UNITED STATES OF AMERICA

FEDERAL COMMUNICATIONS COMMISSION

NATIONAL BROADBAND PLAN WORKSHOP

FUTURE FIBER ARCHITECTURES AND LOCAL DEPLOYMENT CHOICES

Washington, D.C.

Thursday, November 19, 2009

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P R O C E E D I N G S

MR. ISENBERG: We have our first speaker on the phone. Ladies and gentlemen, welcome to the FCC National Broadband Plan Workshop on Future Fiber Technology and Local Deployment Choices.

I'm David Isenberg. I'm an old hand here at the FCC. I've been here about six weeks. I hope I do things according to protocol. Please punish me appropriately -- oh, that -- never mind.

I wish to thank everyone who's been affiliated with the National Broadband Plan and specifically with this workshop. I'd like to start by thanking Stagg Newmann, who's been my mentor in the ways of the FCC. Stagg, thank you very much. Yes, please.

MR. NEWMANN: Just remember your protocol has got to be open.

MR. ISENBERG: Open, indeed. This is the new FCC here -- open protocols.

I'd like to thank Julie Knapp and Walter Johnston and Tom Koutsky for serving as FCC Co-Panelists with our distinguished outside panel.

I'd like to thank the FCC Event Production staff. Krista Witanowsky has pulled this physical facility together. Thank you, Krista.

And to our FCC volunteers -- Whitey Thayer on the timer; Jonathan on -- Jonathan, please stand up. This is also important. Jonathan has cards. If you have a question -- better, pass out the cards, please. If you have a question for any of the speakers, the way the protocol works is write it down on one of these business cards or index cards, and give them -- wave it, and Jonathan will pick it up and come up to me, and I'll chose the most important questions, of course, and ask them on your behalf.

You can sign them or keep them anonymous -- your choice. If you wish to be named, I'll name you as the originator of the question.

Similarly for those of you out in Internet land, who are online, if you have a question, there are ways to Tweet the question and e-mail the question. The instructions should be online. I'm sorry. Remind me your name, please. Ellen here will be moderating the online discussion and transmitting questions to me.

So thanks to all of our moderators. And I'm sorry. You're -- tell me your name.

MS. PAYTON: Jeree.

MR. ISENBERG: Jeree?

MS. PAYTON: Yes.

MR. ISENBERG: Jeree is in the back, and she's loading up the viewgraphs for the -- as each speaker comes up to present, and she'll also be changing the slides when our one off-site participant, John Cioffi, speaks.

So I'd like to once again thank all of my colleagues on the National Broadband Plan, most of whom are busy upstairs with blood coming out of their fingernails as they write the plan right now. This is day 90 of the Plan, and we're all busily working.

I'd like to thank especially Blair Levin, who is the -- our fearless leader on the Plan. Blair has the vision to know what the

Internet can become, and the wisdom and Washington, D.C. experience to know what's possible, and he's walking this fine line and doing an excellent job of it. And I'm sure that the final plan will incorporate both the vision and the practical steps that we can take.

I'd like to thank our outside panelists, some of whom came -- three of whom came over from Europe for the specific purpose of being here at this workshop today. So I'd like to thank especially Johan, who's on this panel. Benoit Felton, wave -- at least put your hand up. Benoit came over from Paris to give us the word on global fiber services, and Herman Vagtair, who is back there, who will be on the second panel, also who is the Managing Director of CITINET Amsterdam.

So today's agenda -- the workshop might be subtitled, "The Future is Here: It's not Evenly Distributed Yet." It's sort of the leading edge of the National Broadband effort. It's the stuff that's too small on a spreadsheet, but too advanced to ignore. The main theme and this isn't a mystery, so I'll tell you what the -- what you're going to take away at the end of the day: That fiber is getting longer and the other media -- copper, co-ax, and radio -- are getting shorter; that fiber and the other media are getting better, faster, and cheaper; that open and simple win -- and you'll see that in the second panel on services especially.

And finally, while I thank each speaker, I point out to the audience here in the room and online that each speaker has a specific role. I've asked him to cover a specific limited set of material in their few minutes and that I've explicitly asked them to not do product pitches, not represent their organization so much as represent -- help us on the Broadplan Plan figure out the future to the benefit of all United States citizens and indeed all people of the world.

So with that, I want to just mention one thing: We have two David Reeds in the audience -- oh, on the panel. And they're sitting right next to each other. And indeed, I think this is the first time that the two David Reeds in our field have sat next to each other on the same panel; is that correct?

MR. PATRICK REED: That's correct.

MR. ISENBERG: Okay. So while that's remarkable, one might ask, and I say this a little tongue in cheek, one might ask are two David Reeds enough? Okay. In the marketplace of ideas, are -- when David Reed from CableLabs contends with David Reed from MIT, will one be able to discipline the other and spur them on to new, greater thinking or will they be sitting next to each other going nudge, nudge, wink, wink -- what you say is what I say and I agree, and you agree.

And so to that end, we at the FCC, have a secret weapon upstairs in the office right next to mine, there's a David Reed. Okay. He is our public option. He will discipline the market where the other two that where the Reed duopoly fails.

So with that little attempt at levity, I turn the panel over to our first speaker, who is a remote participant, and that's John Cioffi from ASSIA, and, John, are you online?

MR. CIOFFI: Yes, I am. Thank you, David.

MR. ISENBERG: Okay. Let's see if we can get your slides up.

MR. CIOFFI: Okay.

MR. ISENBERG: Okay. There's your introductory slide. John, you've got seven minutes. Take it away.

MR. CIOFFI: Okay. Well, thank you very much. Thank you for the opportunity. I'm sorry to all the participants that I wasn't able to attend in person, but happy that I could at least participate by phone today in your workshop.

And what I'll be talking about is really the copper alternative to broadband, specifically twisted pairs or DSL area and its future. In particular, the area is growing rapidly, as we'll see, through the techniques that are generally characterized as dynamic spectrum management, the title of my talk here; and there is very much a path through hundreds of megabit and gigabit per second DSLs that we'll try to outline for you here today in the next few minutes.

The second slide, if you could put it up, slide two -- and it's a bit animated, so you may have to put everything up since we're operating over a phone link here -- but you can see a graph there. This is from point topic. It's through the most recent quarter collected on the growth in broadband subscribers. Now this is worldwide, and you see the upper blue curve there is the DSL curve touching 300 million customers worldwide. A couple things of note there: The green curve is a cable modem curve, and the brown curve, the lower curve is the fiber to the anything curve. About half of those are actually DSLs. Point Topic chose to present the data that way.

So a couple of things, the DSL area is much larger, and it's also -- even though it's larger, it's growing faster as well. The slope of the line is pretty constant in going up at a faster pace than the other broadband alternative.

So this is really the broadband mechanism of choice around the world today, and the key reason for that is it costs a lot less to have a DSL connection than it does with, for instance, fiber connections.

So that is 70 percent of broadband and growing. So moving onto the next page, your question there at the top, you can see it on page three, is how fast is copper, and the answer, you know, this is an important question because if DSL is dominating in such a way and it is cheaper, you know, how fast can it go? Can it satisfy the need?

And to just give you kind of a background on this, the copper itself is pretty fast. A ten gigabit Ethernet is available today. Ten gigabits per second on essentially four twisted pairs of links, exceeding 100 meters. So that's about two and half gigabits per second per twisted. So there's evidence there that obviously this is a very high bandwidth. Bandwidth decreases with the length of the twisted pair, but there have been demonstrations of hundreds of megabit per second DSLs by various companies the last year or so. In fact, a kilometer, or 3,000 feet roughly of twisted pair will easily handle over 100 megabits per second bandwidth if there is no noise. And that's typically the case in Ethernet where there are less impairments than you would see in DSL, which, of course, is in the outside world plant subject to far more severe conditions than is a typical Ethernet twisted pair.

But it's not the copper itself that has an unusual bandwidth limitation. It's all the other impairments, namely, the noise that the copper is subject to for broadband connections.

So that's what DSM tries to address is getting rid of those other impairments or addressing them or mitigating them and thereby enabling these 100 megabit to gigabit per second like speeds. And that does involve quite a bit of signal processing.

Moving on to the fourth slide, the technical challenges in DSL. As I said earlier, to get the full slide up there, it's noise and interference, and there are many sources of noise to a DSL connection. There are in- home appliances of all types; almost anything electronic can generate noise, and it can get in the phone lines. AM radio stations, amateur radio operators impinge on the telephone lines, and they are very easily picked up.

There's crosstalk between the different connections, and that serves as a source of noise; and then as well people touching the lines are getting bad connections and such. Most of these effects tend to be closer to the customer's premises than the other side, closer to the telephone company. So many of the noise source is out near the customer.

And furthermore, those change day to day. Things go on and off. New services may occur in the cable. The environment changes. And so it creates a dynamic environment for DSL, and so really the response needs to be dynamic also, and to date, DSL connections around the world have been largely static in terms of their response. They have had no management at all, but the area of dynamic spectrum management just over the last year or two has begun to come into use, and it actually addresses these noises; tries to optimize each line to handle the daily changes in (inaudible), and so it can make a nice improvement in terms of data rates that are achievable.

Moving on to slide five are a couple of basic DSM functions -- a loop on the right and a loop on the left that you can see. The one o one on the right is basically a diagnostic loop. A DSM system is a management system. It sits back in the network. It monitors the DSL connections every day; collects data 24 hours a day from them; and will look and see what will be the problem on an individual line. Is it a certain type of noise? Is it a certain type of impairment? A bad connection?

And it will help the customer care

people actually repair or remove that particular problem from that line and thus obviously get a higher data rate once it's removed. But even more importantly is the automatic part, on the left-hand side, the dynamic part, if you will, where every DSL is monitored all day long, and many of them can be fixed automatically by changing the default settings in the equipment. And this is really the new feature of DSM that takes it from static to dynamic. Those default settings are being changed as a function of the quality of service observed; the number of times the customer's line may have gone up or down instantaneously; the number of packet errors that are made and so forth.

And that changes from line to line. It's different on each line, and said the automatic part is very important. Now what this does is it allows the service provider to remove a lot of problems before the customers complain. That means their cost goes down to operate the network.

If their cost goes down, they can be more aggressive in terms of the data rates that they try to achieve, and so they get much higher data rates than they could previously with using one of these automatic management systems, namely a DSM system.

So moving on to slide six, DSM has been standardizing the United States and the U.K. and is now just emerging from the International Telecommunications Union, the so-called G Vector standard, just consented a few months ago. And what this graph does is it gives you an idea of the speeds versus time. And there are actually three standardized levels of dynamic spectrum management technology.

Level one is already in service on tens of millions of customers around the world. I'll show you some results from that in a moment. But the level two takes speeds up faster. Level three is the highest level. These are so-called vectored DSL. In the most recent standards that are emerging, those are expected to hit the market in a few years as the chips and equipment become available and conform to that standard. And they very much do get over a hundred megabits per second on connections in the half a kilometer to more than a kilometer range.

So if a telephone company can afford to put fiber close enough, it's cheaper than putting it to everyone's home; then they can indeed get 100 megabit per second type speeds with these standardized DSM technologies.

On slide seven, here some results. This is actually from a European network that's already using dynamic spectrum management. On the left-hand side, you can see before results; on the right-hand side, after results. And the pie-chart there is representing the percentage of customers in that particular network, and basically shades of blue are good here. And brown and orange are bad. They mean that the -- the bad means that the customer is retraining several times a day. That's a 30-second outage and that their packet error rates are very high. And you can see with this automatic management, something like 40 percent of the customers were at risk earlier in causing problems and less than 10 percent are after the dynamic spectrum management is used. That allows him to get more aggressive, and you can see the results on the right-hand side where the data rate distribution is dramatically changed. The number of customers in the video range from 10 megabits per second and above is roughly now 55, 60 percent of that network. It was a very tiny fraction, only about five percent, prior to the use of this technology -- so both stability and, therefore, better data rates.

Now today, there are about 17 million lives under management with DSM Level One in the United States, and that will rapidly grow here over the next year. And there's about six million systems in Europe, and that's growing even faster, and (inaudible) just beginning to see the use of that.

So that's Level One. And then, as you saw in a previous graph, Level Two, Level Three --

higher-speed jet as equipment becomes available that supports that today. All of the equipment that's in the field today for DSL will support Level One management.

So then moving on to slide eight, this is Level Three. These are projections from one of the main participants. I got these from actually Econos, which is one of the -- actually, they're the largest supplier of DSL chips in the world, and these are what they expect to see from DSM Level 3 performance. You can see the 100 megabit line there for single twisted pair. They're projecting somewhat conservatively here in the range of 700 meters, and if you use bonding with vectoring, that means you use the two pairs that typically go to a home together for the service. They're projecting that out to a kilometer, so in terms of the range that you could get 100 megabit per second service with a hundred megabits, of course, being much faster than any other broadband technology today if it's done on a per customer basis, which is what this is.

And it's believed to be sufficient for the needs of most broadband users, at least for the next several years.

And then finally, slide nine, simply if you take this bonding to an extreme, many American homes have actually four twisted pairs in the drop segment. They don't have it all the way back to the central office, but they do have it near their home.

Originally, those pairs were placed there in case they were to order a second or third phone line. The phone company would come out and connect them on one of the pairs going back to the central office. But they can be used if you move fiber closer to the home, if you want to bomb those pairs together, you can even get a gigabit per second. Here, as you can see, symmetric gigabit per second at 500 meters using those four twisted pairs in a bonded unit.

So, indeed, that is a little better than ethernet does today, which is maybe about 170 meters for one gigabit per second service on four twisted pairs, but there's a much more sophisticated signal processing being used here with this dynamic spectrum management.

And so that can be pushed out a bit to the range of about 500 meters or so.

And then finally, the last slide, slide 10, the opportunity is here to pass a hundred megabit per second DSLs and beyond. Three steps have been outlined in standards. The first step is already starting to find its way into wide use. The second and third steps expected in the next few years.

DSL is a wire line growth vehicle for most telcos. While their POTS revenue is going down, the segment of fixed line revenue associated with DSL is going up, and particularly important is the wireless dependency on DSL with the new higher bandwidth i-Phones and Blackberries and applications proliferating in the wireless area, the bandwidth that's allocated for wireless is just not sufficient to handle that going forward in the future without smaller cells.

And as we go to smaller and smaller cells, you have to have a way to get to the middle of the cells, either WiFi or Femtocells and in particular the only way that you're going to get there is with DSL service to those cells on a widespread nature.

So the future of wireless very much depends on the broadband systems getting out to the middle of all these smaller cells and most of the major telecom service providers are very cognizant of that in their efforts to go forward.

And so, again, at the bottom of the slide, this is the future of the copper path to higher and higher speeds in the future, namely, this combination of signal processing and management techniques known as Dynamic Spectrum Management.

So thank you very much for the opportunity to speak here today.

MR. ISENBERG: Okay. Thank you, John. I was lenient in part because I know you couldn't see the timer and in part because I didn't have a mic to ask you to please sum up. I hope this doesn't set a precedent for other speakers.

I thank you very much, John, for spending the time and waking up early to be part of this. Will you be around for the Q&A?

MR. CIOFFI: Yes, I will.

MR. ISENBERG: Okay. Thanks so much. So I implore the other speakers who can see the clock to heed the clock. We now have David Reed from CableLabs, who will tell us about hybrid fiber co-ax and the future of DOCSIS.

MR. REED: Thank you, David. And thank you for the invitation to participate in this workshop. This is one funny anecdote with David. It's not only are we -- do have the same name. We have the same middle initial, so we often try -- David Reed being a common name, we tried to differentiate by saying David P. Reed, and it leads. We were just exchanging notes on some of the funny anecdotes, and I don't know if David will share his.

But one for me is I walked in one

morning and, you know, voice mails and e-mails out -- you know, going out -- and it turns out all of them are asking, "Why did you write that letter to the FCC Chairman?"

So, you know, it adds some spice to life. It turns out that David P. Reeds are very opinionated as well. I happen to have another David P. Reed in my hometown of Boulder, who likes to write letters to the editor.

And so, you know, people come up and "Why do you want to fire the superintendent of the schools?" You know, and things like that. So it adds spice to life.

I'm from CableLabs. For those of you who don't know, CableLabs is a -- founded in 1988. It's a non- profit. We have about 47 members of CableLabs. They are only cable operators that are members. They represent about 80 million cable subscribers in the Americas, Europe, and East Asia. And, as David mentioned, what I'm going to be talking about here is the evolution of HFC. So if we can go on to the next slide? I don't have control of the slide. Okay. There we go. Okay.

So the broadband platform for cable is known as DOCSIS, and this is the road -- this slide shows the roadmap so to speak for the DOCSIS platform and as it has evolved over time.

I look at DOCSIS as a toolkit that is designed to support a progression of services, as described within this roadmap, and, you know, we're at the 3.0. It's really the current version. It's just now being deployed en masse by cable operators.

So this toolkit consists of speed -- an upgrade to speed, as we'll talk about on the next slide. It also has a lot of other things within the toolkit to enable these services, and supports multicast, source-specific multicast, a quality of service associated with multicast; packet suppression to make it more efficient when you use multicast; IPV-6; security -- enhanced 128-bit AES upgrade from the 56 kilobit or 56 bit advanced encryption standard that was used in DOCSIS 2.0.

So within this toolkit, as we're moving

forward, we think DOCSIS 3.0 is very well-positioned, and, in fact, there is no -- one of the things David asks is -- implied that there may be something in the works for next generation for DOCSIS. This is just getting deployed right now. And in the discussion, when David said -- he was kind of interchangeable as saying the post-100 megabit world being post DOCSIS 3.0, and we don't look at it that way for the reasons I'll describe in the next slide, if we can per --

The higher data rates that you give and that are available in DOCSIS we think easily will have headroom going forward over 100 megabit per second downstream service. And as the one who helped to initiate the DOCSIS 3.0 version a couple years ago, it was the -- to meet the competitive offerings of DSL, as John was just talking about in his previous discussion, that really drove a lot of this.

And what these capacity amounts are and what DOCSIS 3.0 introduces that differentiates it from earlier versions is something called Channel

Bonding, which is putting the channels together. John again talked about it within the DSL context in the previous presentation.

So if you -- at a minimum with implementation of DOCSIS 3.0, you bond four downstream channels. And with the modulation that's typically used on cable systems today, that means four channels come out to about 152 megabits per second. So that's the minimum that you'll see in a downstream that is available that a group of customers can share in the downstream. Eight channels is 300 megabits, and vendors today are shipping or will be shipping in 2010 basically chips and products and modems that can support eight bonded channels.

So you can see there's a lot of headroom in terms of the amount of capacity that cable broadband subscribers can get. In the upstream side, began a similar story: You can support bonding, and with two channels that can go up to 54 megabits per second. That's a maximum rate, assuming that the plan is clean enough to support the highest modulation that's specified in DOCSIS 3.0.

And four channels you can -- so you can see how you can progressively get more and more bandwidth in both the downstream and the upstream, and you can choose to bind any channels you want. They don't have to be adjacent to each other. And this is all backward compatible with the legacy motives.

Go to the next slide. It provides a little bit more description of what the upstream bandwidth, since that's a question I often get in terms of, you know, is the upstream for cable Limited. There are many options here. This is one that happens to be in the DOCSIS 3.0 standard today. I look at this is more a long-term type of discussion here. This isn't something that you would anticipate a cable operator would do in the next two or three years certainly.

And in that timeframe, other developments might happen, and so there might be other ways to address the upstream issue, but this happens to be in the DOCSIS 3.0 standard today.

And that's to simply extend the upstream part -- we call it a mid-split option -- to 85 megahertz. The way the cable system works is the upstream is in the lower portion of the spectrum on the coaxial cable. And so in doing that, that will add nearly -- it's actually 175 megabits per second, if you check my math there. I apologize for that, but it's about 175 megabits per second if you're using 64 QUAM at 27 megabits per 6.4 megahertz channel.

And so you can how that extends up. Go to the next slide and last slide.

So another important point here that I think is sometimes lost is that, at it's from the Heritage -- the cable plant being a tree and branch architecture, whereas everything was broadcast. In fact, two of the most significant developments of the last decade for cable have been the introduction of two-way capability and interactive capability on the plant.

And so the way the cable systems

implement those interactive services is called something -- the concept of segmentation, which -- what that means is that segmentation of the cable spectrum increases the system wide capacity. You take some amount of the spectrum, and by segmenting that, you replicate it. You don't replicate it for everybody, but you customize it for a certain service group size, a certain amount of homes, and then it's not duplicated for the next set of homes. It's customized for those.

So in that way, you can really expand the capacity of a cable system, and this chart shows that a kind of a -- in today's system what a typical plant will look like, if you break down the services offered over it to linear content, which is the traditional one-way broadcast, but then some of the major interactive classes of services being switched digital video or broadcast video, video on demand and broadband. And the service group size then for those segmented -- in order to support those different segmented services, you can see vary between, say, 900 for a switched digital video service group size, up to 1,500 for Video-D. Broadband is around a thousand, which means that for those -- for a node or for a group of about a thousand homes, that's where the bus part of the cable architecture shares the architecture.

And so then you can see as a consequence of that the percentage of the delivered bandwidth how that breaks down. It's not -- if you use one or three channels per DOCSIS, that's a very small percentage. In fact, the amount of information flowing over the cable network is much larger when you take a perspective like this.

So I look forward to the discussion and any other questions we have on the HFC network.

MR. ISENBERG: Thank you, David Reed. Now David Reed, from MIT.

MR. PATRICK REED: Thank you. I have a very short presentation that really I think focuses on what I think is the most important question, which is this -- what this panel is about, which is the future of communications and presumably that future impinges on the deliberations around the National Broadband Plan, but I leave discussion of some of those things to the questions I'm asking rather than providing an answer of what the future is.

My sense of how you predict the future, being an engineer and a system designer is the best way to predict the future is to invent it, which is attributed to Alan Kay, but also to some other people. And if we think back, do I -- can I control this -- next slide.

MR. ISENBERG: Just -- actually, you know --

MR. PATRICK REED: There is a controller; right?

MR. ISENBERG: I've been remiss in my duties.

MR. PATRICK REED: Yeah.

MR. ISENBERG: Sorry. But thank you for filling in.

MR. PATRICK REED: Oops. Yeah. So the -- in the years I've been sort of designing systems and building them in the communications range. I constantly refer back to a paper that was published in 1967 by Bob Taylor and J.C.R. Lickglider to gray beards in the field. And the paper was called "The Computer as a Communications Device," and the reason I bring that up here is because communications is not just about the speeds and feeds and the technologies underneath, but it's actually about what people do with it. It's about communications, which is something that humans do.

And so what I'm going to try to do in this discussion is focus on what humans will be doing, extrapolating from work that is going on in the technical field.

One of the observations I'll make is that the way we think about wireless right now is disconnecting us. It's literally making us walk around, staring at phones, walking into walls, and crashing cars and doing a variety of things.

And that doesn't have to be the way wireless technology is deployed. But it's being deployed because it's being modeled after historical communications modes of television watching or making phone calls as opposed to other things like communications can do.

So particularly, and I'm going to -- if you take away a major point, the title here that wireless is much more than a third pipe, to satisfy some notion of broadband, notice a couple things: First of all, that these two devices -- my android phone and my Prius car key, smart key for a car -- are both wireless devices, and they're not about delivering broadband, but they do deliver enormous value to me in various ways, which I'll talk about.

But if you also think about communications as including, for example, Facebook, which is probably the most popular communications medium that's grown in the last five years, or SMS, which is not so much valuable because of the number of bits per second, but because of the interaction it provides, and you start to think that communications is more about situational awareness, access to data and resources, and so forth, and less about delivered content or the ability to call your family.

So the focus that I would like to claim as we think about broadband deployment is that what is really happening, the sort of third revolution after the Internet and personal computing, is really personal mobility, and let me define what personal mobility is.

It's not about mobile devices, although that's part of the solution. But it's about allowing people to move through the world in a much more connected fashion, and so when we look at the personal device, it's more important that my phone be able to tell me what's going on around me than it is to, you know, for example, be able to place phone calls from where I am in the long run.

So the -- in particular, this is what happens when you decouple the owner of the medium, whether that medium is fiber, copper, or spectrum, from the use that people are allowed to make use of that medium. And the decoupling that was done in the Internet era decoupled the physical mode of transport from the protocols and so forth that ran over it.

What we see I think coming up -- and this is my particular notion of what the collection of inventors out there in the world -- in academia and, you know, creators of apps for cell phones are doing -- is creating a power that I might capture in the key here, which is the power something I'll call the amulet.

And amulet is something that puts you in connection with your environment and in control of your -- both your physical environment and your other -- your social environment.

So if you think about it, communications is always embedded in a context, and now we can make that context supported by the infrastructure that we've built. And that's really what broadband is moving toward. Broadband is about creating an always live context, and I think what we have always live on our desktop or always live in our living room, you know, in terms of the Internet will move into the wireless environment, that we will always-it's always on, not something you dial to or something you place a phone call to and so forth.

And in particular, it's enabled by personal identity and centered on communications acts that are not thought of as communication, but really are core communications acts -- awareness -- being aware of what's going on around you; discovering what's around you and so forth.

And a good example of that awareness is keeping track of what's going on with your friends, keeping track of where you are and what bus schedules are going on, and so forth -- and even relatively simple steps forward that allow you to be aware of -- or put you in control of your environment so when you are watching a television program on your TV, you can pause it and take up, you know, watching or listening to it over your cell phone from the point where you paused it. That's a mobile context-related thing that's about the architecture of the communications environment, and it raises security issues. It starts to include things like signage. It starts to include really important societal benefits like the ability, for example, to support first responders who are potentially in your vicinity being reachable when you have a significant accident, and all that sort of thing surrounds wireless.

So moving to the implication for wireless is that we need to move beyond spectrum sharing to inter-working. Spectrum sharing is a negative thing. It basically says making radio systems that are owned by different owners not interfere with each other, which basically decouples and fragments things as opposed to creating opportunities to cooperate and opportunities to be mobile through an environment. That involves a whole lot of technical questions at the radio level, which I'd be happy to talk about, but not here.

But since we're talking about fiber,

what -- if you think this through over the next five or six years, and it's been a little bit mentioned, is that fiber is the key to wireless broadband at scale. And a few years ago, I worked on a research -- you know, set of research activities, as of many others, trying to say can we do it with pure wireless, and the idea there was mesh. Okay. Well, mesh is a really difficult, technically challenging way to achieve universal wireless coverage.

We have at hand a very different way to do that, which is to have fiber and to make, as David Isenberg said, make the wireless part very short range, and whether we do this with cellular type technologies or other type technologies, what that means is that we're operating radios at the point where they are the most efficient -- over short distances, at high bit rates, which, you know, in the case of even home distribution of video content, we know that we can do that over 300 megabit, 802.11n, which is a standard, and has caused all kinds of consumer electronics companies to realize that wireless within the home is totally practical and doable today.

What this leaves, and this is my final slide, is that in some sense we have a new tussle. I expect it will take 20 years to sort this out. It's the 21st century tussle, an the tussle is that wireless is moving to local, and I think fiber will cause it to move more local, which means that the cellular operators and the fiber operators need to do something.

One thing they may do is, you know, grow to do -- create femtocells and things like that. But I think that will work, because when you're in a campus or some other environment like that, it's not -- there is no reason for me to get my access to my physical vicinity or my social vicinity through an operator who has no stake in that campus, no power stake in that campus.

So wireless will become local, and the challenge is getting fiber into those local places and fiber of a very different form, not fiber that controls accounts, but fiber that serves as an

Internet-like infrastructure for a predominantly wireless space.

With that, I'm done. Thanks.

MR. ISENBERG: Thank you, David Reed. Now continuing the string of Davids, David Russell, who will give us the roadmap that he sees -- actually the standards roadmap that is widely acknowledged for fiber going forward from today. Thank you, David, for being here.

MR. RUSSELL: Thanks very much. I think this is the most Davids I've seen since my elementary school class.

I represent a company by the name of Calix, and I'm also active in the Fiber to the Home Council, and so what I'm going to talk about today is where the fiber access technologies are today and where they are going.

So as a little background, the company I work for actually is very involved in the fiber optics standards, and we really specialize in the rural markets. And rural is a very interesting place for fiber, because your loop links are so long in rural areas that it's not well suited to copper-based technologies. So what we do with our customers typically is we're working with them on a transition path from copper to fiber. And the speed at which they move in that path is dictated by a number of variables -- densities, their economic situation caused the capital.

But what we've seen over the last few years is a pretty major shift, where if you put out an RFP today, or if you are planning a rebuild or a new build, you'll do it with fiber. And it's just a matter of time as to when the conversion will take place throughout rural America from copper to fiber.

Now that said, what's driving this, of course, is consumer demand, and the all video world, which is driving that consumer demand. So we're at stage three in the Internet. In stage three, we move from a text-based to a graphic-based, and now a video-based environment.

So our general advice to customers has been if you get fiber in the ground, your incremental cost of bandwidth is essentially zero.

And ONTs that exist today in the market can do a gigabit of bandwidth up and down, into the house already. So as bandwidths increase, consumer demand drives that -- you can leave that ONT in place and just up the speeds with the click of a button, and you're getting higher and higher speeds.

So that's -- that kind of roadmap is what I'm going to talk about from a technology perspective.

So today, there's really two standards organizations that are involved in fiber access standards. The first is the ITU, and they have a working group that's called FSAN, or Full Service Access Network, and the IEEE is the second body. And the standard, the current standard from the ITU and the Full Service Access Network is the 2.5 GPON standard. And in the IEEE, you actually have to standards that are being deployed today. One is the one gig EPON standard, which is a passive standard, and then you have an active or point-to-point one gig standard that is being deployed. And I've put up here the actual accounts of how these different standards are being deployed in the United States.

And you can see that GPON, about 100 operators since one year ago to today, about a hundred operators have started deploying GPON. So the total number is now approaching 300 operators in the United States that are doing GPON.

BPON has been dropping off as people switch over to GPON, and then active Ethernet is also growing in the United States. EPON is not.

So if you were going to go to Europe or to Asia, these proportions would differ from those regions to the United States; that this is what's going on in the United States.

Now when we talk about next-generation standards, each of these standards bodies is working or has now published a next-generation standard. The ITUFSAN is actually working on two standards. The first is what's called NGPON1, which is essentially a 10 gig PON standard. And they also have a second standard they're working on which will come after NGPON1 in a time sequence, and that's not surprisingly called NGPON2. And NGPON2 is to take us beyond 10 gig, and essentially when most people talk about this next standard after 10 gig, usually people get around to talking about WDM PON, and I'll talk about that in a minute.

The second standard that has now been actually ratified -- the IEEE has ratified their 10 gig standard, and that is now a fully commercial, ready to go standard.

Now when you look at these two 10 gig standards, you'll start to see product rolling out on the IEEE standard probably in the next year, and then on the 10 gig GPON standard, it's probably going to be about two years from now. It's running about nine months behind the IEEE standard.

And they both have -- I think the IEEE standard has some advantages in being first to market, being pushed by a lot of entities in Asia.

The downside is they only have one gig in the upstream, and most people say that is too limited. They do have a second 10 gig in the upstream standard, but the 10 gig is not cost-effective, nor can it be deployed outside, so it's not really suitable for single-family deployments. It's more of a fiber to the building type architecture.

The GPON, next generation GPON standard, the 10 gig will be two and a half gigabits up, and 10 gigabits down. But they will also have a symmetrical standard of 10 gig.

Now what's coming after that? The last set, the NGPON2, is really aimed at making -- creating much larger distances, allowing people much higher bandwidths, and hopefully getting to the point where we have one wavelength for home. And there have been a lot of standards that have been proposed -- or technologies I should say.

Some of them I -- frankly are probably not going to make it because they're too brunt force. They're not very elegant. There are some people out selling WDM PONs today that are not standardized, but have difficulties with component prices as well as with temperature -- fluctuations with temperature.

Last week at the FSAN Meeting in Kyoto, Japan, there was a proposal that Nokia-Siemens put forward that our architect and many other architects got very excited about, which was essentially a coherent detection WDM PON that was insensitive to variations in temperature, and we think has some great promise. And so we'll be monitoring that, and I'm sure there will be a lot more presentations about that in the upcoming standards meetings.

But the point I wanted to make here is great promise here. We see these being commercialized after around 2015. And there's going to be some twists in the road here over the next two years as these new standards come about. And so we'll be monitoring those of the next two to three years as those develop. Thanks very much.

MR. ISENBERG: Thank you. We now have a

little bit better idea what we're planning for. John Jay, from Corning, pick it up and take us forward.

MR. JAY: Thank you, David. Yes, my name is John Jay. I am application engineering manager for Corning Optical Fiber. I don't have -- my resume doesn't really have quite the heft of some of the distinguished panelists here, but there are two things I wanted to mention: One is I've been involved in fiber-optic industry standards for 20 years now, and, in fact, I was just attending the meeting that ratified some of the standards Mr. Russell talked about in Geneva last month.

The other thing that this group might find more interesting is I'm actually a founding member of the Fiber to the Home Council. I wish I could tell you it was my idea, but actually one of our equity partners recommended it. My team got approval from my management to try and organize this. I was sent to evangelize and recruit among the industry, and I was on the first teleconference of about four companies to get the Fiber to the Home Council off the ground.

My greatest claim to fame is I insisted that the first conference be in New Orleans rather than a less worthy city, and the first managing director actually was one of my employees who reported to me while she was Managing Director of the Fiber to the Home Council as well.

So it's a privilege to see that it's a -- the important part it's played in developing broadband access networks, knowledge, and information in our industry.

The -- about that time of that first conference, in 2002, I returned back to engineering for marketing, so this is my first time back in this part of the business in several years, and it's very sobering to see the decrease in U.S. competitiveness in broadband performance during that time.

David asked us to talk about the future today, and I think the future is now. And I believe it's time for -- we need some aggressive broadband performance -- network performance objectives to get -- renew and recapture our competitive position. I spend a lot of my time working -- we export a lot of product to China. We have a lot of activity in India. I can assure you nobody there is waiting for us to catch up.

David asked me to talk about future -- passive network future fiber architectures, and it's difficult to do, because really our view is that the fiber access network architectures, technologies, and products being deployed today really carry us well beyond the 100 megabit per second era. I think Mr. Russell's presentation showed that a lot of those technologies that maybe be considered beyond that are available today.

Fiber network technology is well established and proven. The standards for networks like the FIOS service Verizon sells have been in place since the late 1990s; actually, interestingly, much longer than a lot of competing technologies like DSL or VDSL what you're maybe seeing is more conservative.

Fiber networks are highly reliable. It's very common for me to get phone calls from people operating networks installed in the early 1980s wanting to know if they can run the latest technology on there.

So those systems continue to run well. Fiber networks reduce operating costs. At one of the first Fiber to Home Council meetings, Verizon told us that the net present value of the cost savings of service and maintenance of a fiber network Greenfield versus a DSL Greenfield was worth $200 per subscriber.

And, of course, fiber networks have the smallest carbon footprint of access network technologies, and so the advantage of a fiber network access network investment today is you're running a low operating cost position and a small carbon footprint. As you expand the networking capabilities, if you have to look at other technologies, as a better solution in the end, you're scaling off a nice, comfortable base to begin with.

So if we look at -- our view is that the fiber networks installed today are capable of the network performance today. They're upgradeable to the performance requirements in the future, and scalable to the long-term performance requirements that can be envisioned.

When I was working in this part of the business seven or eight years, we were trying to convince people that 200 kilobits service was not an effective broadband service, and they needed one to two megabits of service, and hopefully nobody today thinks one to two megabits of delivery is sufficient. We don't want to be back here in seven, eight years and think that we shot behind the duck and set our objectives too low.

I won't go in -- I think there's a consensus on the capability of fiber network transmission performance, and Mr. Russell mentioned about the standardization well established for GPON today and beyond it. Those standards are there. More importantly, developing standards -- as someone who attends these meetings, I can tell you these standards are -- when they're drafted and even when they're envisioned, it's insisted that they leverage the current investment in fiber product and invested plant. There's strong representation of operators worldwide, and I -- also, but the vendors feel the same way that these physical plant investments have to take us to whatever we can possibly envision.

There's not the economic capability to rebuild and reinstall access network plant with high frequency.

The important thing is is these fiber networks are compatible with other access network technologies as well as generational compatibility among fiber access networks. A good example is there's an effort in the ITU now to harmonize the management and administrative software for ONTs for all generations of PON. Very high compatibility with other access network technologies.

For someone from Corning, I can tell you it's hard for us to envision. There are cases when fiber is not the right answer, but I suppose that's probably true. In all seriousness, in cases where it's not, fiber is certainly the best infrastructure for innovation and investment to finally connect these subscribers.

The fiber network standards in the ITU specifically call out terminating to services such as XDSL, 802.11, Ethernet services. These are all standardized of how to connect these. In fact, one of the technical submissions we just made last month was to help deliver time of day over fiber networks so that it could be used for 3G and 4G wireless backhaul rather than having to create that capability in the wireless site itself. So it's a great cost savings, and Mr. Russell's company actually has products available for putting wireless backhaul off of GPON.

In some cases, it's enabling. 4G wireless you must have fiber backhaul for that capability, and most of the products require fiber up the mast to the antenna, and with all due respect to Dr. Cioffi, at the DSL standards meetings I attended at the ITU last month, the experts there were telling me that the jitter tolerance on DSL standards is too high to support wireless backhaul, that you have to have fiber.

So our view is these networks and products, as they're being installed today, are taking us beyond the 100 megabit world, David. I mention most of these here already. Reach extension. There are standards to extend fiber network out to a 60 kilometer span or more as well as increasing split ratios, reducing cost for operators and construction.

And also in the cable television area, RF over glass or DOCSIS over glass, extending fiber out -- extending the DOCSIS service -- on optical -- keeping an optical format as close as possible to the subscriber.

So this is probably more slides that I thought I had, so I'll wrap up.

MR. ISENBERG: Yeah. If you could.

MR. JAY: And if I could just take one

second. David asked me to mention some of the products that are used in fiber to premise networks. I don't want to turn this into a commercial, other than to mainly point out that most of these are scalable to all the standards that Mr. Russell mentioned as well as some of the further technologies that are being proposed.

MR. ISENBERG: Thank you, John. Okay. John Hanaes, thank you again for flying all the way over from Norway to be part of this panel today, Johan.

MR. HANAES: Oh, thank you for inviting me. Hello, everyone. My name is Johan Hanaes. I come from a systems integrator in Norway called INS Communications. I've been more or less all my career working with telecom systems and telecom networks, and for the last five years, I've been working quite actively with what has been mentioned by these guys, a standard called WDM PON, or not the standard yet, but the technology.

I was one of the initiators of the GIGAWAN Project, which is a EU-funded project for integrational components for the future of WDM PON systems. And I also was a part of the architecture group in the Fiber to the Home Council in Europe, based on the fact that the Norwegian market over last 10 years, there are now 16 new players offering fiber services. We saw that there was definitely room for a new systems integrator in Norway, so last year we established INS Communications.

So when I was invited to talk about the future of fiber optics, I was inspired by an old Roman to maybe look a bit back -- step back and take a look at what's happened before us.

And if you look back to the '80s, there was a lot of activities for finding solutions also for fiber in the access part of the network. At a time when the access speeds were in the hundreds of bits, it makes sense to use TDMA as a technology, and BT was very active trying out several architectures and ending up with a 128 split type of solution for their TPON, a telephony PON metric.

In the early '90s, they started rolling out their system for as much as 30,000 users in the Milton Keynes area, and they had a plan for an upgrade of this network, for worldband for the services they envisioned at telephony obviously, television, high-feed stereo, and video library.

So after a while, when the customers who wanted broadband, they tried to find solutions for it. And based on the fact that they had 128 users connected to the same fiber and they made the flaw that they had two splits in field -- eight plus 16 -- it made it impossible to decrease the number of users per country; hence, they weren't able -- either themselves or through standards to find a solution for offering broadband to these customers.

And in 2003, after the customer shouting for broadband, BT had to actually start replacing these fiber systems with what they branded as copper overlay, which was an ADSL roll out. And the great dimension of this is that the fiber ducts they had for the original TPON system were too narrow, so they had to actually dig again to get the copper into the ground. And, as you see, they did it in this decade.

We also know that Deutsche Telecom had a similar project going on, and they also had to fork lift upgrades hundreds of thousands of users, not by copper, though, that they replaced the systems with active components in the field.

So did we learn something? Well, it might be the tomorrow's services are neither broadcast TV, high-feed stereo or video library. And if we look at the architecture that we have in the central part of the network, the core and metro, we have moved from a one network per service type of architecture in the '90s to what the carriers call the next generation networks -- one network and one platform for all services. These are optical WDM-based flexible platforms for tomorrow's services.

So when rolling out the fiber infrastructure based on TDMA PON, which is a 25-year-old invention, what then about your business customers and your wireless backhaul and future services? Even if you look at the standards picture, we see that if you deploy power splitters in the field today, there are good reasons to believe that you will need to replace these or at least do something to (inaudible) that plan for the -- within the next decade.

And I think that this is one of the -- or some of the reasons why the European market now deploys mostly point-to-point connections. I don't have the numbers in my head, but I think there's something like 80 or 90 percent point-to-point in Europe.

What is the backside of the point-to-point is obviously the high cost of operating a point-to-point system. And since we have such great capacity in the fiber today, we see that WDM PON could be a very attractive solution.

As mentioned by the people before me, we have symmetrical bandwidth in such a system. We have a point- to-point connection in such a system, so we have the best from two worlds bringing together point-to-point and PON.

And if you look at the numbers and the performance of these systems and knowing that bandwidth is the future product in your network, we know that today even with the non-standard systems that we have, the cost performance -- bandwidth versus dollars -- is actually better than the other systems.

And another important role for WDM PON might be in the future to also collapse the border between the access and the metro part in the network, allowing us to have new architectures and new networks offering totally new services.

So we are a group of people that has started a small initiative called the WDM PON Forum. Today, it's a small group on the LinkedIn website, so if you want to have a look, please logon and we hope to expand to a website called FiberIn within the next year. Thank you so much.

MR. ISENBERG: Very good. Thank you very much. So I'd like thank the panelists for enlightening presentations. I am wondering first of all, are there any questions that are specific to cable or hybrid fiber coax or DOCSIS that we could ask right now because David Reed has a delayed -- kindly delayed another commitment to be here, and he needs to go pretty soon.

Here's -- Benoit, which David Reed is this for? How many end users are -- oh, okay. So here it is. Okay. So, David Reed, how many end users are sharing this up and down bandwidth in a typical cable implementation?

MR. REED: So it -- first off, it varies with each operator so there's not a standard number that an operator will use. And it also varies depending upon the users in a particular area. You get different usage patterns from a college area than you would from another type of a demographic.

As I mentioned in my last slide, there's a service group size of about a thousand. And so that gives you some insight into how that sharing occurs in terms of -- in a DOCSIS system we have something called the cable modem termination system, which is a CMTS that is in the head end, and there's a line card. And that defines how much the capacity will be shared upon of the bus, so you can, say, serve up to a thousand with, you know, a line card. You may have multiple line cards per fiber node per service group, so there's no one way, but what-you know, the cable operator looks at the oversubscription, so to speak, of that bandwidth as a real benefit to the approach because you get the benefits of statistical multiplexing on the cable system, and with the network management capabilities on the DOCSIS platform, you can basically monitor the usage in the sense of the overall amount of capacity that's being utilized during any particular time; and based upon the patterns of that, if the usage, the downstream usage, for example, gets too some percentage, the members -- or the cable operators typically have a level that they flag to say, okay, we need to expand the capacity on the system based upon usage that's being tracked on that particular node at that particular time for a peak hour.

And so, you know, there's no one number that I can just give you as a rule of thumb exactly, but there's no question that that the operators look to try to maximize the utilization of a bus as, you know, any network operator would with their capacity.

MR. ISENBERG: Thank you very much. I'd like to invite my colleagues from the FCC to ask questions if they have any, and I know Stagg here has one. Stagg.

MR. NEWMANN: Yeah. First, I've observed nobody is proposing fiber to the person, which I think is good, because most of us don't want to be tethered, and also even within a building, you know, realistically we're still going to be using our twisted pair, our wireless, or our coax probably for the distribution from within the building.

So in some sense, the question I'm trying to ask is how close is close enough with the fiber under the different architectures, with the observed that in the cable industry today we do get fiber within a kilometer and less than a kilometer to most homes. The telco architecture -- I guess the question for John would be, how close do we need to get that fiber practically to realize the benefits you see to future-proof the network so we don't have a massive step change in capital investment needed. And for David "MIT" Reed the same question for you: How close is the fiber need to be to realize the type of future architectures.

I think the fiber in the home guys probably don't need to answer that question. We're probably close enough.

MR. ISENBERG: Actually, John Cioffi, if you're out there, you want to take a first crack at it?

MR. CIOFFI: Yes, I can, and, of course, the range of the fiber is dependent on data rate that the customer needs. If you assume that 100 megabits per second is enough, and most experts today I think believe that is beyond the range that they contemplate for individual broadband connections, one kilometer range is close enough to be able to do that. Fiber typically costs between $20,000 and $1 million per kilometer to install, and obviously if you can divide that cost over a larger number of customers, and typical one kilometer range is what's called the node, particularly evident in the United States, but other architectures internationally also -- typically have a junction box in that range so that is, for instance, the architecture that AT&T is using on their -- in a very large population of DSL subscribers. So one kilometer, 100 megabits per second.

In Europe, you see a lot of networks with two kilometer to three kilometer pretty much range -- just a little shorter line. And you see IPTV service in the range of 10 to 20 megabits per second being offered along with data; and voice in those networks at two kilometer, and then you don't need only fiber at all.

So it really is a question of the data rate and the network architecture, but I think one kilometer has kind of emerged as the architecture of choice for the advanced DSLs when there is fiber heading -- you know, used to shorten the length of the copper.

MR. ISENBERG: Thank you. David Reed, Cable Labs?

MR. REED: See in the cable network that -- you know, the cable industry went through a significant upgrade of their systems over the past decade, where they extended fiber out. It really that -- it's less a distance issue. With the telephone network, it's a distance issue because of the attenuation you get on the copper and the tradeoff in the bandwidth that's available is based upon that.

On the cable system, for the most part, you can -- you're much more able to design your network basically on a household basis based upon your estimate for the amount of traffic required. And so in that -- in those upgrades that occurred over the last decade, they generally went down on average to about a fiber node size of 500 homes past.

So, you know, the distance for that from the home is going to vary due to the geography and the typology. There are some constraints with coax with regard to amplification on how many amplifiers you want to have in the network subsequent to the fiber node, but in general the fiber extends down to about 500 homes past, and based upon that, you can get the speeds of DOCSIS. There's no variation in the speed based upon that.

If you took -- were to look at a cable network, a 750 megahertz cable network, if you were to digitize it entirely, that's roughly about 5 gigabits per second of information that's flowing over that, and so looking on -- or based upon the service mix, the triple play that cable operators provide, that can then dictate what the next steps are if at a 500 homes past node they were to start to need more capacity than can be provided by simply allocating some of the -- by spectrum management within that network. And then they can start doing some node splitting, or it doesn't necessarily mean that you have to extend fiber deeper. You can put in -- because the way the nodes work, the fiber comes down; it terminates. And then you have these coax legs, and you're looking at, say, four coax legs coming up. That can be a very convenient way to split the node so that you have to replicate, say, the lasers and receiver of the fiber node in that location, but you don't have to extend fiber deeper, and you can get a four to one gain in your bandwidth for those dedicated amounts of spectrum that I was talking about -- the segmented spectrum that I was talking about in my presentation.

MR. ISENBERG: Thank you. I put up the -- one of John Cioffi's -- yeah, I'm going to call on David Reed from MIT in just a second. John Cioffi's last slide spoke to this issue fairly directly. On the Y-axis is megabits per second. On the X-axis is loop length in meters. And so you can see that at about 1,500 meters, even the most advanced form of DSL looks like it's about 50 megabits per second. Is that fair -- am I characterizing that correctly, John Cioffi?

MR. CIOFFI: That's a lower limit. Basically, this slide here from what is -- specifically from a chip vendor, and it's not including all the management techniques, although it does include the removal of crosstalk. It still includes some of the customer premises noises, so if you can manage those customer premise noises, you can push these curves up a little bit. But otherwise, you're reading the curve correctly.

MR. ISENBERG: Okay. Thanks. David Reed, from MIT.

MR. PATRICK REED: Okay. This is -- I can only touch on two or three key technology changes that are going on right now. I think the whole area of providing infrastructure for richer wireless mobile experiences is in a huge amount of flux even today as the marketplace is going forward, and just as an example the latest generation i-Phones are capable of 802.11n capacity, but they're not currently served by access points that are deployed enough, so we're basically talking about how do you get 300 megabit per second peak rates to -- on a dense basis within, say, a campus of multiple dwelling units or enterprises or college campuses or whatever. The challenge there is that the fiber or copper needs to terminate pretty close to the access points, and, as you say, there may be copper on the campus or within the home, but if you actually look at what's happening with deployment of gigabit Ethernet, the cabling is actually quite difficult to install. It's quite expensive, and fiber is actually a better choice for a variety of environmental reasons. You can ask folks who are involved in engineering that much more than I, but we've had experience recently at MIT reprovisioning buildings that we're building to create wireless environments that show these very practical challenges.

And in some sense, fiber may be the

answer all the way up to the access point even in -- certainly in multiple dwelling units and enterprises not too far from now and maybe even in residences as we start to see consumer electronics adopting that for inter-connections among televisions and set-top boxes and stuff, which CableLabs might have a view on, although they don't directly touch that.

I think the other thing worth thinking about in this space is that there are technologies emerging, and if you speak to Rajeev Rahm of MIT, a professor there who's expert in fiber technologies, but also in microwave -- fiber microwave technologies, and also Professor Ian White of University of Cambridge in England, they have actually been involved -- and there are a variety of other companies who have been involved in direct interfaces between fiber and microwave systems at very high bit rates that use passive transformation; that basically you can up convert and down convert direct radio waves or whatever directly into fiber and power the -- both transmission and reception over short distances, a few hundred meters, directly by the power of lasers, so you don't need to pull copper; you don't need to pull power. It's environmentally safe -- you know, compatible, low noise, and so forth.

So those technologies I think, you know, they're not being deployed for a variety of reasons, not the least of which is that building cycles are very slow. You don't rewire buildings more than once every 10 years.

But in new start buildings and new enterprise deployments, you're starting to see those technologies scale.

So I actually think there's a possibility -- you can argue with me -- that copper will get squeezed out. It's got a variety of drawbacks, but it would be very interesting to see why not, you know, in some sense, even in -- of ultimately in residential.

MR. ISENBERG: Thank you. My other Bell Labs colleagues, any questions? Tom Koutsky?

MR. KOUTSKY: Um.

MR. ISENBERG: Or would you like to?

MR. KOUTSKI: Well, actually my question was a little bit of a -- sorry -- my question was a little bit of a follow-up to Stagg's, kind of related to, you know, how -- some are related to how close did the fiber need to be, but what -- if you were -- I was actually interested in the British telecom example, where they have the instance of having to trench for copper after already having trenched for fiber, which is interesting to say the least.

I mean we certainly don't want to have to dig more than once in the country. So when we talk about -- I have two questions related to getting fiber closer to consumers. I want to know if there's any level of path dependence in this that let's say and a fiber provider has an infrastructure program where they for whatever reason decide we wanted to put fiber to within 12,000 or 5,000 feet of consumers.

And then they wake up five years from

now or 10 years from now, and realize that that's probably a little bit too far. Is it a simple matter of just continuing to go? My understanding is it's probably not; that you would actually design the network completely differently if you were to try to get fiber to within very close to someone.

So I'd kind of like to have some kind of confirmation from that from people that have kind of thought about these architectures.

And the second one is to more think in terms of what type of access to those fiber nodes, for lack of a better term, do the panelists think it would be required would be necessary to basically unleash the next generation of what I would like to call access technologies or last mile technologies, and I think that -- what Johan was talking about I think was an approach like that, but I'd like to hear everybody else's thoughts in terms of, you know, what would be the kind of interface at a kind of a fiber node that's, say, in their neighborhood, and what would that look like?

MR. JAY: Maybe I could start on your first question.

MR. KOUTSKY: Sure.

MR. JAY: And, of course, I volunteered because the answer is it depends. So I think the problem is certainly not the technical capability of the fiber and cable that you would install to that area. And I think it has much more with how you are provisioning -- how you would provision that versus what type of provisioning you would actually need were you to then migrate fiber deeper into that network.

As you get closer to the subscriber, as you push the subscriber, the issue is not so much the bandwidth or the signal loss. It's the connectivity. And if you have to somehow connect -- if you have to connect let's say several thousand subscribers, and you have a -- you've terminated a feeder cable -- you've terminated a 12-fiber feeder cable, then you might have some problems. If you've terminated a 432-fiber feeder cable, you're in a much better situation.

It will also depend on whether you plan to install a passive optical network like Mr. Russell described, where you would be -- the same feeder fibers will serve 16, today 32, in the future 64, 128 customers or whether you intend to use Mr. Henaes' network, where you connect a direct fiber to each customer or, for example, at British Telecom where they need to provide four fibers per customer.

So that's why it depends. It has less to do with the -- I think in each case, we're talking about probably the same optical fiber, and I think we're talking about more or less the same cables and termination equipment other than scaling them for the different sizes.

MR. RUSSELL: I have a little bit of a different viewpoint. I actually don't believe the British Telecom example is very illustrative. I actually worked for a company that licensed that technology, and, to be blunt, it was the dumbest application of technology I've ever seen. And, in fact, it stopped. It was actually -- the implementation that we did when we licensed the BT technology, it was a fiber to the curb solution, serving about eight customers. So it got fiber close enough that you kind of went -- or you either want to take it all the way, or you want to back up.

And we ended up -- this was not the company I work for today -- we ended up junking the system before we ever deployed it, and switched it to a hybrid fiber coax system.

So I think that is the answer. You either want to take fiber all the way and you benefit from all the -- the fact that bandwidth is then zero dollars to upgrade. You benefit from having no noise. You benefit from the essentially having an infrastructure that is unlimited in its potential or you back up to a place that makes sense.

And I would say the cable industry probably in their node positions is at about the right place, because it's cost effective. And if you look at where the cable industry's nodes are and you equate it to where the ADSL 2 plus nodes are today, they're in about the same place. So I think the answer is one of those two going part way in between.

I can't tell you how many operators there are in the United States that deployed the Marconi fiber to the curb solution that are now begging equipment providers to come in and try and find something to replace it. Hundreds of thousands of homes are stranded by that system.

So that -- fiber to the curb is not the right answer, and BT learned that.

So I don't know if that answers your question?

MR. KOUTSKY: It does.

MR. ISENBERG: Thank you, Tom.

MR. REED: If I could just --

MR. ISENBERG: Oh, okay.

MR. REED: -- from a cable perspective the one thing is that there is some flexibility with the cable operator or an HFC network operator that how many fibers they pre-install to that node and that will vary from two to four to six even, and that will impact economics and for upgrading in terms of if you want to extend it deeper, you've got to still either use a backup fiber or you wait for the WDM solution and the cost associated with WDM to use a different wavelength. And so, but that's the beauty of the HFC. It gives you flexibility to have a dif -- some different levers.

MR. KOUTSKY: But oddly enough was my next question.

MR. REED: I'm going to have to run, but I want to thank you guys.

MR. ISENBERG: Okay. Sure.

MR. REED: And I apologize.

MR. ISENBERG: Thank you, David Reed. As moderator, I'm going to give us another 10 minutes. That will put us 15 minutes over the line, and I think a half- hour break will still be appropriate if anybody on the second panel going to be messed up if we run 15 minutes over on the second panel? Okay. So that's how it will be. We'll stop at 11:15 a.m. We'll start again at quarter to 12. Okay. So we have time for a few -- two or three more questions, but let me ask at this point, with 10 minutes to go, that we have succinct questions and succinct answers. Walter, Julie, do you have anything burning.

MR. KNAPP: I was fine until you said succinct. Just a quick question. Increasing speed and bandwidth is generally thought of as a desirable thing. And some of the new technologies we're looking at here are so much greater in terms of speed and capacity than what we've had before.

Do you ever reach a point in your thinking where you wonder if there is a use for something as large as the pipes we're talking about here or just build it and they will come and how does that affect investment? I'm just curious. Yeah, David.

MR. PATRICK REED: I'd certainly like to -- you know, it's touches on a subject that I didn't get to talk about, but, in fact, the other

David Reeds and I were talking about it just before we started.

The value of speed, especially in broadband systems, is not sort of continuous streaming download. The value is latency. And there's latency at different scales, sort of ranging from how quickly the packets turn around to, you know, how quickly, you know, my Apple TV can download a movie so I can start watching it with the guarantee that it doesn't, you know, run into a hiccup, you know, down the road, and or for that matter uploading a -- you know, when I'm -- my wife is uploading pictures to a picture sharing site, she doesn't want to sit there and supervise the transmission. She wants to say go, and, yeah, it's fine if it's in the background, but if she has -- comes back and finds out that it failed, you know, that isn't a happy experience.

So when you talk about these things, I don't think these speeds that we're talking about are enough -- anywhere near enough -- at a peak rate, especially when they're shared. When they're shared in the merge of PON or in the hybrid fiber coax, you can get that peak rate, but you have to really depend on statistical multiplexing, and statistical multiplexing doesn't always work. We can talk to the cable people about the switch to IP TV, where when you do a channel change, you actually have to buffer up all the stuff that's in there, and that affects the user experience directly.

And so these kind of -- and unfortunately channel changes happen in a synchronized way, so there's no statistical multiplex, and people always change channels exactly at the same time. So this kind of peaky behavior and latency is what I think will drive the issue for a long, long time.

MR. JAY: Just a quick example, Mr. Knapp.

MR. PATRICK REED: David.

MR. JAY: An obvious application that people have talked about over the years for broadband is remote lessons and training -- and even remote performance, and particularly if you think about something like remote music lessons, remote music performance, the -- if you've ever tried to see this simulated, it's very difficult, and the problem is latency. It's like in the old days when you had to use satellite telephone calls overseas and had all the delay in trying to synchronize your conversation.

And the estimate I saw was that remote -- for example, remote music lessons, remote performance might take 200 to 250 megabits not for the video and audio streaming, but to have enough bandwidth so that the latency was low enough that you could actually functionally do this.

MR. RUSSELL: I think I have a little different view, too, that one thing as an operator you don't want to build multiple networks. So you don't want to build a network to residences and then have to turn around and build another network for cell sites, and then have to come back and build another network for institutions, and another network for schools. That just destroys your business case.

So what you want is an architecture that allows you to address all those, and the problem is when you build that architecture, you can't predict where the Verizon cell tower is going to be. They're going to make that decision. So you've got to have an architecture that's very flexible and can scale from grandma's telephone to Verizon wireless wanting a gigabit to an LTE cell site without having to completely deploy a new network.

MR. KNAPP: Thanks.

MR. ISENBERG: Okay. Thank you very much. There's been --

MR. JOHNSON: David, could I just get one question?

MR. ISENBERG: -- oh, I'm sorry. Walter, of course. Please. Walter Johnson -- Johnston from FCC.

MR. JOHNSON: I'll try to make this short.

MR. ISENBERG: Also from Bell Labs.

MR. JOHNSON: Okay.

MR. ISENBERG: From FCC.

MR. JOHNSON: I will direct this to the surviving David Reed. But I'll make this quick. My perception -- and I'll offer it as my perception -- is that government policy has been directed up until just very, very recently on delivering statically broadband to the outside of a residence. If we recognize that mobility is an important principle, how do we start changing government policy to really capture that and leverage it?

MR. PATRICK REED: Gee, that's interesting. That was a quick question to state and an incredibly hard question to answer. I do think that that's one of the challenges, and, you know, right now even in simple cases, you know, the policy around how you get service for cellular inside buildings where buildings are being built like Faraday cages, you know, to use an example.

You have to -- every building owner has to negotiate, whether it's a hospital or whatever, has to negotiate with cellular carriers to get the spectrum that you would think of would be their own managed, you know, because it's inside their building, but it's actually owned by the carrier, right, and each -- you have to negotiate with each carrier.

So I think there is a challenge. It's a huge challenge to start to address the spectrum management thing around what I would call sort of radical inter-working or interoperability so you could actually move through environments and get these services and uses in a variety of different places.

And that's why I said at the end of my slide that getting the -- that I think fiber and those kind of things will ultimately, you know, whoever provides that, and I don't know whether it will be Verizon negotiating with building owners or, you know, or building owners themselves negotiating with Verizon, starting to think about the fiber more and more as a kind of universe of roads -- you know, the kind of road networks that we build in municipalities, which are sometimes privately owned and sometimes publicly owned, but the point is you build the infrastructure to provide coverage as opposed to building the infrastructure to provide account management, and that -- I think the FCC needs to start to think of the unity of those things as it regulates them rather than services associated with wireless versus fiber and stuff. And I don't have an answer.

MR. CIOFFI: David, if -- this is John Cioffi, if I could kind of, you know, summarizing this question of bandwidth is that --

MR. ISENBERG: Sure.

MR. CIOFFI: -- with an antidote, I've been working in (inaudible) and remember a statement vividly in 1989 from an executive at Pacific Bell, which is now AT&T, who said that they would have fiber to everyone's home as part of a national information infrastructure within five years, and that they would never use a single line of copper because it didn't have enough bandwidth. Today, AT&T has 18 million DSL customers. There are a billion phone lines around the world, and it's 20 years later. And the reason we need to make infrastructure to be competitive or to be competitive is we need to do it quickly and we need to do it cost-effectively, and if you have the bandwidth on the copper, there is no need to wait and debate on whether it's a gigabit or 10 gigabits on fiber or only 10 megabits on fiber, if you want to move quickly, that is the only alternative, and it's why broadband today is dominated by the copper connections.

And I think that's going to continue for a considerable amount of time.

MR. ISENBERG: Thank you, John Cioffi. At this point, I think we've simply started to -- started on this discussion of future technologies, and I'd like to thank first of all thank and apologize to the people online who have asked a bunch of good questions and the people in the room who have asked a bunch of good questions that I was unable to get to given the inability to time multiplex. I wish I could just manufacture more or put the time on several different wavelengths or something, but that's right now -- the -- that's still a physics challenge, so thanks to everyone who has submitted questions. They will become part of the public record, and we will resume in half an hour, and thanks to the panelists also.

MR. NEWMANN: Yeah. And let me say to the -- both the panelists from the first session and the panelists who will be on the second session, I think I've managed to procure some coffee, since it's not easy at the FCC, in the first conference room on the left, 402, down the hall.

(Recess)

MR. ISENBERG: (In progress) -- they have to turn off the music and turn up the microphones. Oh, the clicker, Joanne? Who's got the clicker? Bring it down to the first speaker, please.

So thanks to the second panel. Thanks especially to Herman and Benoit, who flew here from Europe over the last couple days to be part of this. Thanks also to the rest of our distinguished panel, and without further ado, I'll turn it over to Dick Lynch, the CTO of Verizon on the Future of FIOS.

MR. LYNCH: Okay. Thank you very much. With that, clock staring at me, I promise I will beat it. How's that sound?

Okay. What I was asked to talk about -- and I'm going to do this in a very short order, I hope, with very few slides -- is talk about FIOS essentially, Y-Fiber to the PREM, where we actually are with our deployment, and then what we see as the future fiber.

Why fiber to begin with? If you think about all of the various applications, service set whatever you want to call it, that is currently being used today, and you look at the requirements of each of those increasingly complex service sets, it becomes pretty apparent that the bandwidth per individual is going to have to increase over time. And what I show on here, on the bottom right-hand side of this, is a chart that has stood up for quite a few years now, and what it essentially says is that about every six years we see an increase of 10 times in the usage per customer. And that has really not varied dramatically over the last X number of years, 10 years or more.

But what I think is critically important here is that that is a band. And I will tell you that within that band the slope is increasing, and it's increasing more for the uplink than it is for the downlink. And so one of the things that I'd like everybody to think about here is that if we continue to talk about performance of networks and performance of any bandwidth delivery solution only in a downlink sense, we're missing a very important link to the future, which is that the uplink really does need to be there.

Now why is fiber the right solution for all of this bandwidth demand? I believe that fiber has a lot more head room than anything else that is out there. First of all, in the last panel, you heard a lot of the technology, so I'm not going to burden you with that here, but today Verizon provides a 50 by 20 service, and I will tell you that that 50 by 20 service is a commercial decision because today we're capable of doing more than that. The existing infrastructure we have in place truly is capable of more than that, and you'll see more than that coming from us as the customers really demand it.

Now I happen to be very aggressive in terms of bandwidth expectations, but I will tell you that today very few customers by 50 by 20. They don't really yet see the need for it. That's still the tail of demand when you get to that particular kind of speed. But we see it coming. We see three digit numbers in that area.

I believe fiber is also the leading competitive solution, both in terms of quality and reliability. Cost effective solution was a challenge when we first started. We believed we'd get there. Certainly, in the beginning, it took some effort.

But today the cost per bit to build is better with fiber than it is with anything else, and the cost per bit to operate is dramatically better than it is today with copper.

Why lower operating costs than with copper? Well, first of all, it's more immune to the weather. Copper does have pretty significant environmental impacts. But probably more importantly than that, there's less active equipment. We're using a passive network. We're using PON. And so we do have an awful lot less failure points if you accept the fact that an active element is certainly going to be more likely or more prone to failure than as a passive component.

And as having spent, as many of you know, an awful lot of time in wireless, I have to say that there is not enough wireless spectrum available, and this Commission can't find me enough wireless spectrum to satisfy what we can deliver on fiber.

Look at fiber as having the same amount of spectrum as the FCC's total cache of spectrum to give. Our technology is pretty straightforward. If you look at the topology of our network, it's really not all that different than a historical copper network. You take feeder out of the central office, and you go to distribution points, and then those distribution points you have drops into the various premises.

So from that standpoint, it is not a surprise. It's something that's pretty easy for us to replicate along the lines of where our copper plant always has existed. But what's important is that the same amount of plant needs to go into that big building in the back as going to the home in the front, a fiber. Maybe in the biggest of buildings, we need a few more than one. But the fact of the matter is that we really do have the capacity out there as a result of the fiber that we've deployed in the feeder.

Where is our program today? As of the

third quarter of this year, we've passed about 14 and a half -- actually, probably it's a little more than 14 and half by now -- premise. We've got about a 29 percent penetration of data customers on that today. And I will make a point on that, too, is that that 29 percent actually is calculated using the entirety of the denominator, so even the customers who we opened up for sale yesterday, even though they haven't had a chance to buy yet, are actually in the denominator. So that 29 percent, I think, suggests that customers really do want this, and we will continue to pass more and more PREMs as we go forward.

Finally, the future of fiber. No pun intended here, but the future of fiber I think is very bright. Building costs continue to decline. You take innovations like bendable fiber, optical network terminals that are built for desktop use in an apartment. The scale of fiber and the construction over the world continues to drive costs down.

Our operating costs, both year-over-year and versus copper, continue to decline.

And so I think that that's something that will continue as well. The profitable field of use is also increasing. With these new ONTs, it's a lot easier to bring fiber right into the living room, and put a little tiny ONT on the desk or on a table someplace. You've got higher penetrations, and so you can divide that common cost by an awful lot more customers.

And also with the improvement in electronics and improvement in optics, we can push further and further out in those less dense populations. And I don't expect that that trend is going to stop anytime soon.

Let me just say as far as performance improvements are concerned, the technical capabilities we have today exceed what the customer wants today, and I think that as the customer continues to demand more, the technology will continue to be able to accommodate it.

And finally, I think -- and this is maybe a sales point here -- but I think this is really the only technology today that is not bounding demand. If you think about some of the other technologies that have been discussed here, we're talking about hundred megabit. We're talking about 50 megabit, and we're saying things like well, customers really don't need any more than that. I'd rather be in a position of delivering to the customer what they want, regardless of what that is, and I think fiber can do it.

So with that, thank you very much. And I'll pass this on to Joanne.

MS. HOVIS: Thank you.

MR. ISENBERG: One second. Oh, well, we have 15 seconds, let's say. Do you see your customer traffic rising to fill the available head room? Brief answer, please.

MR. LYNCH: Let me answer it this way, David: Yes, I do, but it's going to take time. It's not going to happen overnight. Maybe we can expand on that when we get to the question and answers.

MS. HOVIS: Thank you. Working? Yeah. Okay. I'm Joanne Hovis. I'm President of CTC, which is a public interest consulting firm focused on the nonprofit and local government communities. I'm also here in my capacity as president-elect of NATOA, the national association that represents local governments and communications -- a community that is very closely following what is happening here at the FCC; has some very strong interests and opinions, and also has something of a track record and a history of involvement in this market in seeking to meet the needs of internal anchors and constituents and intends to continue doing so, hopefully in real partnership with the FCC.

Let me start by suggesting something, and then tell you a little bit about what I know from a municipal perspective, about what we've done, what we've learned about fiber, and where we think we may be going.

Let me suggest that local governments, nonprofits, universities, educational institutions, and our consortia that bind us all together are in some ways the laboratory in progress on optical development. We have 15 years of experience of building and operating fiber networks to meet the needs of our internal anchors and institutions; and increasingly experience in meeting the needs of the public as well.

Localities are ideally suited to trying a range of technologies based on local market conditions, and they are not tied to legacy investments. They are not tied to legacy business models, and in that way, they are an important opportunity for experimentation and innovation.

And these local choices and local experiences can really inform this debate. There are, at last count, 57 municipal networks that reach all the way to the home and business in the United States, primarily in rural areas in some of the most remote and conservative parts of the United States. I will add to this also that there are thousands of municipal and county fiber networks that connect schools, libraries, health care institutions, government buildings, such as firehouses and police stations and so on.

And there's 15 years of experience doing that. And in many cases, these networks either provider would be very interested in providing open inter-connection points for last mile deployers that want to push those networks even further out into the community.

When I say that we are in some ways an opportunity for experimentation and innovation, let me share a couple of examples with you that David encouraged me to share and to focus on. And these are hopefully, I think, little proof points that might be an interesting way to think about what can happen when the incentives of the operating entity -- in this case, an entity that is not focused primarily on profit, but is focused on community needs -- run in certain directions.

So here's an example. This is an illustration. In Montgomery County, just up the road from here, in Maryland, many of the elementary schools in the county, which has areas of great prosperity and wealth and areas of great poverty and both urban and rural areas, many of the elementary schools are served over fiber that was built by the county gradually over the past 15 years -- a very extensive fiber network.

Those schools receive a symmetrical 100 megabits in service, and the operating costs of the county, which does not charge the schools, is $71 per megabit per year to these schools that get 100 megabits.

The schools that are not served over city fiber -- excuse me county fiber -- are leasing T1s from a carrier. The cost to the schools per megabit per year is just under $2,000 after the e-Rate subsidy. Before the e-Rate subsidy, it's just under $4,000 per year, and those schools are getting 1.54 megabits. The schools served by the county at $71 per megabit per year are getting a hundred megabit symmetrical. I think that's an interesting proof point and one of many as to what is feasible when you have an entity involved in construction and provision of services that has incentives that run in the direction of greater bandwidth, more services, lower costs, and, frankly, ideally, competition.

My time is short, and I'm not talking nearly fast enough. So let me move really fast here, because I've got four more slides to get through, and I barely covered the first one. There are a range of drivers that drive municipal projects, particularly the ones that are focused on last mile, and getting to the home and business. The 57 municipal networks I told you about that currently reach the home and business are those that are operational so far. There are probably a couple hundred other communities that are in various stages of evaluation, including some big cities, like Seattle; San Francisco; Portland, Oregon; St. Paul. Seattle actually two weeks ago a letter to the mayor who, as one of the three main planks of his campaign, said municipal fiber to the home -- it's an absolutely key part of our future development.

Seattle is served by Qwest, and has no potential for seeing anything like what Dick just describe to us anytime soon. So the drivers in Seattle are all of the ones that you have here up on this slide. You get a sense of the things that they're very concerned about, ranging from economic development to community development -- the core things. Technology built Seattle, and they're very cognizant of it, and these drivers in terms of the way they think about architecture, and the way they think about the technology they want to use very much push toward more bandwidth, more coverage, full buildout, reaching entire communities and lots of services at affordable costs, because when you are a local government or a nonprofit or a consortium that is focusing on this kind of market, your success is based on how many people you reach and how much you develop -- you deliver to them as opposed to how much you generate from the smallest number of customers possible.

One of the key pluses that local

governments see in terms of building these networks themselves is the potential for community intranets, the on-network services that would never transverse the public Internet, where the bandwidth can be significantly higher. And from the standpoint, of some of the big cities that are considering this kind of technology, the real game changer is interconnecting their networks over long-haul fiber. And what's so interesting about this from the open access or the competition standpoint is the fact that when you have big fiber networks that are interconnected, a new provider can insert at any point on that network and reach an enormous subscriber base, including one that's potentially quite far away.

So, for example, the Utopia Network in Utah could be interested in interconnecting with the City of San Francisco, and a service provider in Utah could be providing services to San Francisco -- voice and video.

Now I have 27 seconds. I'm going to talk very fast. There's -- my colleagues here will talk about the debate over point-to-point versus passive optical network within the municipal network. Within the municipal community, there have been choices of both. There are a wide range of different choices about technologies. We would say the key thing should be local decision-making and local process as opposed to decisonmaking elsewhere in the country, and the flexibility of local communities and decision-makers who are answerable to the public rather than to the industry.

And then finally this -- something called enhanced PON, something David asked me address very briefly, is an emerging architecture that may be of real interest.

As the cost of PON has come down really dramatically, there is something of an emphasis still on point-to-point architecture because of the flexibility and the great bandwidth that it offers, but we are suggesting, and the city of San Francisco is evaluating because of its interest in open access, but also its interest in keeping cost of deployment down as much as possible that a variation on PON, we're calling enhanced PON, that looks a bit like this would give a certain amount of flexibility and options while giving us all of the advantage is of the lower costs of PON that have been realized through the economies of the fact that it has been the dominant industry choice throughout the world, but at the same time pushing up bandwidth and allowing direct fiber connections to some users.

The key thing here, from a municipal standpoint, where, a city like San Francisco that has been very focused on open access is one of the drivers of its investigation of fiber to the home is that there's always going to be a central entity. In any network, there will be some kind of central decision-making entity. Whatever the technology choice for the architecture choice, the key thing is governance. The key thing is going to be the commercial decisions rather than the technology decisions, is the true goal is openness or competition. Thanks.

MR. ISENBERG: Thank you, Joanne. Tim Nulty?

MR. NULTY: How does this work? Okay. My name is Tim Nulty. I've been involved in building rural telecommunications systems all over the world since 1985 and that include early adoption of all kinds of things like wireless local loop in rural Poland and fiber to the node or the building in Hungary and Sri Lanka. This is almost 20 years ago. Currently, I'm the head of a project to build universal fiber to the home in one of the most rural parts of Vermont, which is the most rural state in America, a fact not widely appreciated, and several other projects in extremely rural parts of Minnesota.

I'm going to take for granted, just to make this go quickly, I'm going to take for granted something that still may be debated in this room, and that is -- but it's not for me -- as far as I'm concerned, the issue is over -- and that is that universal fiber into every single premise is an absolute goal and necessity, and it will happen. The only question is how quickly and how it goes about.

David Reed's vision of fiber everywhere as the roads system and then various mechanisms for getting from some kind of fiber final connection point to the device I take as beyond debate now. It's over as far as I'm concerned.

And I'm going to go on and talk more about how and some of the things that most people seem to think -- well, some myths that I think are not true.

One is I will state flatly that in every single part of rural America where you can aggregate an average of at least 10 premises per mile, you can economically deliver universal fiber without any grants or any Universal Service Funds support whatsoever. Now let that sit for a minute.

The $7 billion we spend on Universal Service every year, which is approximately equal to the AARA money, if that were spent directly on building fiber networks, I believe that in three years we could wire the entire, absolute entire, rural America. We're talking 40 million people.

Now the economics of this -- the territory I just talked about everywhere less than 10 per mile. When you get into the really sparse areas, actually size matters more than density. It gets harder and harder to aggregate a critical mass of customers that will support the network.

And when you're down in the -- you know, you're in the 20 per mile area, then you can live with 6,000 to 8,000 paying customers will support a complete network. When you're in the eight or nine, then you need 25,000 or 30,000 paying customers.

And in rural America it gets hard to aggregate those kinds of numbers in really sparse areas.

Number two, the economics and the most rural parts, the sparser areas, are much better for community or municipal or some such, you know, co-op or something like that, than they are for traditional investor-owned. This is not necessarily true for the denser areas, but very part -- it does not mean they're not economic. They're very economic. But it works better for a municipal or community for the simple reason that the costs are lower. You don't have to pay -- they're nonprofit entities, and they're municipal, they have access to tax-exempt municipal financing, which is, even though it's considerably more expensive than the RUS, it's still satisfactory. You can live very comfortably in the most rural parts of America with financing of six, seven eight percent on these projects -- even nine percent in some cases. Another thing is if you take it as a policy goal, which we used to do in America, and, in fact, the Communications Act of 1934, which seems quaintly modern nowadays, states as a policy goal of this country that we will have universal access to telecommunications services. If we take fiber, universal fiber, as a goal, then open access, and by open access I mean nondiscriminatory access. I don't mean free access. I mean nondiscriminatory access is actually better for the economics than the opposite. Now that sounds anti- intuitive, but it's not. It's actually true. It's once you've decided to build this pipe, anyway you can get stuff on it, paying stuff of any kind, makes it better, makes the economics better. Number three, the electronics don't matter. A debate about GPON versus active versus electronic is really a relatively trivial decision, a relatively trivial matter. What really matters is the availability and the topology of the fiber itself. If you build a fiber network properly, so that it is transparent to the technology you hang on, it literally doesn't matter.

We're building a network extremely similar to the FIOS. It's one generation earlier because they started earlier, not because we're smarter. But the - it's one generation later because we started later. But it's essentially the same thing. PON makes every bit of sense at this point, from a price point of view, a maintenance point of view, a robustness point of view and so forth.

But the network we build, which is essentially a modified homerun or a modified point to point, makes it possible to upgrade, to change, not only the whole access network, access technology, but piecemeal. So right away, if somebody needs - if somebody in our area comes along and says a 90 megabit - 90/45 GPON multiplex circuit - is not good enough, you know, united technologies, I want more, we can patch right around and give them a gig, ten gig, or a terabit. We can provide terabit point to point services today to anybody who actually wants it, and you can do that because in a properly structured, modified homerun network, you can individually upgrade specific pieces customer by customer or customer block by customer block, and that's what counts. The fiber is what matters, not the technology that it gets hung on.

Now, in this area, we have a slightly different point of view from FIOS, FIOS structure is there, the topology of their fiber network rather differently from us, and the difference is very important, in my view, but otherwise, the networks are quite similar.

A final thing, it's not a technological point, and that is that optical fiber networks properly structured are the absolutely most perfect natural monopoly ever invented by mankind. What do I mean by that? They have - if once in place, they have effectively infinite capacity. The obverse of that means they have zero marginal costs, and they have very high barriers to entry, and finally, the services being provided, at least some of the services being provided, are considered extremely essential to the people getting them. That is the textbook definition, PhD from Cambridge, a long time professor of economics at Cambridge and Oxford, that is the textbook definition of a perfect natural monopoly. A perfect - the question is, should a perfect natural monopoly providing essential services be an investor owned activity? That's the real question. And I will leave you with that. I think I hit - I actually got under the seven minutes.

MR. ISENBERG: No, you're --

MR. NULTY: Oh, I'm one minute over, I beg your pardon.

MR. ISENBERG: Thank you, Tim. Herman Wagter from Citynet Amsterdam.

MR. WAGTER: Thank you, David. Thank you very much for the invitation and the possibility to tell a couple of things of what's going on in Europe and what our experiences are.

Citynet Amsterdam - to be short, I've been involved from the beginning in the idea of creating a passive or a dark fiber access operator in Amsterdam, which I've been doing for the last seven years, including all the lawsuits, legal issues, political and everything that goes with it. So I've been seasoned with that, but not as experienced as Tim and others. But what is happening in the debate in Europe is that, in our culture, we like our infrastructure to be quite well, and you see that the governments and municipalities think infrastructure as a competitive advantage, and they know it takes a long time and is very costly and difficult to do, but once you got it, it is something which will help you be competitive for a very, very long time.

To give you an idea, our estimates are that if we triple the capacity in the - market, it will take ten years if you do your best to roll out fiber to every home, which means that in the meantime, for the people - it's very good that these - or whatever is increasing its capacity because the amount will increase over time.

But the real debate which is going on is, if you look at the fact that we have competition currently which we like, and nobody is going for a utility owned infrastructure company, how do we get to an investment, and after that, again, to a level where competition is vibrant, because that might not be so easy.

To give you a little bit idea of our cities, they're all, going back, and the interesting part is that we have to dig, and that the density is quite high, but if you do look at the densities, there is an overlap with the densities in most urban areas in the U.S. And if you look at the cost of deploying fiber over there, and here I'm talking about our experiences of doing full point to point fiber, means homerun inside every apartment, then ten percent of the cost is fiber, ten percent of the other cost is other equipment, and 80 percent is labor, which is a good thing if you roll out - if you want to stimulate the economy because it's a lot of local labor. And if you go to more rural areas, less dense areas, what you see is that the amount of hard work grows and the amount of labor decreases, but essentially it's the same amount of money, which is approximately average for the Netherlands, 900 euros per connection.

I've looked up some data from the FCC, from - what the densities are in the U.S., and you see also there in the right hand corner that for 90 percent of the population, actually the densities are quite high, so relatively comparable.

The real hard question comes, like Tim said, on will it be a natural monopoly or not or how does it go. If you look at the average cost of all the investment, you accumulate all the investments done in - or, alternatively, from - to a backhaul to - or the - network, the ratio is approximately per connection one to three to ten. Of course, there are exceptions, but this is, in general, the ratio of costs. So the middle part of the internet is actually the cheapest, which is also true for electricity, gas and water, as soon as you get closer to the home, the highest part of the investment is over there.

The nice thing about the middle part or left part is that you can allocate - reallocate investments to use if you lose customers and you can incrementally increase capacity.

However, for the last mile of the local loop, there's only one potential customer who either takes the services or not or uses the - or not, and if you have an overbuilt, you have 50 percent if you divide it 50/50 of costs which is - or 50 percent of utilization of the infrastructure, which adds to the average cost.

So it's very clear that everybody has been delaying the investment of fiber, but the general idea is that it will need to be done in this time. So if you do this, this money question, and while utilization is such a high part, brings up the real question - question is, well, right now we have to access networks which are completing, but it seems like it's a historical accident. We used to have something made for TV and something made for telephony, we found out they both could do something called packet switching and other things, so now they're competing. But as soon as you start - somebody starts rolling out fiber, will somebody else roll out fiber in the same area? And in most cases in Europe, there is no evidence that people are doing that, there are more evidence of cooperations coming up to prevent it, like in Switzerland, where it's just dealing out with each other, you do this part and you do that part, and maybe we'll put in four fibers, because the fiber is not the most expensive part.

So it makes - the real question is, how do you get that cooperation, and after you get the rollout, which also might be that a cable company starts converting - fiber to the home, which we see in some places in the Netherlands, small cable companies do, do we end up with geographically separated, isolated monopolies?

If that is the case, then the question is the topology. I'm not talking about technology, I'm talking about topology, how you lay out fiber relates - makes competition easier or more difficult. And the lower part is the - what we call DPON and - network, which will make it very difficult. The Japanese variation is in the middle, and a point to point network is in the top. We've chosen for a point to point, although it's a little bit more expensive, because it will give a very long lifetime because it - almost any technology and any mix can be supported.

And the next thing is, if you do the E calculations, there might be a five, ten, 15 percent difference in investment, but the most dominating fact in any access network is utilization ratios.

So if you have open access and you have multiple users and you penetration goes up with ten percent, it immediately economically obliterates any CAPEX difference in investments, and that's a very, very tough thing.

So every customer, every line used by another operator is for - in infrastructure company $12 cash flow per month per user, which is a lot of money, which means that the real debate is, how do we get there, and how do we influence the fact that how we end up with a topology which will support as much competition as possible.

MR. ISENBERG: Okay. Thank you very much. Benoit Felton from Paris. Even though he sounds like an American, he's really --

MR. FELTON: I'm from Yankee Group.

Okay. I'm actually going to very - okay. So the slide on who I am got squeezed, it doesn't matter, I'll tell you who I am. It's actually fairly significant that I'm French in this context for two reasons; the first one is that I live in Paris, which is right now kind of in the middle of all the fiber happenings in Europe; and the other reason is that being French, I know all about cultural arrogance, and so I want to highlight the point that I'm not here to give you lessons, but I am here to hopefully show you what's happening elsewhere in the world, and I'll leave it up to you to see if you want to see that as a lesson or not.

There's been a lot said about the various service levels that you can get out of various technology choices, so I'm not going to go back to that in any depth. I just want to point out one thing, which is that there are many areas in the network where you can have bottlenecks, not just the access, but the access is the only area, I'm going through this really quickly, but it's the only area where the technology choice actually makes a difference. All the rest is choices about how you manage your network, but it's not dictated by your technology choice.

The second thing that I just want to say about this slide, and, in fact, I don't show LTE here, but I could have, because the message is, don't look at top line speeds, top line speeds tell you nothing, average speeds tell you everything. And very often technology choices and vendor discourse are focused on top line speeds, and that's not a sound measure of a technology choice.

Now, interestingly enough, I'm going to contradict myself immediately by talking about available service speeds. I did this little exercise, having discussed it with David, to try and see, I hope the map is big enough for you, it's certainly not big enough for me, but to try and see how the availability of 100 megabit service evolved over time.

Two years ago, in 2007, the only places

in the world where you could get the 100 megabit service were Japan, a significant portion of Japan, a significant portion of Korea, a few cities in Taiwan, and Hong Kong, and Stockholm. So that's the single red dot here in Europe.

Two years on, this is what the map looks like. You can see that things have expanded in Asia, you can get 100 megabit service anywhere in Japan, more or less, anywhere in Korea, anywhere in Taiwan, still in Hong Kong, obviously, but you can get it in Paris, you can get it in Montpelier, you can get it in - you can get it in Lisbon, you can get it in Bucharest, Sophia, Moscow, Amsterdam, of course, and most places or a significant number of places in the Netherlands, most places in Sweden, Denmark, Norway, and Lithia, and in Helsinki, and Finland.

MR. ISENBERG: There's one dot in the U.S.?

MR. WAGTER: Right; there's one dot in the U.S., which is Cablevision's 101 megabit per second service in New York City. I'm going to come back to that in a minute. So this is only two years, so we're not talking about a large amount of time. Now, I'm assuming that if I do this map again in two years, there will be red dots more or less everywhere, and hopefully there will be a lot more red dots in the U.S.

But I want to challenge you with this view; this is where you can get one gigabit per second service today. Hey, Japan, Korea, and Hong Kong, and Taiwan, no, not Taiwan, soon, and Sweden. So in two years time, if I do this map for one gigabit per second, probably the whole of Europe will be red dots, as well. Again, will the U.S. be? I don't know, but this is what we're talking about.

MR. NULTY: Burlington, Vermont.

MR. FELTON: One gigabit per second?

MR. NULTY: Yes.

MR. FELTON: Commercial offered to customers?

MR. NULTY: Yes, offered if they want it, yes. Not many people take it.

MR. FELTON: Okay. I'll add it to the map.

MR. NEWMANN: -- service, right. I can get a gigabit in the U.S. anywhere I want if I want to buy OC --

MR. FELTON: Sorry, I should have been clearer. This is end consumer packages. This is services that homes can subscribe to at rates that are certainly higher than your regular service, but they're reasonable for a home. So, for example, in Hong Kong, you can get that service, one gigabit service for 250 Hong Kong dollars per month, which is roughly $100 U.S. per month.

MR. NEWMANN: Okay. That's what I wanted to find out, what you're defining as available.

MR. FELTON: So the second question inevitably is, why are we focusing on speeds, and this question was asked in the first panel, and I think there were some very good answers given. What I wanted to do here is just map, not so much by speed, but by what the technologies allow you to do in terms of speed and latency. This is a view in time of the services we're talking about. So you might be able to do a single HDTV stream with ADSL today, you can't do two HDTV streams with ADSL, so you're already in VDSL territory or DOCSIS-3 territory for that. If you wanted to have your hard drive in the cloud, well, depending on the amount of data that you shift in real time, you might have enough services with VDSL, but you might not, you might actually need fiber to be able to do that.

And then, as you can see, all the rest actually requires very high quality DOCSIS-3 or fiber. If you want to be able to homework in conditions that are equivalent to what you do in the office, you need fiber, because the low latency is crucial. And again, it's not necessarily the speed. Using wordover network doesn't use a whole lot of band width, but if you don't see what you typed, then you don't use it, that's what we're talking about.

And finally on this slide, the thing I

want to highlight is that video communication is going to be a crucial part of what these networks allow. Interestingly enough, it's maybe the only service that we talk about in this context that is something that kids were dreaming about 40 years ago, thinking that they would have that in the year 2000, well, they don't, and they might, but we've still got to get there, and if we want to get there, the networks have got to support that and they don't today. The last thing I want to talk to you about is price, because, of course, this is crucial, as well. This is a comparison of 600 megabit download offers around the world. I'm not going to go through each of them, but you can see that, first of all, Cablevision's offer that I mentioned today is by far the most expensive.

You can also see that the offers that you see in Asia are significantly cheaper in general than in the rest of the world. And I want to focus finally on the Hong Kong broadband network offer, which is the third here in that line, and is also the cheapest in this set of offerings.

This price is only very recent. Two weeks ago, Hong Kong broadband network announced that they were dividing the price of their 100 megabit offer by two and a half. It used to be two and a half times more expensive. They shifted it to what is the equivalent of now $17 U.S. Per month price, sorry, purchasing parity directed. Why are they doing that?

I mean it may sound like an insane business decision, it's not. They know that by doing that, their market share will go for 20 percent to 40 percent, and their revenues and their margins will grow in the same proportion. Once you have deployed the network, any strategy is good if it gets you more customers hooked up to that network. Focusing on getting more revenues out of the customer is less efficient than focusing on getting more customers on the network at lower revenue points, and that's what I wanted to conclude on.

MR. ISENBERG: Thank you very much,

Benoit. I invite my colleagues from the FCC, if they have any questions. Jon Peha.

MR. PEHA: I want to follow up on a comment you made, Herman Wagter, to anybody. You said that you - you chose a point to point architecture, or topology, excuse me, gave you greater versatility, a greater potential for competition, cost an extra five to ten percent. You didn't talk about this, but I assume it also matters where aggregation points if you would go to it the GPON way.

What I was wondering is how reversible such a decision is. How hard is it if you had gone a different direction and then decide, you know, decided at some point later that you wanted that versatility and that ease of competition.

MR. WAGTER: We've done some rough calculations based on what we know is that if you subtract the part which is already inside the building, because that's individual for each customer, and it's a large part of the investment, it would take us another five to 600 euro per customer to reverse the decision, if you would have deployed - with deep splitters, meaning splitters and cabinets underground very close to the customers. We cannot put cabinets in the street, everything has to be on the ground. So if you put splitters down there, you have to reverse it to point to point, it will add another 600 euros.

The - we'd also note some calculations on a life cycle. If, for instance, at some point in time you'd have to do a mid life upgrade, would it make sense financially, or if you had to write off the - network and redo it again after 15 years and the point to point could do 25 years, you mainly see that the price points and the investment levels economically are more or less the same, so you trade off.

What really hits home every time, and I cannot stress it enough as - as soon as you start adding up, saying let's open this up, which we can do because you can mix technologies, if you want GPON and you want something else, because we don't operate, we don't do the electronics. People come in and stole electronics and deliver services. As soon as the actual penetration goes up, which means the utilization of the network, it financially obliterates any extra cost you've made. An extra ten percent is way more economically viable with than anything else, and that's the reason why our incumbent has joined forces in this and is going to be operator on this dark fiber network and is saying I'm actively encouraging other operators to be joining me in this network because it will make more money, it just will make more money, that's what we learned from - these are public statements from - incumbent, is that it's - before the tooth and nail, but in the end, it just makes more money if you happen to have an access network - the rest is closed.

MR. ISENBERG: Tim Nulty.

MR. NULTY: Because this issue is extremely interesting, I mean I think it's actually one of the most important questions in the whole debate, the desirability of point to point, to me, is a given and obvious. The numbers and the economics that Herman has quoted I would suggest are highly dependent on the densities, because we really looked at this stuff very intensively. When you have your normal head end, central office head end, a modern IPTV kind of world can easily in a building, you know, not much larger than this room, can service 100,000 people, and you want to have as many people as possible because you're spreading a large expense over the lot. A hundred thousand people in a rural area means you're going to be serving people 150 miles away, you can't do head end, you can't do complete 100 percent pure homerun when you're serving people 100 miles a way, not only because of the cost of it, but just the sheer problem managing these cable runs, 864 cables running, it just can't work.

So what you have to do, given that point to point is the desirable end, is to say how can we move the aggregation point as far upstream as possible and as close to the central office as possible, and that's driven by two things.

Our actual choice is to have the aggregation points secure buildings, not cabinets, I hate cabinets, won't have cabinets, so they're forbidden. Any vendor who comes and tries to sell me cabinets is shown the door. A secure building that is lighted, heated and secure, 20 - 30 feet square, like that, and to have a minimum, you can manage comfortably up to five or 6,000 customers coming into one of those things. On the other hand, the DB loss of the lasers is typically, if you want to be really reliable, no more than 20 kilometers. So you draw 20 kilometer, by root 20 kilometers, not just a circle, around these little remote hubs, and you try and do that so you get as close to 3 - 4 - 5,000 people in them as you can, and that's where you get your best economy.

In a building like that, you can get virtually all, but quite, but virtually all the - 80 or 90 percent of the benefits of true point to point because in a building like that, you can switch out your OLT's, you can put new stuff in, you can have co-location, customers, you know, other - or service providers who want to get onto your network because you're open access. In our area of 600 square miles, we'll have nine of these things. It isn't very hard to get a person into the --

MR. ISENBERG: Thanks, Tim. Okay. I'll ask people to keep their answers a little bit on the succinct side even though we all - we know that here on this panel we have experts with direct hands on experience, and, in part, we'll be delving into that after the panel later on. Stagg, did you have a follow on question?

MR. NEWMANN: Let --

MR. PEHA: I'm curious about Tim's point and what the views of the other panelists are. Has the equation changed for rural areas that we can expect to see fiber deployment and investment in the rural areas?

MR. LYNCH: I think the best way to answer that question is, that as the technology continues to improve, the optics improve, the methods and procedures that we use improve, you're going to continue to see that economic break point moving out. And, for example, now with FIOS, we don't have to put a head end in every central office.

You know, I think Tim mentioned 20K before as the logical reliability limit for fiber, that's been stretched, that's well beyond 20 now. And, in fact, I think on the first panel somebody said it's up to 60 kilometers. I think it - maybe that's a stretch as to whether I want to deploy that far out today, but I think you will continue to see the march towards the more rural area being more economic, regardless of, you know, individual opinions here on the panel, it will continue to move on.

MR. WAGTER: Okay. Although I'm working in the city where the densities are extremely high, we do a lot of rural areas, and especially in other countries like Norway. What you see over there is that the cost of the fiber and the pipe isn't that much of a problem, it's the labor. And as soon as you can get people to dig themselves, and communities, like fiber to the farm in Norway, the equation changes enormously. Furthermore, if you do it in cooperation, like many of the cooperatives or energy that are existent in the U.S., you have a 100 percent penetration which helps also.

MR. FELTON: I just want to add one last point, which is the question of how you define economical then becomes crucial, as well. Obviously, as Joanne was saying, municipals don't have the same framework for what's economical as most, you know, private companies who depend on shareholder money.

Usually it's going to be very hard for - and, in fact, you know, to me Verizon is a very interesting example because they're one of the few companies that has had the guts to turn to the market and say, yes, this is a long term investment, and we're doing it nonetheless, but I see a lot of incomes around the world that can't or don't want to do that.

But basically, in a three to five year time frame, even an urban deployment is not going to pay for itself, let alone the rule of deployment. If a municipal like the city of Pau, for example, is looking at a 15 year return, then yeah, sure, it works, and it's economical by their standards.

MS. HOVIS: And I would add to that that of the municipal networks that are out there, perhaps the seven are in suburban areas, not as urban, the rest are in small towns and their surrounding rural areas, and they use different kinds of technologies, topologies, architectures, different business plans, all very local, but they are making it work. There has to be something happening, that's right.

And I should add that they're making it work over some pretty tremendous odds, including frequent threat and reality of litigation and to competitive PR campaigns. And so there's some networks that had to fight three years of litigation before they were able to even start construction. So there are costs and delays associated with that that they - that are not faced otherwise.

MR. ISENBERG: Thank you. Stagg Newmann.

MR. NEWMANN: First, an observation, slightly humorous but with a point to it. I have a three step proposal that Blair rejected to dramatically change the U.S. adoption, that was first put a teenager in every home, second, construct pre-wired fiber high rises in all the metro rings in the U.S. that will accommodate about three million people, and then relocate all but the two percent of Americans that are necessary to maintain rural America to the high rises, very low communications costs for that.

The point of that, and it's really a plea, not a question to the panelists, is, we are acutely aware of the cost problem to pushing fiber deeper, and we want to come up with a whole set of very specific policy objectives that can really lower those costs, such as when trenches are open, let's get fiber in them, et cetera, et cetera, and so very specific suggestions on policy levers that we can do to lower the cost of pushing fiber out there, because it is primarily a civil and political engineering problem, not a technology problem would be most appreciated.

A question I do have for each of the panelists, particularly those of you operating networks, is, what applications or usage characteristics are you seeing from your users on the fiber network that we are not seeing on DSL or HFC networks, these networks that support the really high speeds, how has the usage or applications changed?

MR. NULTY: Actually, the - although the business plan of a fiber to the home network is based currently on a triple play, that's actually the most boring thing. And just an example we're finding in Burlington, where people have, you know, real fiber, an increasing number of people who are dropping, just canceling their cable service, even though the cable service is much better than the alternative, we concurrently provide 100,000 fully uncompressed HD channels.

That's much better than people canceling it, because they're finding - one by one, it's not happening mass, but it's happening, people are finding, you know, they got their Roku box and their Hulu, and the internet speeds are so good and so reliable, they're finding that nobody watches it anymore, including the kids, and they're canceling it, which actually we like, because the cable business is a lousy business, and the quicker we can get out of it, the better, which you may feel, as well, I don't know.

The other things that are really happening and just beginning to take off are the kind of things that you can't do without fiber, and that's genuine, as he described before in the last panel, genuine interactive education and interactive health care. You simply can't do interactive MRI's, real time doctor visits and so forth on anything that isn't extremely high speed, and that's beginning to happen.

MR. NEWMANN: Are these - the things like that, are these business to business, home to business, or home to home that you're seeing?

MR. NULTY: Both; I mean one of the interesting things about the fiber network is, although you're constrained with - in terms of your access to the upstream internet by what it costs to buy band width from tier one and tier two people, so peoples' internet service is typically in the seven, eight, nine, ten megabit, but to one another, internally, inside the network, in Burlington is 22.5 up and 45 down, which effectively means 22.5 symmetrically, and a lot of that is beginning to happen back and forth internally.

MR. ISENBERG: Herman and then Dick Lynch. But --

MR. WAGTER: Okay, I'll start.

MR. ISENBERG: Please.

MR. WAGTER: There's three observations, the - or two observations, the I'm busy investigating or getting my hands on the data of a relatively small village where the fiber penetration is up to 80 percent across all age groups, which is about 7,000 users, and I got my hands on a graph of the accumulated users of data up and down over time, and to my great surprise, the amount of data going up was equivalent to the amount of data going down.

We haven't got our hands yet on it, what's the reason behind it and why is that, but that is a significant change in user - for the small city. We're going to investigate what's exactly happening there. Now, what we see in Amsterdam, in the bigger cities, which is a totally different arena, is that the first users immediately start placing home servers, and also bringing their small individual businesses to their home.

So many people with a Mac, working for the media, going with video files for commercials want everything, and just being able to send these files ten minutes before the deadline to somebody is great.

Reporters on motor bikes with raw cameras, who take raw pictures in a raw format which are ten megabytes per each and dying to - we had a place open with three - megabits wireless connection, and they always went there for coffee and - laptop open and sent the files because they could send it. And so the home server and the small business type thing dominates the first wave, the second wave you have to see.

MR. LYNCH: Let me give you a little comparison here. A typical FIOS user uses about three to four times the capacity per unit of time.

MR. ISENBERG: Of the - three to four times?

MR. LYNCH: Three to four --

MR. NEWMANN: Compared to DSL.

MR. LYNCH: -- compared to DSL. Now, ask yourself why that is. And you can talk about specific applications, but the essence of what we see is that the FIOS user is much more comfortable with the latency of the real time capability and the up links performance, and so it drives two way video, it drives two way music.

So it's essentially driving streaming set in another way, which, you know, a DSL connection or probably a typical - type cable connection available today really strains the capabilities of other systems to do that kind of thing. So it's the consumer seeing - and I'm talking consumer now, I'm talking the averages that I personally - subscribe to peak numbers, I like averages. So in terms of the average, you're driving it through video, you're driving it through the two way capability of the fiber.

MR. ISENBERG: Anybody else?

MS. HOVIS: This is to some degree projected, but I can tell you what's driving a lot of the municipal decision-making, and some of it is already happening. So in Lafayette, Louisiana, one of the key applications is distributed development of software, of video, of gaming, technology that people in multiple places can work together as if they were sitting in the same office working on a --

And the city of Lafayette has very, very consciously cultivated that and brought its business community in and extended open invitations to people in other parts of the country who'd be interested in using this and experimenting on the network.

This, by the way, is also the thing that drives the city of Seattle, that really set off its planning toward fiber to the home several years ago, was this concern of where are the software developers going to go if they don't have the kind of band width they need to be able to collaborate with their partners and their counterparts around the city, around the country, and in the rest of the world, very importantly. And what that means in terms of the distributed development, the kinds of speeds we're talking about here allows every home or business to become the equivalent of the university. On a network like that, you're able to function in the way that a researcher or a university or a software - a code writer at a university could over one of the regional optical networks, where they have that kind of capacity.

The other big thing that we see as a driver, again, thinking from a municipal perspective in which the focus is not on entertainment is various forms of aging and place and tele health applications.

So the city of Portland, Oregon, in its fiber to the home pilot which is in the planning stage, has been very focused on working with the non-profits that currently have aging in place, pilots, and require more band width.

In Case Western Reserve University, in a partnership with about 50 local non-profits and local communities, including in some areas of just utterly extraordinary poverty that surround the university, has had a real focus on tele health, as well.

For example, the constant monitoring of people with diabetes in their homes, that would allow them to stay home and not have to make constant visits to emergencies rooms or hospitals, but also allow them to live at home, because in some cases it takes just 24 hour monitoring of various aspects of their health. So that's been another key driver that we think is pushing toward a lot of the non- profit municipal deployments.

MR. FELTON: I just want to add one last thing. Service providers that offer fiber services don't offer very differentiated services from triple play today. So it's easy to draw the conclusion people are not doing anything different with fiber, but to a large extent we have to realize that it's not being offered to do anything different with fiber.

What's interesting to me is that I think in the next couple of years we're going to see two waves of new services emerging, one which will be the service providers themselves as they need to further the differentiation with DSL and cable to accelerate migration of customers to the fiber networks.

The other one is going to be the googles and yahoos and twitters and facebooks of this world as they start realizing that there's a critical mass of customers there that's big enough that you can start addressing them specifically. The interesting consequence of that is going to be that for existing DSL grade users, the internet experience will degrade.

MR. ISENBERG: Tim.

MR. NULTY: Just adding two examples, the largest private sector employer in the state of New Hampshire is Dartmouth Hitchcock Hospital which is located in Hanover. And a large percentage of the medical staff at that place actually live in Vermont.

We approached Dartmouth Hitchcock to support our project and they did so, but they've said they don't actually need it themselves, they're not much interested, they've got all the band width they need as an institution, what they care greatly about is the fact that they can't reach their medical staff, and that having the kind of fiber network we're building to their medical staff, to their home, is of intense importance to them, and nothing else will do.

They cannot have real time analysis of MRI's by a specialist doctor looking at somebody who's just come into the emergency ward any other way. Another example is the Vermont Law School, which is in our area, has told us that they suspect - they are quite fearful and they expect that within five years, their ability to exist as a free standing law school in rural Vermont, a quite successful and well regarded one, will if not disappear, certainly degrade badly because they won't get customers, kids won't come where this doesn't exist.

MR. ISENBERG: Thank you. That is actually consistent with many things that I've been hearing. The ability to work at home at high res is just huge.

MR. NULTY: Right.

MR. ISENBERG: I have now - finally I have time to take some questions from the audience and from the internet, and I thank the audience and the folks out in net land for hanging in there and for their participation. So one question here is, especially for Verizon, and it's about last mile congestion, and the question is, do customers see their speeds drop at any point, and if so, how often does this occur? Do your end user networks get congested? Start with Dick Lynch.

MR. LYNCH: Well, I have to I guess answer the question in a couple of layers, because sitting here as an engineer being asked the generic question, do your networks ever get congested, certainly you engineer them so that the congestion is not seen by the end user, that's your goal, you don't necessarily always get there, so I'm not going to say that it's never happened. On the other hand, if you're asking me about DSL versus FIOS, I think we have to look at it from the access point. The DSL connection clearly aggregates back at the central office and no sooner than that. So if you talk about the access point on DSL, that remains uncongested because it's yours. When you get back to the central office, it's always imperative that we continue to drive that aggregation technology for minimum blockage, but there will be blockage, whether the consumer sees it or not is all - the engineering challenge.

In a FIOS environment, you're talking about sharing a two point for gigabit down link pipe, 1.2 up, among 32 consumers. So when you do the statistical multiplexing that was mentioned here earlier today, it is highly unlikely that you're going to see congestion in that end link using FIOS, as well. So again, you're back to the back bone, you're back to the aggregation point and beyond, and the challenge we constantly have is that the growth sometimes surprises us, but the engineering objective continues to be the deliver to the end user customer, that which they are paying for.

MR. ISENBERG: And as a FIOS customer at home myself, I have to say that's mostly my experience. But I do notice, and this is an anecdote, so please treat it as only anecdotal, but I've noticed several times around 3:30 or 4:00, when kids get home from school, that the network responses do tend to seem longer.

MR. LYNCH: Again, a lot has to do with where that point of congestion may be.

MR. ISENBERG: Okay, sure.

MR. LYNCH: Is that at the server, is it in the back bone, is it at a point beyond the network, network interface, somewhere else, because it's a popular site, so it's hard to be specific, but I'm not going to say that we've never had congestion on the network.

MR. ISENBERG: Okay. Do you mind if we beat up on you one more time?

MR. LYNCH: I'm used to it, go ahead.

MR. ISENBERG: Here's one that - actually, I'm, you know, as a fiber to the home advocate, and I guess I - I'm not sure whether I can say that with my FCC hat on or not, but it's better to ask forgiveness later as we in large organizations know. So the question came in, current demand for Verizon 50/20 is low, it costs

$150 a month, how much do you expect demand would increase if it were $50 a month?

MR. LYNCH: I'm going to answer that by saying that's a marketing question.

MR. ISENBERG: Fair enough.

MR. LYNCH: Look, I mean reality says - I mean economics 101 says that if you lower the price, you're going to get more people to buy it. But the real question that we have to assess is, what is the value proposition for the customer versus the business, and that will always be the balance point for the pricing.

MR. ISENBERG: Okay.

MR. LYNCH: So I can't directly answer.

MR. NULTY: Can I defend Verizon? It's not something --

MR. ISENBERG: You're not supposed to do that, but go ahead.

MR. NULTY: The point Dick Lynch made about where the bottleneck occurs is extremely important. Traditionally, the upstream network as a whole has not been the bottleneck compared to the final mile. With a fiber connection, exactly the reverse happens. There's very little bottleneck on the final mile, and the bottlenecks upstream become the controlling factor. So, in fact, in Burlington, we don't offer a service, an internet connection service of more than eight megs because if you do, they'll never find - they'll never experience it because the upstream bottlenecks, wherever they occur, will almost always control and people will feel cheated because you've told them you were giving them 20 megs and they can never get it because the bottleneck is upstream, not downstream. It's an extremely important point that is not commonly understood.

MR. NEWMANN: Let me just put a point on that. If you look at flows across the internet, say California to the U.S., the TCPIP protocols today can typically not support flows more than a couple megabits per second, from what we've been told. You said you were really high - streaming applications are your local ones where they stay within your network.

MR. NULTY: Right; well, but I mean the point that's been made earlier about the importance of latency remains in place even under this condition. The lack of latency with the higher speeds remains a characteristic.

MR. NEWMANN: Agree, and that's why a thing like local content and delivery and all that becomes so important to this environment, yeah.

MR. ISENBERG: There's a question from the web about the longevity of your capital investment in fiber and in other technologies, and the analogy is made to the rural electrification act, where we are still seeing the benefits of infrastructure installed back in the 1930's, and so the question is, what are the lifetime expectancies of these various investments?

MR. NULTY: The single most stable and inert substance I think known to mankind is glass. I spent a part of my life as a senior official in the disposal of nuclear waste. We dispose nuclear waste; the primary and best way to do it is by incorporating it in glass, because glass will last more than the 25,000 years which the - is the half life of the most dangerous elements in nuclear waste.

Nobody knows how long glass will last. As long as the copper network lasts, which is wonderful, the fiber - the one thing we know is it'll last a lot longer.

MR. LYNCH: I'm not going to argue, sand is pretty good, it stays around. But I don't think that the question is how long will the stuff physically exist, it's how long will it have a useful life. And I think that the fiber useful life is yet to be found because I think it extends well beyond the view and capabilities to envision the future requirements from anybody in this room, and I will take the liberty to speak for everyone in that regard. The electronics is going to be outdated very quickly. You can't expect any of the electronics, any of the active elements in any of these networks to last more than probably five or six or seven years, and the reason I say that is because were going to need lower latency. We're going to need higher capacities. When you have active elements, they do deteriorate and at some point they will fail. So you take all of those things into account, and the fiber doesn't become the issue. The fiber I would agree with Tami, it's going to be around a long time.

But you've got to watch your active elements; watch your capacity; and you've got to stay out of the plant. The more you move the plant around, the more likely you're going to be to break it. And we've learned that from 100 and some odd years of copper. If you put copper in and leave it alone and never move it around, it lasts fairly well. It may not do what we want it to do, but it does last.

So we've got to stay out of that fiber plant.

MR. ISENBERG: Good. Okay. Question that I have. I asked you earlier what about the suitability of FIOS for non-residential services, such as LTE backhaul, et cetera, and you said FIOS can do that. And so my follow-up question is how can -- what is it that gives FIOS the flexibility and capability to do that because isn't, for example, LTE symmetrical inherently? Could you speak to the properties of LTE backhaul and Verizon's fiber capability?

MR. LYNCH: Sure. Let me first of all tell you that every wireless carrier today has a vision and a desire to get to a fiber backhaul to every cell site, and you don't need LTE to want to do that. There's a wide --

MR. ISENBERG: And right now 20 percent?

MR. LYNCH: -- it's probably higher than that.

MR. ISENBERG: Okay.

MR. LYNCH: It's probably higher than that. My guess is 40 percent today, something like that.

MR. NEWMANN: Yours or industrywide?

MR. LYNCH: Verizon Wireless.

MR. NEWMANN: Verizon.

MR. LYNCH: Yeah, but I know that the

industry is all that different that that.

But to your specific question of can FIOS deliver backbone capabilities for LTE. Yes. And, in fact, historically we as an industry had this what I would call rather strange demarcation between what we call inter- office capabilities and endlink capabilities. And there is no technical difference to the performance for the user at the end. We just had this structure set up that we did it one way or another way.

What we've said is, look, fiber is fiber. It can perform just as well as any of the old inter-office fiber or inter-office facilities, and so for us delivering to a LTE backhaul, delivering to a Femtocell, delivering to a business is all about what the customer wants to liver, and if you can do it over FIOS, do it that way. And that, in fact, is the way we're delivering most of the backhaul to customers today.

MR. ISENBERG: Okay.

MR. LYNCH: Okay. Anybody have a

burning follow- up point or in the audience a burning question? I knew Dave Burstein would raise his hand at that. David, please?

MR. BURSTEIN: This is (inaudible) talking about having minimal congestion.

MR. LYNCH: Is this a pick on Dick Lynch meeting or?

MR. BURSTEIN: The best network engineers in the world in this room, and I'm not going to ask folks who are consultants when I got a world-class engineer.

MR. LYNCH: Thank you.

MR. BURSTEIN: We're talking -- you're saying that there's very little congestion in FIOS; agreed. Can you put a number on it? About how many hours, say, per month would a typical FIOS customer see 20 percent degradation and, say, 50 percent degradation? Five hours a month? Five hours a year? Five hours a week?

MR. LYNCH: To be perfectly honest, and I do mean us honestly, I'm not trying to hide a number. I don't have one that I can give you.

MR. BURSTEIN: Can I ask you to follow up?

MR. LYNCH: You could ask me to follow up. Yeah. But I don't really come prepared with that kind of number. Yeah.

MR. ISENBERG: Okay.

MR. NULTY: I can give you an answer. At Burlington Telecom, we did extremely close traffic monitoring because we wanted -- we had a, you know, a commitment that we would provide -- when we said we would provide X amount, that's what you got all the time. And the problem was never, actually never to my knowledge, the downlink. The question is always -- the customer experiences a degradation. Where did that degradation come from? Was it in the downlink or was it higher up? That's the problem.

Nowadays, in those few places that have a fiber downlink, a fiber local link, a final mile, in our case we never saw a single situation in which experienced degradation was due to congestion in the final link. It was always higher, and the way we dealt with it, because we had a constant dial-up, dial-down relationship with our tier two and tier three providers, the minute we saw any sign of usage getting close to the point where it would cause degradation, we dialed up the tier one, tier two, three bandwidth (inaudible) so that it went away.

Now as an interesting fact, you know the old 80/20 rule with traffic. In Internet that's not that. At least in our network, in any given month, 10 customers, count them, 10, take up 85 percent of the usage. It's never the same 10 -- never the same 10.

MR. WAGTES: This bandwidth usage thing, there is an interesting study by -- in Japan done by Mr. Cho, which also shows in aggregated over millions, five millions of users of 100 megabits or something like that, that approximately five percent of the users are very heavy users, but every second the five percent changes.

MR. ISENBERG: Very good. Okay. David Reed has a comment.

MR. PATRICK REED: Yeah. My comment is -- and maybe it's a question is that I was sort of a little bit disturbed by Stagg Newmann's comment that you can't get across the United States at a rate more than about a megabit. In fact, I do actually track that a great deal, and, in fact, was also asked in the CRT hearings over the past summer, which were about network management, to dig into that, which actually was a big part of the Canadian thing, and let me just finish. So what is pretty clear is that, as everyone on the panel has already said, is that congestion appears at various points in the network; right? And oftentimes it's dependent on how much built out it's been and so forth.

But what seems pretty clear about the U.S. Internet backbones and the U.S. Internet services, that is, essentially the clouds or the data centers that are run by Google and Amazon and so forth is that those are capable well above 20 megabits sustained capacity across the United States to almost every point. And what limits things today sometimes is the local network, but it's almost never a fiber-based local network, and it's not often the hybrid fiber coax networks if they are configured well.

Where I think most end user experience today suffers is not very well provisioned servers. That's kind of a first order thing, and that was alluded to, and then where it will start to happen is in some cases those laggard end user providers, the low-end DSL providers and so forth that aren't investing to keep up with demand and keep with the Googles and the Amazons and also the service providers and so forth, and what seems to happen is an economic progression. As you create what Benoit talked about a distinct customer base that is significant enough, you know, that service providers will invest against it, you know, then, you know, you'll see the ratcheting up, and the expectations will continue to ratchet up to whatever level we can predict.

So I just wanted to clarify that process. It's a process. It's not any point in the network that is driving it.

MR. ISENBERG: So thank you all for -- thanks to the distinguished panel. Thanks to my mentor in ways of the FCC, Stagg Newmann. Thanks to our other distinguished FCC participants, and to our volunteers back there on the computer, loading the viewgraphs and the timer, and the question collectors in the room and on the Web. Thank you all. I think it was a really great panel.

(Whereupon, at 1:11 p.m., the PROCEEDINGS were adjourned.)

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I, Carleton J. Anderson, III do hereby certify that the forgoing electronic file when originally transmitted was reduced to text at my direction; that said transcript is a true record of the proceedings therein referenced; that I am neither counsel for, related to, nor employed by any of the parties to the action in which these proceedings were taken; and, furthermore, that I am neither a relative or employee of any attorney or counsel employed by the parties hereto, nor financially or otherwise interested in the outcome of this action.

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