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LARGE-SCALE IPv6 TECHNOLOGY DEPLOYMENT --

FROM MILLIONS TO BILLIONS

LECTURE ROOM 2

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 >> KILNAM KHON: The first we have a keynote speech from Geoff Huston, titled IPv6, past, present and the future.

 The reason why we have a keynote speech is I certainly expect -- in the morning. And that's actually what happened. And he's going to make -- I told the -- I hope you enjoy.

 Then after the 45 minutes, keynote speech, we have a question -- not just topic, the previous discussion, or anything. About IPv6 IPv6. So please prepare your questions or discussion. Any question. Please try to come up with difficult one.

 Okay. With that, let's...

 >> GEOFF HUSTON: Thank you, Kilnam. It's a pleasure to be here. I work in the research -- certainly I've been involved in IPv6 for many years. But I love this. I love this, because I've been told for the translators don't speak too quickly.

 So you watch in a civilized manner. Civilized watching, and no climbing. Those are remarkable times.

 So to start off with I'd like each of you to think about what your answer to this question is.

 How many v6 have you seen, and I appreciate that's a difficult question. I'm going to help you. You may have sat through 20 or 100 or 1,000. Or you've done more than that. Just been asleep by the time it's all over. Because certainly I know I have seen thousands of v6 presentations.

 And so the first thing I'm going to look at is spin the clock way back. Way, way back. Isn't it a good picture?

 I love it.

 Spin the clock way back and look at the past.

 The Internet did not occur out of a vacuum. The telephone network which was actually developed from the wired telegraph network could say early, mid '80s, the telephone 1876. And by the time we get around to the 1960s, the telephone system was amazingly big. AT&T employed half a million Americans at its height. So did BT in the U.K.

 They ruled this industry. They were massive. And they were so big they made incredibly stupid technology choices.

 Does anyone remember ISDN?

 In fact I think there are still ISDN telephones in public booths in Japan. That was a hideous mistake. I'm sorry. AT&T invented in the Bell research labs in America was another technical mistake. It was a complete white -- it was the voice person's view of data. And it was wrong, wrong. Totally wrong.

 And interestingly, over the last ten or so years, things that took the world by storm were never, ever meant to happen -- was not part of the plot. You weren't meant to do SMS. But the world just did. And we weren't meant to be running IP. Advance -- OSI, not IP. So no matter how big you are, you can always get it wrong.

 And is the question is will the Internet get it wrong?

 Because we are now mainstream. We're everything.

 Voice runs over IP. There are far more -- in Skype than the dear old international PSDA. The PSDA, as a technology is finished. It's over. It's living through its dim afterlife. And here we are now about to did everything over IP, and at the same time we're just about to stop -- it up. If there's one thing you need in a protocol, it's addresses, the same as in a telephone network. No telephone number, no ring.

 So you know, there's a problem at that we've known about for years, but we haven't done much about it. So what are we going to do?

 We knew about this a long time ago. In fact, even before the Internet truly mattered. Because we knew back in 1990 -- isn't that a cute set of slides?

 PrePowerPoint. Only 23 years ago, no PowerPoint. You had to do all the slides by hand. And this is Frank Zelinsky's presentation. A ripper, isn't it?

 All these graphs and numbers.

 What we're going to -- or we're going to run out. We're going to run out in 1994, just four years hence.

 The reason why was kind of suspect. It provided the number space in class A, B, and C. And a bit like Goldilocks, the A networks, thee were view few of them, but they were massive. They could expand 20 million hosts. No one had networks that big. And the C networks, although there are a lot of them, even then 256 hosts was just not enough.

 So we concentrated on those B networks. And there were only 65,000 of them.

 We're going to run out in 1994.

 So what did we do?

 We hacked. What we did was we got rid of that class structure, and got enough bits to make your network work. No more and no less.

 And there's a -- progress as we did that. And it worked. We were going to run out about around '94. And we -- on time. We bought that time by using a subtly different technology. Minor hack quickly deployed. The Internet was tiny, it just worked.

 But there was only going to be temporary. We had to do something.

 So the other thing we did was we said we need a protocol that works better. We need one that -- run out of -- but being engineers and not business people, we had no idea how the world was going to transition. That wasn't our problem. That was somebody else's problem.

 Thee slides run -- we thought we'll let it go and figure out transition later.

 So transition now was not a now problem. We bought a lot of time. At the time five years seemed like an eternity. So we went to -- didn't just work, it really worked. After a few years, it looked like we wouldn't run out until 2050. What's the problem?

 The industry, everybody just went to sleep.

 Because CIDR was doing such a great job.

 Back at the engineering labs we were working hard on requirements. What do we want from this -- we wanted larger address space. But don't forget, every bit you add, doubled what you had. So even 48 bits was 40,000 times bigger than the v4 network. Why do we need more said some.

 Surely 48 bits is enough.

 Other folks said that's as stupid as ATM. 48 bits is a lousy number. 32 is good, 64 is good, 128 is good. Even 256 is good. But would that fit on bite boundaries. Like ATM and its 53 tips of sill header -- 48 bits and others said think big, 128.

 And others said can't decide, think variable.

 The variable people don't know what they're talking about. That's just crazy talk.

 But the requirements didn't stop there. The other problem we had was routing was exploding in our faces. So -- new to control routing.

 And folks were suffering from what we called broadcast storms. No broadcast anymore. Everything should be multi cast.

 Clock -- plug and play, and -- devices was just around the corner. If all of those needed to be configured manually, there wouldn't be enough humans on the planet to do this. These devices had to work out for themselves what they needed to do. Autoconfiguration. And we didn't like packets being fragmented. And we didn't like small packets, and we really, really didn't like network address translators.

 And we wanted networks to renumber very quickly. And we wanted things to be backward compatible. That was our shopping list. Which you know, sounds reasonable, doesn't it?

 You were designing a new protocol, wouldn't you do all those?

 I would.

 How did we go?

 Here's the technology. What we did was the right spirit of things much we got rid of stuff. If you thought -- v6s even simpler. Although that flow header, those 20 bits proofed to be a real problem.

 Because everybody has a different idea of what they should be used for.

 So those -- useless. But the rest of it is kind of elegant. It is our v6. It's this big, I got this many hops before I kill myself, here's where I came from, where I'm going to. Simple.

 What did that mean in requirements?

 We did 128 bits, we killed it. Stone dead. So many bits.

 Scaleable routing. Didn't fix it. No broadcast only, multi cast.

 That means every single host machine now has to do multi cast. How sophisticated as the network gets simpler. As you push in one point, something else bulges out. Not sure it was a good idea.

 Configuration as you heard from one of the gentlemen today, I think from Samsung, v6 is just around the corner, no, DHCP 6 is everything.

 Doesn't give you DNS. You're hosed. Only half of the solution.

 Oops.

 No fragmentation. Bad idea. Caused massive problems for us. Now you can only fragment at source. We raised the packet size to 280. Why?

 The 100 Internet seemed very reasonable. 1280 seems, where the hell did they get this number from?

 I have an idea. It just seemed like a good number. Now why?

 No Nets, just public addresses. Because now we've got these unique loads which aren't really unique and people are talking about NATs in v6. The gentleman talked about one solution in their networks that was using NATs and v6. People have grown very used to NATs. They want them. They like them. They like private addresses.

 So -- spaces so big you don't need to do it, they do it anyway. We're engineers, not society engineers. We don't understand the way people use networks I think when we designed the protocol.

 So people just wanted to use private addresses.

 Ease of renumbering, failed. Backward compatible, failed. Failed. Thousand times failed. I speak v4, you speak v6, we can't talk. Something in the middle has to talk. And not only that, if I'm speaking v6 and you're speaking v4, that thing in the middle needs a v4 address to speak to the v4 other end.

 You can't do it without pools of v4 to help you. V6 can't speak to v4. English can't speak Korean.

 I need a middle person to translate. Same in these protocols.

 Nothing is easy.

 So what you need?

 Three things changed that really fundamentally affect the network. We expanded the address field. We changed the way packet fragmentation worked.

 That was kind of bad. And we changed addressing to allow machines to have multiple addresses. And we have no idea how to do that. The solution to NTT east's problems is actually multi addressing in v6. The one realm of addresses goes towards their infrastructure in telephony and telephone. And the other realm goes to Internet addresses and retailer. In this practice this is the good, the bad and the ugly. Address field expanded?

 Terrific. The fragmentation happening at source?

 For the DNS, you couldn't have got it worse. This is a disaster.

 This is a really bad idea. Because it's a major problem when we combine DNS with DNSX. Because all of a sudden the packets are bigger than 1280 and UDC and fragmentation at source doesn't work. Oops.

 And the router network realm address -- addresses have purpose. If we knew how to do it, it would be fantastic. It's so confusing, we don't understand it.

 One bad, one ugly. There was a lot of push with v6.

 And one of the best folk to illustrate this is our good friend Latif Ladid, give you vibrant memories of his use of massive slides. And certainly they made many, many claims about v6. This is going back a lodge, long time.

 Were they right?

 Was it really more secure, was it better for wireless?

 Did it give you all of those wonderful things?

 Was it faster?

 Did it renumber, did it auto configure?

 Years ago -- because as we started to think of things you could do in v6, some say I can do that in v4.

 Every single thing -- basically back -- the only thing we couldn't do was build regressives. But they were looking for the killer application, the one thing so that -- explorer, the browser that made v6 dramatically better than anything you could do in v4. Couldn't find it. So we couldn't sell v6 as this is better.

 It wasn't that kind of a message. It was in terms of function, better. And indeed it ran into some of its problems in detractors from its own technical community.

 There were some folk who said -- this is one, this is a message from Noel Chippa, has the patent of the multi protocol router, the sing that Cisco built. He originally was at MIT and built the first one at Protean and still owns the royalties. He knows what he's talking about. And his thing was, it wasn't a big enough change. Like all good academics, if you're going to change, make it radical. Get right out there. And he was making a claim that you went conservative. These were minor changes.

 If you really wanted to be radically different, maybe you should have gone further.

 Why is the U.S. playing with next generation -- why has Europe got fire programmes?

 Why are we looking beyond the Internet?

 Because that message from 2003 is still true today.

 That v6 is not a way out there protocol. It's -- small number of aspects much and it's still much the same philosophy of communication.

 Should we have been more radical in 6?

 Well, the whole folk behind SDN, open flow and all of that work say yes, let's get out further. So maybe he was right.

 And the -- spent many years at Cisco, Tony Lee, who said look, renumbering was meant to be so good in v6, you could renumber every hour. New address, new address, new address. Wrong.

 It's not like that. It's the same as v4. Renumbering was hard. It's not brighter, it's not shiny.

 It doesn't perform miracles.

 So about ten years ago it was still pretty clear that v6 wasn't going to happen naturally. Providers wouldn't say, if I do v6, I'll make more profit. Things will happen. And users weren't saying, I know all about v6 and I want to buy it.

 That wasn't the case. So at the same time -- measure from poor Francis. Network address translators. And it was again designed in -- v4 address and translated into another. You think, well, that's simple.

 But all of a sudden, next -- happen. A number of devices can hide behind one address. To the world this looks like one device being super chatty. But this little device fans out to its private -- so that every communication is preserved and the users behind the net don't even know that it's there. This was brilliant.

 This actually managed to preserve -- nothing else. This was so good, we've been running the entire Internet on net since 19 -- it's so good we don't even know how many devices sit behind NATs. We suspect more than a billion, but NATs are so good we can't even count them because we can't see them from the outside.

 So it seems that the bottom line even in 2003 was maybe; maybe we didn't have to do ISDN, maybe NATs would work. It was an issue of what's the long term market going to do?

 The other problem is that whenever you give people a lot, they use a lot. There was a question about how big is the prefix -- customary v6 network?

 I think -- said it. And I think the answer was 56 bits. The old practice was more. It was 48 bits.

 So that everyone got quite a large number of addresses per customer. And we did some aspect in 2004, and found if we continued to do this, v6 would last for 50 -- and you think 15 years is okay. Well, no. We've been trying to get it up and running for 15 years.

 If we can -- this is madness. So it seems strange that even then -- and this is back in 2004 -- you have 128 bits of address. If every grain of sand was one address, the size of the earth -- what a lot of addresses. And yet we're going to get through them in 15 years.

 What's our aim in v6?

 How long is it meant to last?

 How long before we had to go through -- a pain of transition again. We thought maybe we'd like at least a century this time. Because v4 hasn't done very well in that respect. We'd like to buy more time.

 So we went and changed the rules a little bit. But oddly enough, even back in 2004, when we contemplated this change, we got the feedback -- the install base of v6 is too big, it's not going to change. All three of them.

 And gladly things have moved on.

 Then we started thinking about what the scale we're looking at it we're thinking about 100 years?

 You can be right, and you can be so wrong.

 Rene Decartes, late 18th century, philosopher. How fast have we get people to move, how fast did that rocket go in Apollo -- faster than a horse? Of course.

 So he was right. That's so wrong at the same time.

 How are we thinking?

 And then we started to think NATs -- maybe v6 is not a natural evolution, it's a clash.

 If you want an Internet that stays at the size we have now, maybe v6 isn't really necessary. But if you want an Internet that is a million times bigger, every device in my pocket, every light bulb, if you're thinking that vision -- industry, and by then, 2005, we started thinking about it in those terms. That the -- with larger addresses that really look way beyond today's problems. And the issue was good solutions in the future, make the present -- and that's where the debate was around then.

 I found this slide. I don't know if -- I looked at it for hours. Because it's fantastic.

 Anyway, some of the engineers in our community started to get a little savvy and started to understand the process of regulation and business. As well as engineers, we started looking at economics and public policy.

 And we started to think that maybe the reason why v6 wasn't happening was actually very deep inside the structure of this industry.

 That the neoterm pressures even then made v6 not an optimally -- I'm a teleco, a telephone company operator, I have a billion dollars to spend on new product. The mobile man says give me all your money, and I will turn it to 500 million dollars. The IP man says give me your million dollars, I'll build an IPv6 network and I'll return -- nothing. I'm going to spend it all.

 And the year after that, P.S., you'll thank me.

 Who wins?

 Well, obviously this wins every time.

 And the investments always got deferred. Because it was cheaper and easier and -- and we even got the customers to pay for it.

 Does your modem in your house, your DLS modem or cable modem, does it do NATs?

 Yes. Did you pay for it?

 Yes. Did the network pay for it?

 No. Brilliant. So all of those things said that the business drivers were actually frustrating 6. And we started to appreciate that and started to appreciate this was no longer technology.

 So we needed to think a little harder about why the long-term vision is really necessary. And we started to think about what's becoming quite fashionable now, the Internet of things.

 Silicon is just sand. And it's cheaper to -- attending one, because it's a volume industry. That's why these phones now cost $60 to manufacture.

 $60 of R&D, off the line. This is cheap to manufacture. This is an economy that lives on -- a million doesn't cut it.

 A billion is just getting there.

 So maybe we have to think about the economy of billions.

 Individual transactions don't matter. The billions of almost valueless transactions adds up to huge amount of -- and maybe that's where we should be thinking much so we started to think about v6 as a new market in a new world. In the same way that we revolutionized the industrial age, production and assembly processes, we start stopped building one offs and started to make a car every 10 seconds many maybe v6 is the same revolution.

 So getting right into this. I'd like to drop you into a few slides that actually did then and showed our thinking five years ago.

 Because exhaustion wasn't something in the future. We could predict it. We could predict it really well. And we knew when it was going to happen.

 And even in 2008 -- off by 7 day, it actually happened by the end of January. So the stats worked. New policies and panic. But we were kind of there.

 And in thinking about the fact that exhaustion could occur quickly, right, some were saying so what. You talked about exhaustion for ten years. I'm not interested.

 But others were saying, what do you really mean?

 What happens when we run out of addresses?

 There's no other plan. You've got to think of this in terms of v6.

 And because I was doing all these slides, I found a Russian train that had a jet engine on it. Which seems really cool until you think how did it go around corners?

 Because it could do great in straight lines, but I think that's all it did. And someone else saw that, they said no, Geoff, you're not thinking -- you need to think about nuclear trains. And he gave me this picture. But I digress.

 We had this plan and it was a very clever plan. We would never -- run -- because as the Internet grew green, as the -- the trunk blue, that v6 deployment line would rise. As soon as every device has dual stack, you don't need -- game over.

 And if we could have done that before we used the last v4 address, we were home. It would work.

 Even in 2008, people who thought we could do this and what we wanted to avoid -- after that.

 So if we wanted to avoid that, what did we need to do?

 Well, at the time we had one year. We had one year to do everything.

 It was a big network even then. It's a much bigger network now.

 And that is from the system of God talking to Adam, I believe and we thought the scale of the problem divined a broad plan. 1.7 million users, millions of routers. All that infrastructure within six months.

 Pigs needed to fly.

 Really. It was that bad.

 But this was -- industry. NTT employs more than three people. KR telecom employs -- they're big companies and they take a long time to change. Samsung doesn't invent new products in a day. Big and fast don't go together. So we weren't agile. We couldn't do that.

 We have to contemplate -- exist with NATs for sometime. Will you the issue is how long?

 Professor Lee this morning said v4 forever. I'm not sure forever is real. Not -- but it may take us a decade or two. That's the problem.

 And real -- the plan, it's just not looking very good. And at the time I was left with this existential question: If both of these options look really bad, what's going on?

 Why are we here?

 I didn't know.

 Neither did you. The slide was empty.

 I've moved on, and so did economics. And we started to think that maybe the answer was in economics. And started to get the -- answers. As soon as you think about that, you start to think about the economics of climate change.

 The problems -- can I do something to change it?

 Well, no. Can awful us together do something to change it?

 Yes.

 Orchestrate everybody. When short-term interests and long-term interests differ. Same with v4 and v6.

 Long interests are all about 6. But the short term impetus is all about using NATs and getting the job done. So maybe it's a -- industry as a deregulated industry and system isn't enough. Maybe we needed a kick in the pants. Maybe we need the involvement of politics -- all of this debate happened without measurement. We -- so the other thing we started to do in 2012 was count. And count like crazy.

 Found was remarkable. Half of the Internet service providers in 2012 do v6. And the other half had plans. That was easy. And interestingly, almost every single device, and almost every single thing in this room that you're playing with right now does v6. The only ones that don't are running Windows XP. So oddly enough, every single device has dual stack. That's in the -- but only half a percent of the Internet at the time was using 6.

 And the problem was in the last mile access networks, whether they were wired or wireless.

 That was a year ago. And that brings us to the present.

 That's in China, building new apartment blocks like they're going out of style. Cookie cutter style.

 A year ago we had the world -- v6 and change. And we were told it was time to get move being. To reach out and actually start doing this.

 I think it's useful one year later to ask a few questions about who's doing it and where are they?

 Did it work?

 In APNIC, we're keenly interested in this question. Why?

 You can't have a meaningful debate about this project without understanding the environment you live in. Without understanding what is actually going on. But there's this question that we've all found really difficult: How do you measure millions of people? And do so every single day?

 One option is to Google. Because almost the entire planet visits Google sooner or later every day. Your servers, you'd know a lot. But Google would tell me nothing and they'll tell you nothing. Because that's Google. It's -- there's a second option.

 I can use Google. Everybody watches You Tube.

 Everybody watches You Tube.

 And You Tube has -- everybody watches You Tube, even folk in China and You Tube has ads on the Internet. Ads have a little tiny piece of code in them. You can get folk to run code. By simply having the right ad.

 So we pay attention. Really simple. This ad said to your browser, if you ever saw the ad, don't click, don't spend my money, just -- this machine causes those three things to happen.

 Your machine will try and gain -- invisible one by one pixel. You'll never even see it. And the first one only works if you have v4. Sounds interesting. I'm giving you a choice between v4 and v6. Which one will you prefer to use?

 And the last one only works if you have 6.

 How do I know if you're 6? The object you're trying to get comes from my server. I see you. I watch -- as 400,000 people every day continuously.

 So when we -- that often, what we saw in the past 12 months was kind of interesting. 12 months ago little under half a percent of the world did 6. Which for 2.2 billion users -- today we see 1.29 percent. Actually not today, it was in June.

 I heard a lot this morning about how Europe is leading the charge.

 So -- in percentage terms, that's not right.

 The area of the globe in percentage terms that has done an enormous amount of work in the last 12 months is Europe -- that's lifted its rate of v6 use from 1 percent to 2 and a half percent in 12 months.

 Asia, that purply line, has been relatively constant.

 So it's not everywhere. But let's look at Asia. And here I broke things down, East Asia, south, southeast, central. If you look at the United Nations statistics division, they divide up Asia this way. Again, one thing stands out. The group in Asia that's done work in the last 12 months, it's east Asia. So who is in east Asia?

 China, Hong Kong, Japan, Mongolia, Korea, and Taiwan. Yeah pan-rose from 2 percent of its users to a little under 5 percent. So whatever problems -- other providers have actually moved very much across that last 12 months.

 China is interesting. I think we need to talk about China.

 And Taiwan too. But certainly it's interesting that it's not every economy, it's some economies.

 And that happens every part of the world. Didn't -- once, some folk have been very active, some less so.

 So here's top 20s a year ago. And today.

 And let me make it a little clearer. There have been a few movements.

 April 2012, Romania switched on almost it could switch on. Mobile and wired. 7 percent of it's population are now recorded as v6. France, the competitive provider, free -- FR. 4 percent. Switzerland, Swisscom, just two -- Japan, 4 percent of its population. 4 million users.

 Look at the United States; it -- 72 percent of its population. That's on a par with Germany, to some extent of 2.2 million users as well.

 From -- way behind things is perhaps not quite accurate. They're moving and moving quickly. That was in June. So I can circle economies in Asia. Japan, Singapore, China Taiwan and Australia.

 Obviously it's a long way further down.

 You can color the world. Lot the of people color the world. -- is -- don't get many that ad impressions coming into Africa. It's a difficult one -- then up to who was doing hard work in the last 12 months.

 So who started low and finished high?

 Switzerland turned on 650,000 people. Japan turned on 2.3 million users. United States turned on 4.2 million users in 12 months. Germany turned on 2 million users in 12 months.

 Those three economies just hit -- so yes, it is happening in certain places, in certain ways.

 And that's the list. Again, from this area. Japan, Singapore, Taiwan. Population of 23 million turning on another 71,000 is not a big deal. Not.

 And New Zealand, I know -- not a big deal. Not. Do better. Do a lot better.

 We've -- can plot things too and we can look at the entire sort of period.

 Romania. United States.

 Moving very distinctly.

 China, we need to talk about China. Trajectory to the United States. Some things are happening. I can even tell you whom in the United States it is. Verizon wireless. It is service and Comcast.

 In Japan, it is KDDI, it is true blue telecom, it is soft bank.

 Those are the folk who are turning on v6 in Japan right now. And similarly in the other countries, Taiwan, it's the academics, the students, the universities that we all use many and so on. In Singapore we think it's star hub and mobile 1. There's an interesting one there. Peru. Peru doesn't figure in the top 20 in the list. Someone told me they were big in volleyball. But they're big in v6 too. And I think they deserve an accolade. Well done, Peru.

 That wasn't until June, and then I looked again a couple weeks ago. I looked at that United States number, and I was trying to go, what's going on?

 Because just in the last few weeks it's getting -- AT&T inexorably rolling out. Dominant service provider. Just -- in Philadelphia and headquarters Nationwide, cable TV, own the routers, Docksys 3 modems. They control them.

 Nationwide programme of turning on every single consumer. All those devices that were out there waiting for a v6 address behind a Comcast modem, as they get it, they turn on. So the lift in Comcast is almost vertical.

 So U.S., is it not an example?

 It's actually working quite well. Germany. Deutsche telecom and the cable provider back in January decided it was time to move. They did. Same with Japan.

 Singapore made a decision in April. And Australia -- I put that there -- I'm not very happy about Australia. And they shouldn't be happy about it either. They've done nothing.

 Whatever's been going on, I think it's been largely by accident.

 Buzz the only country where I cannot see movement, nothing, South Korea here, nothing. There's just no movement here. There's no massive -- on either side, Japan -- and we're about to talk about China -- movement. But in Korea at this point, nothing.

 China, wow. I sit outside China, and there are folk watching You Tube inside China, and there is a bit -- the problem is that there's a firewall in between. And it requires a bit of effort to see You Tube much because it's not something that just happens.

 So a lot of folk bring up various fors of virtual private networks. And they have varying degrees of v6 capability. That's the first issue. The second issue, as you've already heard, is that the major area where there is massive v6 deployment is inside university campuses. And I tend to see that in the students are in -- there's a lot of 6. And when the students are at home, there's a lot less.

 Things move week by week. So part of the ups and downs of China might well be that the academic and research environment is a strong uptick, but students go home, and they do. And the other heart of this is looking at China from the outside to the inside through their various firewall mechanisms that are run nationally, distort my vision. I can't see it clearly.

 So the -- going on a bit. And maybe if the Chinese themselves ran the same experiment, inside China, they might see a dramatically different picture. But from the outside, I find it hard to see clearly.

 So the few -- that's a shopping mall. That's the roof. Go and see nothing else. Ancient war war stuff there. This is a loop hole that is as big of 20 of these classrooms and they project this on it. As a club, that's so cool.

 It's not everything. It's not everywhere. Not everyone has it.

 But it is happening. It is happening. So what we're seeing is that some providers all over the world, some of them have got the message and are doing quite intense amounts of v6 work. So when we talk to the industry -- the last year, and I think if I talk to Korea telecom today, I would find that it's consistent. We will move when everybody else moves.

 Because if you're too late, and you're the last network running v4, you're isolated. You turn off v4, before the last network turns on v6. Stragglers get lost.

 You've got to time your moves with everybody else.

 So that -- I'm going to go to a new product called to talk to everybody when everybody else goes to a new protocol to talk to everybody.

 As a business person running an ISP, national, local, whatever, I would give you that answer too.

 But the real question now is who are you waiting for?

 Because if you are waiting for Deutsche telecom, you're too late.

 If you're waiting for AT&T, too late. You're waiting for Comcast, or KDDI, or soft bank, you're too late. They've launched. That he ever inexorable, they're never going to stop.

 Who are you waiting for?

 I would suggest that after this long and rather torrid 15 years, the waiting game is close to over. Because if you're really waiting, a jump -- whether it's in wireless or wired, I think it's now time to break out of that mold. I think you've got current business plans that go, we need to start moving much.

 You're too late. We can't build a reasonably sized network using -- slightly larger than today's. We can last for a few years. But ultimately, that technology -- there's a limit to the port addresses you can use. There's a limit to the complexity and fragility of the NAT. There is a limit to application technology. There is no plan -- if you're waiting for our people to move, maybe you've waited enough.

 And maybe you've heard a v6 presentation. Because now when I ask you the same question, you can add one more to your list of presentations you've sat through. So thank you very much for your attention. And I'll hand the floor back to Kilnam.

(Applause)

(Off mic)

 >> KILNAM CHON: Comment?

 >> Geoff, I think this is wonderful message. But one question for -- and actually you point out already. As we know, the IPv6 is not -- lot -- actually doesn't work. So of the -- but with the current status of IPv6 is -- problems. How we adjust the reality, you know, for example like you mentioned about in China. Or actually as -- some of the IPv6 application, for example in Taiwan, they are only using for academic for the voice IP. And they don't appear to -- because it is only internally for the phone system in every school.

 So how -- (off mic) for example like you mentioned about China issues. And how we can adjust that so we can see more detail about the real movement of the IPv6. That's what I mean.

 >> GEOFF HUSTON: Right. What we were trying to do is see what we could do in measuring the entire world many and we weren't an ISP. We didn't control a network. We didn't run anything. So we didn't have access to NTT's data or in my case, Telestar's data. So we started to think how can we just simply measure users?

 Right?

 And that's when we clicked to think, I don't want to measure the domain name, I want to measure an individual theme much because for v6 all of that needs to work for a packet to go from you to me.

 So then we thought, to send me a packet for millions of viewers. What does everybody have in today's network?

 A browser much that's the first clue. And the second thing which sort of hit us really hard was you know, the code coming from the website. They run other people's code. You don't even know it's doing -- couldn't plant that code on your system.

 So that's what we did. And we started to use the advertising net -- and browsers because it is cheap and it is astonishingly cheap. I'm not sure Paul even knows the bill that we paid. It is very, very cheap. And very effective. We get 300,000 UP -- a day. Could I measure other things not using that technique?

 I connect with browsers. And if you really want measurements on other things, you have to go back to a well-used area in most public regulatory regimes that say ahoy licensed carriers, we want the statistics coming in -- and most countries do get statistics from their carriers, and maybe they should consider asking those same folk for their numbers about v6. The best I can do is look from the outside. I can't see exactly what's happening.

 >> Anybody want to make any comment? Or the -- also speakers. Would you like -- after hearing those others, would you like to make a further comment?

 >> KILNAM CHON: Can you come close to the microphone?

 >> What was the actual cost?

 >> GEOFF HUSTON: We get to around $50 a day to get -- we end up spending a few hundred dollars a week and we get effectively millions of points a week. We measure all the way down to the Pharaoh islands, measure extensively in almost every single economy and every single network service provider.

 We -- into corporate networks because everybody watches You Tube much we measure inside schools and universities, we see a huge range of the Internet. And because our ad is really boring, nobody -- as long as nobody clicks, it's free.

 So yeah, it is a very effective way of actually looking at the entire Internet one by one by one for years. And for v6 I think this has been informative -- we can get numbers as if we're -- (off mic) that aren't secret, that aren't proprietary. That everybody can look at.

 One thing I do think about this transition, everyone makes decisions on good data. Good data needs to be public data. And private data, you don't know. You can't tell.

 Like Samsung, like NTT, allows folk in China to actually understand, what's everybody else doing?

 Is it time? What's being done next?

 And that's certainly the reason why we're doing this.

 >> KILNAM CHON: Paul?

 >> I'm wondering if you could mention briefly the ability for websites to use the same code to measure their visitors.

 >> GEOFF HUSTON: You can help in two ways. It just isn't ads, as well we've actually got a small piece of -- you put up under your page. Invisible, as folk load up the page, this Java script runs and performs exactly the same test. And we'll happily share the results. Once we can tell you about the number of v6 visitors.

 The other way of doing this -- because we thought a lot of folk -- so we invented a little Google analytics plug-in. Instead of just running Google analytics, a few more lines of code and you can see directly in your own analytics for -- your site, who are capable of running v6.

 So if you're a magic content provider and you're really -- what would happen if I did? How many folk would use the other protocol?

 That tool will help you.

 So all of this is on labs dot app. APNIC.Net. Go to our website. And we'll all help you.

 >> KILNAM CHON: On the follow-up question, I'd like to ask the chair -- basically one -- they're asking for the name.

 As you measure -- as you now -- I think right now a lot of people access Internet or You Tube. Actually through their phone and you know, the panel. Is there notebook or PC?

 Is any distortion for your method?

 >> GEOFF HUSTON: There is a slight distortion. Apple some years ago decided they didn't like adobe's attitude. So iPhones don't run flash. Oddly enough they support Java script, they support almost everything else. They don't support flash. So in the ads I can't see iPhones. I can see mobile -- I can see android devices, Samsung devices. All those are easy. But iPhones are hard.

 So what we needed -- an ad network that runs Java script. And it's the iPhones much we found one and we're thinking of turning on a second ad stream and see if we can't look at iPhones to get that missing part of the market. However, iPhones are only 12 percent of the market, of the mobile market. So I'm not missing out on a lot.

 So more power to android.

 >> IPhone have more market share in the U.S., though. This is the first question.

 The second question is the same -- almost -- the panel, for example, the iPad. You know, as you know, the iPad, the -- problems.

 >> GEOFF HUSTON: Again, as I said in the grand scheme of things thee are relatively minor issues. We're trying to use Java script to get at those devices, because it's exactly the same -- do we miss out a lot?

 I don't think we do. As I said, I'm seeing Verizon, which is -- (public address announcement).

 >> Next door on iPhone.

 >> GEOFF HUSTON: I'm seeing Verizon, which is one of the major mobile producers in the U.S., they're reaching out to all the other devices, and that's giving us a good indication. As I said, we're working on -- Apple by contact with them as well.

 >> KILNAM CHON: Anybody?

 First -- China, on -- from million to the billion. Invitation. You showed the -- you focus on the education community. Which could come up with a billion.

 My question come this way: 20 percent for the IPv6 is very impressive. Probably one of the first group, which passed the tipping point, which normally is 20 percent. It reached. So the -- from now to -- education community in China just a year ago, year and a half ago.

 Okay. Then my question is do you have any good insight when did this 20 percent -- become a bigger than IPv4?

 This is my first question.

 Second question, one way to reach a billion is a country -- China, you have a billion people. Not just in education community. The rest of China. Probably you make -- if I'm the -- the right -- in China, I guess I would propose, okay, let's have a major move. IPv6. As a default.

 For the -- China as a nation. Because use -- you could do it, technically, by now.

 Then how does it -- why China is not thinking that way.

 Because if you do the analysis, you get so much by moving to IPv6 as a country. But it's not happening. So it --

 >> XING LI: Okay. I will answer the question one by one, the Internet, academic, traffic exceed like 30 percent. And that we're seeing. However, it's not -- naturally the case. Because current policies, IPv6 is free and IPv4, you need to pay. If -- you say we're back to before. That's for sure.

 Yeah, if they can all provide it -- that's the second. And actually, the Chinese comment has a plan. By the year 2015, three big ISPs promise to each provide more than 3 million fresh IPv6. So in total it's about 10 million. And of -- end of 2015.

 So those three ISPs are moving in. But in reality, or frankly speaking, they are really struggling. Because there's not enough fun funding from the government. So they need to put their money on that.

 So it seems their final decision is net 44 plus IPv6. That's the majority of that.

 Now, really -- the home gateway costs a lot. They need to replace the home gateways. Again, that's the economic decision.

 So it's not easy.

 Also, you mention China as a whole. Probably maybe government can have some kind of author to ask everybody move to IPv6. As the -- before routing particle. But in reality, it's again, really hard. Because China -- from planning commission to market-driven economy. So ICPs, they are open stack companies. They do -- they cannot do that.

 Put -- no pay-backs. And the three ISPs, also they're public companies. They cannot do that. It's economics again.

 Also, the long tail fact -- okay, the government asks top 1,000 ICPs provide IPv6 services to -- also at the end of the 2015, however, the total number of ICPs is much more than that. So the long tails. And there is no way to use IPv6 only without translation. Yeah, right. So that's the story.

 >> KILNAM CHON: Yeah. Get a speaker, microphone. You can move to the microphone. For future.

 >> The question to -- and comment. So if this -- want today achieve 3 million users by 2015 and 20 million users by -- I forgot what year. But if they couldn't achieve these goals, what government -- would they do something?

 Or what would happen?

 >> KILNAM CHON: Okay, I believe they can have the dual stack service. But the ISP be --

 >> GEOFF HUSTON: I think -- are investable. The v6 only network and expect to talk to the world. That's not an option. The issue really comes -- I look at this network here. There is no v6. What's the v4 address?

 Well, it's 2.2.7.

 Wow. 2. That's -- network. That belongs to want-to-do France. France telecom. Orange. That has no reason to be here. It's the wrong address.

 How much chaos do you want in your v4 network?

(Chuckling)

 >> GEOFF HUSTON: How much crap do you want?

 If there's one group -- right now, it's our good friends in France, beyond France telecom orange, because I'm using their address. That doesn't work anymore.

 So part of this thing is you can't sit in the space we're in now forever. And it doesn't really... to some extent where the government sets objectives or not. It's a fine thing for the government to do, I noticed Thailand did it as well. But largely this is a deregulated industry -- individual players need to make -- and they make investment decisions. I'm merely suggesting now that part of the reason the decisions are made is based around understanding of the rest of the Internet.

 Understanding the -- in which they're working. And what's pretty obvious in the last 12 months is a number of very major players in the more developed markets have jumped. Why?

 What's led them to that decision?

 If you're sad -- you can probably translate it back into your own context. When should I invest?

 Why should I invest?

 The last thing you want to be is the last v4 network. Because that's when no one's going to talk to you. Those are the sort of decision frameworks that are going through. And I can quite understand China -- essentially saying this is a problem, how can we communicate that to the players, the actors?

 Maybe if we set objectives, it might communicate the fact that -- ignore this problem; you need to think about it and need to understand when and how you should be investing. And that's a reasonable thing to do.

 >> KILNAM CHON: Kwo Wei-Wu and --

 >> Yeah. Actually, I agree what she's saying, if you're governing -- really the recent practice, you know, is -- whatever they want to make a decision or make a strategy or make -- need to go back to the realities issues. You know. Industry. I think we cannot just push the -- without a major data or something like that.

 Don't forget whatever you do, no matter how much v6 you're going to push that, from government side or from the ISP side, it cost. Cost.

 In the first five year you told them this is the near future. They might be buying. And you keep telling them another year. And thinking about it, how long are we talking about IPv6, it's coming and coming and coming?

 Sooner or later to be honest -- we don't have a solid data to tell our government, to tell the -- teleco the -- I think the -- the solid measurement is a very first step, you know. And as a professional, I think we need to be very real -- realistic and provide the data to the government to teleco operation and tell them how much they need to do, how fast they need to do it.

 Not just bullshit. Because sooner or later you have to go -- nobody believe you anymore. So be careful. And actually in the next session we are going to talk about IPv second national strategy. We're thinking about that. Think about how many IPV assignment we run. In how many years?

 Ten years?

 And we told the people, say for -- it's dead. And -- and if you are listened to the guy five or seven years ago, I think then we're really thinking -- that man lost a lot of money in investment.

 So I think to be a professional, we need to be very -- the decision making is not cheap.

 It costs.

 >> PAUL WILSON: Yeah, it's ball again from -- bigger things at the moment that Geoff is revealing in his figures, not universally across every country but in aggregate, there is growth that's looking rapid. And I think again we heard that NTT has gone from point 8 percent, 2 percent over a period of 6 months. That's a -- that's a very, very rapid -- at this point from -- in terms of your percentage and if that were to continue, you'd have a very quick transition from the -- not just single cases, it's a lot of single cases and also the aggregate data.

 And I think it's worth -- I'm thinking about why that might be happening now because as Kwo says, we've been talking about this for a very long time and maybe just seeing a glitch or some temporary situation.

 I don't think we are, because things have -- several things have definitely changed in the last few years. I think there's -- there are some delayed effects involved I think we also should understand and may come as a surprise. Might before a -- in the Asia Pacific first. And what we're seeing is a steady increase in the awareness amongst APNIC membership and emerging need for additional address space. Because you may understand that -- and I -- IPv4 distribution system would come back to APNIC periodically to receive more address space.

 The day that we start allocating the normal allocations, it did not represent the end of IPv4 for every ISP. Every ISP has gotten some period of time, a window for them to use up the existing pool of v4 and then run out. If and if we assume that they're doing that more carefully now because of the exhaustion factor, then we can see they're actually going to use v4 space and making it last longer. In order to find that -- transition in right. And of course APNIC is only part of the picture. The ripe NCC has -- recently. I would expect the address space demand to only start climbing slowly over the coming years. Aaron has not yet exhausted. But I think according to Geoff's figures -- do you have the dates, Geoff?

 >> GEOFF HUSTON: November 29th --

 >> PAUL WILSON: Aaron has some exhausted earlier than that. Will be a smaller factor. I think we're actually seeing lower reaction over the coming years of the exhaustion of IPv4. But the reaction is definitely there. And I think -- seeing.

 The other thing that I think will be a technology change that we need to look at -- and I'm sure that the mobile providers are definitely responding in advance of this one, and that's the fact that 4 G networks really do have the capability to take over last mile services. So no longer will we be sitting on a mobile phone with a single address but increasingly using mobile wireless access points which themselves are NAT. After that -- what that means is that you deliver a public address to that mobile access point so it can do one layer of NAT, or you deliver a private address and it has to do two layers.

 If anyone has experienced a sort of consumer experience of double NAT, in general Internet use, it's really not a pleasant experience at all.

 I was the -- I happened to be the victim of what I think was a consumer test by my own ISP who one day decided to deliver me a private address and after two weeks of extremely poor performance on my own system, absolutely noticeable performance in a home network where you would receive time-outs, which side -- receive connection we sets, you'd receive partial answers and partial website loads and so on. I called my ISP and said what are you doing?

 You've provided me a private address. I was by the way -- and they said, no, you've got a private address, you've always had one. And I said no, I haven't. And the conversation ended after an argument. But a couple of days later the public address was -- my usual level of average Internet connectivity. What I think goes on there is an ISP is trying out a new mode of service provision that is -- addresses a customer and see how much customer support problem they have. Which is a very wise way to do that sort of -- to undertake that sort of -- that test.

 You run -- something new on your customers without being able to predict the response. And I think the response at least in my case, if not for the entire customer group that was subject to the test, was not a good one. So the public addresses came back.

 But my point is that if you try and deploy a mobile access point as an NAT, over an LTE connection, which is absolutely feasible given the bandwidth that's achievable with LTE, you definitely want a public address to be delivered to that device. And that's where the -- the mobile service providers really have got to think about where they're going much because they know that that's not going to be possible.

 And if they start -- there is a proliferation of mobile hot spots, whether it's with your phone or with cheap little devices that anyone can buy these days. They must see that happening much and if they find customers having a bad experience, it will damage the name of the service provider or damage the name of LTE, it will really cause problems. And I'm sure as I said, they're aware of that. There are two reasons there why I think both the addressing environment and the technology changes may be driving the changes we're seeing.

 And as the -- with Kwo's point about being accurate and not -- not telling the world that the sky is falling, over the last ten years, particularly the IPv6 forum with the kind of presentation materials that Geoff showed before really was over -- the need for IPv6 to be deployed immediately and urgently. There were stories about IPv4 address space running out around 2002, or 2005. Or 2009. It was always -- ahead in the future. And we were anxious to tell these guys that that was not happening. This is -- is not accurate. And it's going to damage the case.

 And I think it has damaged the case. It's like people thinking I have been hearing about IPv6 for so long now and I still don't need it. I still don't need to move. I'll just keep doing what I'm doing. And I really think that's changing now. And somehow we need time to spread that message. Both that it is needed and it is also actually feasible and possible.

 Thanks.

 >> KILNAM CHON: Thank you. Let me change -- people last ten minutes.

 Why I prepared this one, I couldn't come up with a good speaker on -- so I want to spend the next ten minutes so that I give each speaker like a one-minute -- because each one of them have -- one, okay, give a background. Today we have 2.5 billion Internet users. Around the year 2020, we will have 6 billion Internet port, coefficient users. 5 billion human users, and device, machine.

 And looking into 20 -- 10 years beyond, not -- human being is about -- we have only 7 billion. But a machine, we are heading toward the trillion. Is -- machine to machine communication, Internet, is this -- of the IPv6?

 What do we do on this area?

 So with that introduction, Samsung, you have a -- page on IPv6. I guess you are working -- would you like to make a comment?

 A comment on that. And one minute each. Then we have one more minute.

 >> BYONG-JUN LEE: I think in IT case, as with the IPv6 case, NAT solution was introduced. Some devices or things, we will be using.

 They may not need IPv6 address in the middle.

 But eventually, to support mobility, to support direct connection to each -- like things.

 So I -- I see -- I feel this issue back in ten -- NAT was introduced and the longevity of IPv4. So I see -- see, I expect a similar type of issue in terms of ISP much my perm view.

 >> KILNAM CHON: Okay. Professor.

 >> XING LI: Actually, my answer is mixed. In theory, again. IOT is a killer application of IPv6. So that very need -- another ten years, still like IPv6, like single digits. And probably I would see people use other protocols rather than IPv6.

 >> KILNAM CHON: Okay. Mr. --

 >> I think IOT is at strong candidate for the application. The important point is these things do not -- this would be wireless. So the wireless and the -- other things, you -- using the Sim card LP, or Wi-Fi or something much that's the point. Permanently.

 >> KILNAM CHON: How about -- you are from Japan. How is Toyota. Automobile is huge. Are they using IPv6, or what's their plan? If you know.

 >> XING LI: Sorry, I don't know about it. On the -- connecting the car to the Internet is using -- LT. It's not our field. Sorry.

 >> KILNAM CHON: Does anybody know?

 Typical -- you know that?

 >> ICHIRO MIZUKOSHI: I saw the news on the website just before that Audi has pronounced the Internet access point in the car. So -- yeah. It would be connected to the Internet through the access point in the car. I have.

 I'm not sure it could be -- before with something. Yeah?

 >> KILNAM CHON: Geoff, would you like to comment?

 >> GEOFF HUSTON: The comment about using the Mack address is a big issue with this. Why have those addresses been used in preference to everything else?

 The answer is easy. It comes from the manufacturer. There is no installation. You just take a device and plug it in much because it has a unique Mack address, you plug it in. Done. V6 needs to be at that level for it to be used in the same area. It needs to be unique at the point of manufacture. The issue with v6 versus Macs is all about routing. I can't place an arbitrary device in an arbitrary location with a six address and expect routing to work.

 Whereas a Mac address -- it doesn't communicate.

 What's your vision of the Internet of things?

 Is it just your car and nothing else?

 Which case a Mac address. And go use a deck net address as well for all that matter, because can't leave the car. If your vision of that Internet actually has this device communicating in a broader realm, Mac addresses won't cut it, because you can't route them at the scale they -- this tension is sitting in terms of this vision of the Internet of things. Do you want to be able to communicate with your theme across to the manufacturer? Across to other realms?

 Across to the energy controller in your house?

 Or do you just wish the washing machine would talk inside -- you know. And that's why the Mac address model I think doesn't quite get big enough in vision. You can do it that way, and it's simple, but it doesn't reach far enough into what we could do.

 And extending our imaginations into what these devices could do, how far they could reach, that point I would say you can't do that unless you use a routerable protocol with zillions of addresses. And the only routable protocol with zillions of addresses is that one. That's the only one we for that kind of vision. That was my pitch as to why I think these things kind of work.

 >> KILNAM CHON: I agree with you. And that -- deployment, I think there should be an intermediate gateway to be able to route, you know, from end to end. That's why I mentioned IPv4.

 Would you like to -- want to mention?

 Why not.

 >> PAUL WILSON: The IOT to me is a buzzword that means what we're doing already. That moment.

 Home network we mentioned before. At last count it had 20 devices on it. It included the portable phones. My kids, they're a couple -- that happens to be on the net these days, which is a common thing. Music. As -- nothing -- I'm not an older techie. It seems normal to me. And that's the way things are running. And that's the way we expect them to keep continuing.

 Things all over that will be connected.

 So I think the -- this is just what the Internet is about. The -- it's what the vision of the Internet has been for a very long time.

 The Internet is a useful term. But I think it is just the Internet.

 So the killer application that I've named most often as the real killer application for IPv6 is the -- that's it. You just -- you will stop having the Internet in a short number of days -- alternative. The Internet in 20 years time without IPv6 will still be called the Internet, but it -- will not be what it could have been, even what we enjoy today.

 So that's what the Internet of things means to me. Nothing special, business as usual. But we've come to the point where business as usual requires IPv6.

 And I'm not saying that anyone requires -- must do it now. That's a message of urgency that's unnecessary because obviously we happen to be running the Internet here and now with the current deployment of IPv6. But it is really -- it is really happening quickly many and anyone who has a dependency on the Internet -- should understand where they're going to get IPv6 from in future. In proportion, again, with their use. And in accord with their use of the Internet.

 It's a bit of whole range of service providers. You receive hosting services, connectivity services, upstream services. You've got hardware, you've got software, you've got all of these things delivering something to you. Some ICT to you. And ICT implies the Internet.

 And every one of those, through the -- what they can do about the Internet, where is the Internet in their provision of Internet services to you?

 And of course as a home user, that's not an urgent question or anyone you will probably be fairly well looked after. But as a major enterprise or Internet services organisation, it's an urgent question to have a plan because it is about our future survival.

 Not really an answer about IOT, Gil, but a general closing.

 >> KILNAM CHON: Closing remark. Anybody want to make any comment before we close?

 Okay.

 >> We have in the Internet almost every days. And if IPv6 is -- I think we need to wake a long, long time.

 Second of all, I think actually (Kwo) people want to do the monitoring, but IPv6 is just one of the alternatives, not only solutions.

 So I think we have to be careful that -- need to depend on IPv6. Have some advantage, but not necessarily only solution for that.

 >> KILNAM CHON: Thank you.

 I hope this will help, this will help to move to the IPv6, move to the millions, to the billion.

 All right. Let's give a big hand to all the speakers.

(Applause)

 >> KILNAM CHON: And thank you for attending this 3-hour session. Thank you very much.

(Applause)

-END-