cooperative system and everybody relies on the next stop to do the right thing. There's this magic about the Internet is you rely on the others to do the right thing. That's a fundamental thing, this trust. If that were to go away, there would simply be no Internet.

Now I have arrived. This is a picture of Dr. Carlsberg on 125 Root Canal Road and he can take care of my tooth problem. Maybe I can have a beer after that. And that's it. Questions?

STEVE CONTE: If you're sitting in the back, please raise your hand. If you're sitting at the table, just raise your hand and Alain will acknowledge and you can push the button, but, please, questions or comments.

UNIDENTIFIED FEMALE: So what happens when there's a war and someone decides not to cooperate?

ALAIN DURAND: We had a number of examples of that, not necessarily with war but civil war or political uprising in some countries and we have seen in those cases somebody in the government or related to government going to the service provider and saying, "Just get the traffic, get the fiber." And what happens is that most of the country goes dark – emphasis on most – because there are always people who reconnect things through other channels, through different ways of communication so that the traffic will go but that's what happens. Another question?

Oh, to this point, one little anecdote. I was in a country recently that I will not name that has very little connectivity. It was on a Friday night. I was having dinner with a friend of mine and then after dinner, it was like 9:00 p.m. I was expecting lots of people in the street and there was nobody and that's weird.

And then we saw a lot of people gathered together, maybe 500 people. I said, "That's weird," and some people starting to approach saying, "You want some? You want some?" and they had little pieces of paper. And what it was is if you paid a couple of dollars, you get a piece of paper with a WiFi code and you can type in this WiFi code and you'll hop in on a hotspot that was maybe not that official and you will get network connectivity. So people were selling this. It was amazing. Question?

UNIDENTIFIED FEMALE:

So what's the most recent development with being able to identify what computer people are sending from and what their identity is and where they are? There's some rumor about technology being developed in certain countries that might be considered somewhat repressive about being able to come and find you and route you out of your house for saying things against the government.

ALAIN DURAND:

For a long, long, long while everything was done in the open in the Internet. Then things changed a little bit and all those addresses are public. You can look them up. Like this address 1920.something, you can actually go and look it up in some of the IR database and they will say this address belongs to a service provider. So let's say there's a problem somewhere, the law enforcement community can look up this database and figure out this address belongs to this service provider. They have a contact there and they ask, "Who was using that address that day?" And the service provider goes through his log and he says, "This is user Alain Durand was using this address that particular day." That has been done for many, many years. There's nothing new there. Absolutely nothing new.

Some of the development has been that we have been running out of IPv4 addresses for a while now and a lot of creative technologies have been developed to deal with that. IPv6 is one of them but even with IPv6 you still have some problem because not everybody is using IPv6.

So there are boxes called [inaudible] nut that essentially take your private address and mix it up with others to de-multiplex it. Multiplex it on one side, de-multiplex on the other side to share an IP address with multiple people. So now it's a little bit more complex because the law enforcement community has to figure out what was the actual port number being used, not just the

address and go to the service provider but go through logs or through some configuration system, figure out who was using that particular IP address and port number and then go to the user. This is no different again than what was done before just one more hop to go through.

Some people have been trying to develop technology that will obfuscate their communication. One of the well-known technologies called [inaudible] where your communication is spliced and scattered into many different bits and sent from many different parts of the Internet so it's really, really hard to trace it back. But there have been some efforts to try to reverse engineer that thing and this is an arm race.

This is the same thing as the story a couple of years ago or 200 years ago between the bullet and the arm plate. Well, the arm plate got bigger to defend against the bullet then the bullet got faster and was able to go [for] the arm plate and cycle [wins] and repeat.

So that's the same thing here that is happening. Some people try to have more privacy and obfuscate some of the techniques that are being deployed to find it and just expect through some ways keep going. I'm not sure if this answers really your question but—

STEVE CONTE:

It's an interesting question and from a technology perspective, absolutely plus one to everything Alain had said. It's a question of privacy. Everyone wants some privacy until your privacy is encroached on and you want whoever encroached on your privacy, you want to be able to tell who that is so you can go to the law enforcement or whatever.

And that's one when we looked at the layers that Alain had here too. We looked at the political or rather policy layer. We want our own rights protected until they're not and then we want to be able to find out who that is. For the bad guys, if we had privacy rights for all the nice people out there and we all played nice, that's great but the bad guys will be using that same process and procedure too so they'll be hiding behind a layer of anonymity or privacy securedness and stuff and we wouldn't have an opportunity to go after and identify who the bad actors are.

This happens on all space through the Internet, the addressing and numbering but through DNS. There's people who have illegal pharmaceutical sites and illegal counterfeit products and phishing and farming and all kinds of stuff.

A couple of years ago one person has been coming—safety sector has been coming to ICANN for some time now and a couple of years ago they formalized the relationship through the

Government Advisory Committee, the GAC, and formed the PSWG, Public Safety Working Group. There's individuals from all over the world and in all walks of the public safety sector involved in that. They operate through the GAC. In fact, there's a session on Tuesday. It looks like it's open where they'll presenting new findings to the GAC. So if you're interested in that kind of thing, it's a tough question and it's not an easily solvable one because my country's version of privacy might be different from your country's version of privacy too and we have to—the technology doesn't drive that, the policies do and we have to learn how to align that and make as many people as happy as possible and still trying to adhere to individual and regional needs.

ALAIN DURAND:

Thank you, Steve. Just to illustrate more of the ALAC multiple layers or technology layers and then the political layers so you have the technical answers and the political answers. Thank you. One more question? One in the back and then I got you.

UNIDENTIFIED FEMALE:

Sorry, my question might be too primitive. I'm asking about you talk about by transferring the data you need a postman, post office. So who actually acts as a postman? Is that the government or an individual or an institution or things like that?

ALAIN DURAND: Thank you for your question. It's actually a good question. When I talk about the postcard going to the white house, I was talking about the different post offices and the question is who plays that role in the Internet? Is it the government, is it a private association? The answer is those are the service providers and the service providers cooperate all around the world to send and exchange traffic. In most places they are private entities. Some places the government has some say in who is a service provider or not but in the end in most environments those are private entities that have private agreements with other service providers. Does this answer your question?

STEVE CONTE: Hold on one second. We've got an online visitor so if you could repeat that into the microphone?

UNIDENTIFIED FEMALE: For example, if I want to just login to the network and set up a— if I use the file server myself and I just log in there, how does it work actually? Just login in the network according to the rules and codes and then I will be connected. Is that I'll be serving as a postman or is that a central control system or anyone can just be a file server—can be a post office, I mean.

ALAIN DURAND:

The question is how do you connect to the Internet? Oh, as a server, if you want to have your file server or something. And the answer is if you simply want to browse the Internet, all you need to do is buy a service from a service provider and you pay them either monthly or weekly or by the data volume that you have and you're connected, done.

If you want to run a server, you have different possibilities. One of the easiest thing to do today is to buy the actual machine somewhere around the Internet on the cloud, run your server in the cloud so you don't run it at home. Alternatively, you can do it at home but if you run it at home, you need to make sure that your server's going to be on all the time.

I used to live in California back in the early 2000 and California had a lot of power problems back then and we had rolling blackout and power would go out randomly a couple of hours a day. Not really good in the Silicon Valley but that's what happened in 2000 and something.

I had my own server because I wanted to control everything and I learned that it was a bad idea. A) It was a lot of work for me and B) battery went down and C) power bill was quite expensive. So six months later what I did is I just bought a server and I bought

some rack space somewhere and I bolted my server in a rack space in a cool location facility and I ran my server from there.

A year later, I moved and it was hard for me to find another cool location where I could easily go to change the server if there was a problem so I decided, “Forget this thing. I’m just going to buy a virtual machine.” And the machine is in the cloud. I just don’t care where it is and I run my server from there.

A while later I realized, “Why do I really want to do that?” All I want is mail essentially, so I’m just going to get mail from somebody.” You have a choice – Apple, Google, Microsoft, whoever you like, and they do it for me and I’m very happy. So that was my own personal progression so to answer your question, if you have connectivity, you can do whatever you want. You just have to know what you’re buying. What’s the question over there?

JOANNA:

Is it okay if I use this mic? All right, my name’s Joanna. I’m from Poland. My background is in human rights so when you mention privacy I instantly have a question. I was wondering if this was the time and the discussion to ask about Onion networks [for] anonymity. Because you mentioned that it’s often a policy decision how the networks work so with that in mind I was wondering what your opinion on the help that Onion networks—

whereas my background is not technical so this might be a completely failed question—whether Onion networks help in making those policy decisions. What’s their interrelationship there between the network architecture and the privacy issue? Thank you.

ALAIN DURAND: This is an introduction level tutorial. This is a really good question you’re asking and we’ll be happy to have an offline discussion with you about this. I’m afraid this is a little bit outside of the scope of this tutorial.

STEVE CONTE: With that said, I do recommend there probably is a discussion this week on WHOIS. Look for that and also, as I mentioned, the PSWG. They’re really involved with the policy side of things on the technology.

ALAIN DURAND: Any further questions? Going once, going twice. Okay, you know you have three things to remember, right? I know your name, I know who you are. I know your address, I know where you are. I know your route, I know how to get to you. You remember those three things, you’re gold. Thank you.

STEVE CONTE: That's kind of spooky. Thanks, Alain.

We're going to break for lunch. Our next session here will be at 1:45 in this room and Carlos Alvarez from our Security, Stability and Resiliency Group will be talking about DNS abuse and the types of abuse that happen in or with the DNS. So invite you to come back and join us then too. Thank you.

[END OF TRANSCRIPTION]