The Policy Implications of End to End
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Panel 8: Yochai Benkler, Dwayne Hendricks, Dale Hatfield, Howard
Shelanski.

MODERATOR: Okay. This is a perfect transition. A
perfect transition to a set ‘cause I need some other people here.
I need Benkler, and I need Hatfield, and I need Dwayne up
here, and that means Andy, you’re gone. I mean, you’re the only
one that says nice things about me and so it’s hard to get rid of
you so easily, but —

Okay. Let’s bracket this question for a second. I just want to, I
want to bring on another set of — some more information here
to complicate the debate a little bit. This is the information that’s
going to be completely familiar to some people. Just give me a
second, okay? I mean, I’ll recognize you in a second, unless
you want to keep your hand up. I want to — I want to introduce
some information about how we regulate spectrum, which is
fundamentally — which is, yes. I’m sorry, you too. Yeah. Yeah,
although we’re going to have a chair problem for a second.
Okay? Take that chair up.

SPEAKER: Yeah. I was going to say you may get to me, you may not get to
me, so maybe I’ll just sit down for the time being.

MODERATOR: No. No. No. Let him bring the chair, that’s fine.

Okay. The question is, how we allocate spectrum. Peter Huber’s
statement was, giving what we’re doing right now, you’ve got to
have this existing structure. And that raises the question of other
ways to start using spectrum that might change how we build
these devices for the future here. Now, I want to introduce them,
first the question, which is [??], but not to everybody of ways to
allocate or use spectrum. And so Yohai, this is an opportunity
for just a brief discussion of that.

BENKLER: Yohai Benkler from NYU Law School. There were, up until say a
decade ago, as a practical matter because of the cost of
processors in consumer devices. There was — some people
thought, two, I would say now, one way of allocating spectrum
though two ways that I think are one, were either licensing by
the FCC or something like a market. The basic assumption was
someone had to — using traditional wireless technology, someone had to decide who would be the most powerful signal in the given channel. That one, originally, at least since the Radio Act of 1927 was the FCC plus the licensee. And at least since ’59, maybe since ’52, there is a competing argument that, in fact, that should be a property owner and this is obviously causes critique, and auctions are a very poor distant cousin of market-based allocation with the idea that, in response to different marketing centers, owners will allocate and assign spectrum to the best highest value use.

Once processors become cheap enough to enable a spread spectrum and frequency — both frequency [??] command direct sequencing spread spectrum, sharing of spectrum, we get a new, in a sense, more fundamental choice that, with some poetic license, can be said to mimic the question of end-to-end versus intelligent network but at the level of institutional design. And that is the possibility of license-free spectrum where there’s no such specific license and the decision about who uses which frequency is for what use is not done by any actor, via the licensee, or an owner, but is done by a series of equipment imbedded protocols that coordinate and clear usage of frequencies on a transmission-by-transmission and essentially packet-by-packet basis by coordinating with each other. This introduces a real fundamental choice as opposed to the one between licensing and markets, of whether or not you have the decision made by an owner or a controller of a channel. You specify a channel and you specify someone who controls how it’s used as oppose to at the ends, as it were, among the users using equipment imbedded protocols to permit them to share very wide [??] of spectrum. So those are, in a sense, the — and we see implementation of this. Now, I’ll add one layer.

Once you actually shift to license free spectrum, that doesn’t mean you’ve determined, for example, that you’re going to go to a rooftop-based-fully-distributed-only-end user, no center model, though that’s possible. The Nokia has brought rooftop networks and is moving towards implementing a purely user-to-user network based on end user equipment that creates the network or uses it depending on the particular use of a particular user, at the particular time.

You can also have something that is slightly more service provider-like model with a base station and clients which is what Apple does with airport, or you can go all the way to a cellular service with spread spectrum, which what Metricom is doing. Implementing base station [??].

All of these ride on the same license free spectrum, so you
permit an [??] in service models without imbedding the notion of an owner of a network determining how to use it by allocating the spectrum to a licensee, to a decider, a single decider of how the network will be used, either on a transmission-by-transmission basis, or on a service model basis.

MODERATOR: Okay. So we move to a place where the spectrum is not controlled. This is the unlicensed space and then the opportunity for innovation in how to use the spectrum is preserved. That’s the sense in which it’s compatible at the end-to-end design.

Now, this also is possible as an overlay to existing spectrum allocation, wide band protocols, and when you’re dealing with this, right?

SPEAKER: Right.

SPEAKER: So, tell me how the world of unlicensed spectrum overlays with the world of license spectrum, or could overlay with would of license spectrum. And I’m sorry. You should introduce.

HENDRICKS: Right. Dewayne Hendricks, Dannon group, which is a Silicon Valley based company.

Let me start out by talking about something that you guys probably don’t know exist, but does and has some impact on this discussion. I’m a member of what’s called the Amateur Radio Service, also known as HAM Radio. I’ve been a HAM since I was a teenager. And HAMs got interested in some technology that DARPA had sort of been funding. Now, a lot of you know how DARPA did [??] and all that stuff, but what you don’t know, there was a couple other things they were funding. One was a pack of radio development called PR Net in the early 70’s. And that effort went on for a number of years and developed a lot of interesting stuff, including protocols and spread spectrum radios for the military.

The average radio community essentially took of those ideas and started working in Packet Radio in the early 80’s and developed a device called a TNC, a Terminal Node Controller. And in ‘85, they got the FCC to change the rules so that we could essentially send ASKII data type over the air. And this opened up a new era for Amateur Packet Radio.

So, what we have today, which started in ‘85 are essentially two global networks in terms of coverage that you guys don’t know about, but are actually working and covering the very ground that we sit on right now. Okay.

One’s a TCPI-based network and the other one is the protocol that came out of the Amateur Radio Community which is called
AX.25, which stands for Amateur “X” 25, okay. So, with the TNC there’s essentially a software in there that makes this device essentially a ad hoc-ish Packet Radio Network. And the Amateur networks are not owned by anybody and essentially, these devices essentially will go out and sniff the air and find out like devices that are operating dynamically, and build routing tables and start routing packets.

So for instance, in the San Francisco system, here I can put an e-mail message into the system and it’ll go hippity-hop-pitying across the country to the East Coast [??] by storming forward and it'll take longer than the wired Internet. It'll take, maybe a few hours, but it'll get there. And it’s all done by people who, you know, put up these stations on their own. Okay. So it’s the existence proof for the fact that you can build a new infrastructure that nobody owns, that’s wireless and it works. And that the technology is available. In the case of the IP network AX.25 is using the protocols you guys know and love.

MODERATOR: But this is using unlicensed spectrum?

HENDRICKS: No. It’s, Amateur Radio is a licensed service. We share a lot of spectrum that’s used by unlicensed services, but I wanted to give you a grounding, in that this has been going on since ’85, okay? And so there’s been a lot of work by people like me in this community to do spins on IP protocol to make all this stuff work. Different routing protocols, different issues you get into in a radion environment.

But the unfortunate thing in a lot of this, know how an experience and the reality of it hasn’t filtered in the commercial sector. So I was sort of like sitting here, and sort of laughing to myself about the gentleman over here talking about you can’t do ad hoc-ish radio networks when we got one running right here that you can’t see, okay?

SPEAKER: [??].

HENDRICKS: Well —

SPEAKER: [??] technologies always appear to incumbents [??].

HENDRICKS: Yeah. Okay. So that’s the grounding point for you guys as we move into the discussion about what’s happening with unlicensed.

The commission in the early ‘80s, essentially, did a Notice of Inquiry, which introduced spread spectrum into the rules. And what they introduced, if you read this in a [??], it’s pretty groundbreaking that they introduce some new spectrum management policy, introduce the concept of spectrum overlay and they’re using the capabilities of spread spectrum and essentially, say
operate over existing services. So I’m going to call. I’m not going to use spread spectrum as a term or ultra wide band, I’m going to all it wide band technologies ‘cause that was the terminology we used in the NOI, wide band technology.

Essentially, again, the concept where you have some radio service that can operate over a lot of other services without causing them harm, okay?. So this is a new tool in the spectrum management tool kit for the commission. So they tried to get this thing going and it ran into a lot of problems the incumbency issues and stuff, but in ’85 we got some rules at which [??] the part 15 spread spectrum rules that operate today, and have been a tremendous success, and that there are a zillion devices. I mean, nobody really knows how many devices there are out there operating under these rules.

It was happened of late, is that, actually, early on, you know, like in the ‘87 time frame, people started taking — there were severe limitations put on these devices of one-watt power and HAMS know that you can do a lot with one watt, but the commercial sector really sort of didn’t really — they’re used to using giga watts or whatever for broadcasting.

And we have a [??] called QRP Operations which is called, Low Power QRP. And we knew what we could do at microwave frequencies [??] if you really did good engineering. So we found out that you could take these devices which designed for land applications just to go a few hundred feet, and actually make them go, you know 30, 40, even longer distances, depending on the frequency.

SPEAKER: Miles.

HENDRICKS: Forty miles. Sorry. What’d I say?

SPEAKER: Thirty, forty miles.

HENDRICKS: Okay. But miles. Okay. So you can essentially use these devices to set up wide area networks. And so that’s what has happened and that you’ve got a set of manufacturers in the early ‘90s that came out with Silent, being one, today there’s others like Breezecom and others that — Areonet, that’s part of Cisco now, that produce these devices that are being used all over the world to set up wide area networks on unlicensed spectrum. Up to, you know, megabit data rates, okay?

In the Bay are here, we have a number of public access wide area networks that cover the Bay. There’s a group up in the San Francisco area that’s doing this. There’s a group in the South Bay. Okay? So — and this is all ad hoc.

Now, I want to start [??] talk about the regulatory issues. And
that — Chairman Kinard, earlier this year, sort of [??] a public statement, where he said, look, we’re in the spectrum drought and that we sort of — run out of spectrum. And sort of like what I would call the prime beach front property part of the radio spectrum of which I would characterize as 30 megahertz to 3 gigahertz, this all allocated with a lot of different services, call it the incumbent services. So, everybody wants to be there, okay? Nobody wants to be up in the middle-of-the-wave range, you know with — you know, 28 gigahertz and above, which the commission had numbered years ago, they were all making it, it was called the emerging technologies, you know, initiative.

Okay. So that’s where all the new stuff goes up there where is that really cost effective to build devices? So, everybody wants to be in 30 megahertz to 3 gigahertz. But the problem is, is that using conventional technologies you can’t do that and if you want to put a new allocation in, somebody else has got to move, okay? So you have condition of scarcity, and so one of the ways the commission deals with this is with auctions, okay? You know.

MODERATOR: The condition of scarcity using given technologies, is that what you’re saying?

HENDRICKS: Yes.

SPEAKER: Is that what you’re saying.

HENDRICKS: Okay. So, like what they tried to do in the early 80’s with these wide band technology NOI, where the commission has been essentially re-addressing this and with the leadership of Dale Hatfield and Chairman Kinard, there’s been a number of new initiative move forward to get back to what was the ideas of the early 80’s where they’d come up with a new spectrum management paradigm. So, in the speech I was referring to that Chairman Kinard made, how he talked about some solutions that the commission was looking for to deal with the spectrum drought and they were softer-defined radios, ultra wide band technologies, and fostering the notion of greater spectrum efficiency, and a concept called secondary markets. Okay?

Secondary markets are a very important bridging-type of approach to take licensed spectrum and make it available to other people on a dynamic, sort of a commodity basis.

MODERATOR: Okay. But your wide band technology would be able to share allocated spectrum space.

HENDRICKS: Yes.

MODERATOR: Without interfering with the allocated spectrum [??].
HENDRICKS: Right. Well, okay. This is what — this is where we’re going to start crossing swords because I’ve had the opportunity to go into regulatory regimens like different countries where we don’t have the problems here and I’ve been able to deploy these technologies to some good effect. Okay? Mongolia, you know, places just around the block.

So, I think what you find, and that you guys know that it’s really direct experience which is going to tell you a lot about something rather than sitting around the coffee table talking about what might be so. Okay? So the approach I take, is sort of regulatory active, where I believe in deeds, not words, so you go out and you do it. And you make it work and you show people and say, well, let’s not argue about whether or not it’s going to work, there it is, you know, go knock on it.

MODERATOR: Okay. Let’s just be clear what we say is going to work.

HENDRICKS: Okay.

MODERATOR: There’s a certain amount of spectrum, which is called unlicensed spectrum right now.

HENDRICKS: Yes.

MODERATOR: Okay. And people and go in there and do whatever they want —

HENDRICKS: Right.

MODERATOR: — within a certain range of power wattage, blah, blah, blah, okay. And you are talking about technologies to make it possible in a sense to re-farm allocated spectrum spaces —

HENDRICKS: Yes.

MODERATOR: — so that devices could be used to be transmitting across spectrum allocated to a certain use — television use or something like that — without interfering with values.

HENDRICKS: Yes.

MODERATOR: Okay.

HENDRICKS: Now, there’s no magic here to do that in that — I think — again, I’m coming from all this experience in the HAM radio community where we’ve essentially been using conventional technologies for the most part — since ‘85. But we know what it takes to do ad hoc from the aspect of radio networks. And so more recently, we’ve been experimenting with these wide band technologies to see what you can do with it. Okay?

So, if you look at the commission’s approach, it’s sort of like, try to make rules that don’t give an advantage to any particular technology. It’s essentially, try to be technology neutral, okay?
But they don’t — so, you look at things like power spectral density, okay, as a way of taking that neutral position. So, they don’t care what you do, is that you’re going to put out power which is what radio’s all about, moving energy from one place to another, okay? So, you figure ‘cause everybody’s using the same spectral density, then there shouldn’t be any major problems in terms of the way they use the unlicensed service in terms of putting different services into the same part of the spectrum.

But if you look at, actually, the networking architecture of the technology, that starts to make a difference. And that’s what the commission doesn’t look to. So, I think what we found in the amateur radio community is that there are certain rules that if you follow, you could build scalable packet radio networks that don’t interfere, okay? And these two rules are pretty simple, and they come from the work of a guy name Tim Shepherd at MIT and have been validated in the amateur radio community which uses wide band technologies, so you get power spectral densities which are below the noise floor. You use [??] energy routing, and then you use automatic power control.

These are the three key things you need to do to build multi-megabit scalable packet networks. Because what it means is that you don’t essentially put out systems that talk over 20 miles, okay, unless you really have to. But it should be the radio itself that makes the decision dynamically about whether or not it needs to do that depending on where it needs to move the packet.

MODERATOR:Okay, and one last bit of the story. For the radio that made that decision, and to choose the protocol it’s going to be declined, that requires the development of —

HENDRICKS:Software-defined radio.

MODERATOR:Right. And so software-defined radios are just these devices for selecting which protocol they’re going to use given the context in which they find themselves.

HENDRICKS:Well, you have to be careful in software-defined radios that there’s a big umbrella that concept covers. Part of it means essentially taking — doing a new implementation of the radio, whereas it’s going from the analog into using digital devices, and then like DSPs and programming those, okay, so, it’s a different architecture.

The idea of the ultimate software-defined radio is basically an attendant connected to a DSP engine and a [??] converter, okay? We’re not there yet. But the other aspects of software-
defined radios are what you know in terms of an intelligent networking device that’s running networking protocols.

MODERATOR: Right.

HENDRICKS: So, if you marry those two things together, that is truly what we call a cognitive radio.

MODERATOR: Okay. Dale?

HATFIELD: Yeah. I was trying to make notes. There’s a lot I could respond to. Let me just sort of go somewhat randomly. One, I think it’s a little bit of a false dichotomy to talk about licensed and unlicensed that way in a sense that — I’d like to see somebody do that — there’s nothing keeping anybody from coming in and getting spectrum from us today and organizing a network that would operate on exactly the way that he’s talking about. In other words — in fact, I think we would welcome that and obviously, it would require participation in the auction for going to and picking up the spectrum like our WCS spectrum which is relatively underutilized. So, these things are not incompatible, but one could do within our existing system, one could operate in a — for a much more a decentralized system and I think with our blessing.

Second, there is, of course, the notion [??] the commonest problem here is that — I think the trusted end point’s argument is that do you trust the other guy not to blast you off the channel by using too much power? So, you’ve got to have some sort of a mechanism — Dewayne says, you have to have rules. Okay, who writes those rules, and then most importantly, who enforces those rules? So, we still have to have —

MODERATOR: You have a job. Don’t worry. We’re not going to fire you.

HATFIELD: [??] some sort of a regulatory structure. But I’ve only got a week more to go so — (Laughter)

The other thing is, of course, ultra wide band. And that’s different because there’s the licensed and the unlicensed spectrum and the ultra wide band then, would overlay some of the licensed spectrum. And the issue here, again, is can you — there are systems out there who have a certain amount of margin that are built into them for adequate operation — for their operation. And the question is, how many of these additional sorts of devices can you put out there that raises the noise level and eventually, you’re taking that margin away from them, and eventually, of course, that system will fail.

I’m not arguing with the premise that you can’t add some additional emitters into the environment. But ultimately, there
may be a limit and so forth. So, we have to think about that.

MODERATOR: How do people who have spectrum allocated to them respond when people like Dewayne come in and say, I want to re-define [??].

HATFIELD: Well, we have all kinds of examples. In fact, one of the difficulties I — let me sort of go off the — just for a moment — that there are some systems that may be designed in what my opinion, are very fragile systems. Because the engineer says, how can I minimize the cost of this system? So, they make a system that’s very susceptible to even a little incremental additional noise.

Now, you get somebody like Dewayne who wants to overlay a signal on that and they say, oh, my goodness. This guy’s going to fail because they don’t have any margin. Or even they say, you can’t even operate on an adjacent channel because you’l spill over into my channel and cause my system to fail. So there’s some real issues there that tend to make Dewayne’s overlay notion more difficult to implement in the real world.

SPEAKER: Yeah.

HATFIELD: Exactly. Apparently, the notion of cognizant radios; here again, I would emphasize that with secondary markets these are not incompatible notions.

If, for example, somebody could go, and knowing your location, knowing where the nearest TV channels are, and taking advantage of listening to cognizant radios listening and so forth, there’s nothing keeping somebody for here, again, designing a system that would operate on a noninterfering basis today by negotiating with existing license holders. That’s the whole notion of the secondary market and that’s what we’re trying to promote is this type of operation.

Now, Dewayne may not still be happy. We haven’t gone far enough, but we are trying to do that first with the unlicensed bands and then trying to have some of these additional notions so that we can work it within licensed spectrum to either by going out and getting the spectrum and operating it straight away on that basis using licensed or by using a new secondary — getting access to a spectrum on a secondary market basis.

Pepper might want to add —

BENKLER: It answers one after another, I suppose, along the idea that someone will pay a huge amount of money in order to get some spectrum where they will then implement a high positive externality strategy, i.e., building into the physical layer of the infrastructure is highly unlikely unless you get a consortium of a
set of equipment manufacturers to do so. In which case: a) you’re still going to limit the amount of spectrum based on what’s available for purchase, whether it is or isn’t contiguous would be a happenstance of what’s available, etcetera; and b) that means that set of equipment manufacturers will become an [??]. So there are serious problems with a private party going out and deciding to provide this public good of an uncontrolled into and at the physical layer network by purchase. That’s one problem. The tragedy of the commons problem means that you need the shift regulation from allocation and assignment decisions to equipment regulations. So, you need to set a relatively broad set of protocols that prevent spectrum hogging and then to enforce [??] somewhat like Part 68 or in terms of equipment certification.

With respect to raising the noise level with a larger number of users, that depends on whether or not you’re protecting incumbent services. Is there a two related —

HATFIELD: Come and help me out with the GPS on this, folks, will you?

BENKLER: No, but the point is that you’re designing — if you think there is — and this comes back to actually the comment that I made right at the end of the last one.

If you think there is a public value in having one layer of — or one path in the overall physical layer of the communication infrastructure that is purely dedicated to end-user-based networking; that the network itself is implemented in coordinated and collaborating end-user equipment, there’s one such layer that doesn’t require any up front investment, and that is what’s given to us by Mother Nature, i.e., the spectrum.

And the thing that’s preventing that is regulation that prohibits anyone from implementing license-free or sharing-capable equipment because of the concerns of incumbents. So, you’re building a network that is intended to protect sensitive incumbents in a sense of legacy infrastructure that has all of these problematic incentives of the divergence between private interest and public value. And in order to protect them you’re preventing the emergence of the one infrastructure that actually could be fully end-user equipment based. As ad hoc-ish packet networks that have no owner, no center, no one to try to play the games of capturing private value at the expense of the public values that are imbedded in the end-to-end argument.

MODERATOR: Howard?

SHELANSKI: You make a strong argument.

MODERATOR: Take the mike.
SPEAKER: You make a strong argument. I think there are two versions of the argument. There’s the strong version of what I’ll call the reasonable version. (Laughter)

The strong version of the argument is that — excuse me? You’ll be able to rebut; effectively, I’m sure. No. The strong version of the argument is that we don’t need a centralized allocation, in fact, we don’t even need a market. We have a technological solution here.

BENKLER: We don’t need an infrastructure market. We need an equipment market.

SHELANSKI: I’m going to suggest that that’s not necessarily true, unless you can explain to me how the smart equipment that will, in some sense, shut people down when they violate certain kinds of rules that keep the commons operating. How this will allocate amongst the value of uses. Because I think that’s quite important. Somebody’s going to have to make a decision whether it’s a market or centralized decision-maker, that one use versus another that goes over this commons may be more valuable.

SPEAKER: [??] do that over the Internet [??]. You’re going to have the same —

SPEAKER: Same issues.

SPEAKER: — same conflict.

SHELANSKI: But if you believe that there is never going to be — that’s the next thing I was going to go to — if you ever thing there will be a capacity constraint, you’ve got to do it.

Yohai’s example is an excellent one for a situation for which we are not putting up a capacity constraint. But the second we hit a capacity constraint the smart equipment could lead to terribly inefficient results. I think we ought to care about that as policy makers.

SPEAKER: [??] infrastructure.

SHELANSKI: Well, I would want to know what the background rule will be and who will tell people with who moves and who doesn’t move.

SPEAKER: What if they don’t like what they’re getting?

SPEAKER: Actually, before you do that, I’ve been collecting theoretical but sound theory-base answers to the following question which is: Is the communications — electro-magnetic communications research — resource of ether, except there is no ether, it’s like [??], limited in its communication, and [??] and one way to formulate that question is, for a set of end transponders inhabiting some space as you increase end, scale end, does the
capacity of that — communications capacity of that physical space grow proportional to end, grow sublinearly or does it grow [??]. Okay? The pink shepherds was one proof of concept that it grows proportional to end or better.

There’s another set of communications theory that says it grows proportional to end or better. There’s an argument even from traditional communications theory that basically says that the amount of thermal noise, that is natural noise that is fixed, and that the rest of the energy we put into the space is our own. And therefore, you know, it’s artificial noise, and therefore, it’s not noise, it’s signal. And you just have to have appropriate stuff. So, from kind of a first principle’s argument, you can have enough processing capacity. There is never a scarcity, okay?

And so, the only interesting question is, if we invest in the research to figure out how to reach an operating model like this, which involves perhaps [??] modulation techniques that it may even help dynamic auction of, you know, [??] in your space.

The question is, should we be moving toward that [??] which I claim is — I would like to at least argue have as much value as the original ARPA investment in the Internet or should we continue to operate the system as if there’s a scarcity, and thereby create it?

(Multiple overlapping speakers.)

HATFIELD: Let me respond. Let me say one thing here. I don't think anybody would argue that an engineer can't always figure out how to get one more user in the spectrum in any given location. I mean, you know, there's no issue there. The question is, every time I add one more user, it gets more costly.

(Multiple overlapping speakers.)

SPEAKER: There are arguments such, that adding introductorily to reduce the cost of [??] —

SPEAKER: Right.

SPEAKER: — and they come from sound communications [??].

SPEAKER: Because the additional repeaters sort of in the —

SPEAKER: It’s repeaters, it’s power management, it’s [??] —

SPEAKER: Right.

SPEAKER: — when you attach more users per unit area the distance has to shrink —

SPEAKER: Shrink.

SPEAKER: — the average distance has to shrink, therefore the power has to
shrink.

MODERATOR: Yeah, so you’re not yelling.

Howard?

SHELANSKI: If that’s true, then clearly, investment technology is always better than investment regulation. And so, I would suggest that there is at least a theoretical possibility of fully implementing the kind of proposal that Yohai and Larry’s put on the table.

I think, on the other hand, that it’s not always the case. That if we haven’t — if we reach congestion before the technological solutions are reached, that there will be a necessary market solution, especially if we adopt the proposal for all SWATS of spectrum. There could be no place obvious to move, especially if its costs for certain people to stay on the spectrum. Now, you would get private deals but that’s allowing the market back in.

MODERATOR: Okay. But Howard, does enabling this market solution slow the possible transition to the solution that David and Yohai are talking about?

SHELANSKI: Sure. Because it puts pressure on people — it — otherwise, people have no other way of solving the problems. They can’t do it through market negotiation. They invest. That’s a very interesting technology-forcing brand of regulation, one that does

BENKLER: Remember it’s not a brand of regulation, it’s a brand of deregulation. Regulation is prohibiting people from using devices not removing the prohibition. The fact that there are incumbents that spend a lot of money in persuading the government to prohibit us from — this is not — it’s not regulation to permit people to use “smart” radios to the people who use “dumb” radios can continue to use them.

SHELANSKI: That’s the reasonable — that’s the reasonable part of your argument. We have terribly inefficient spectrum use.

SPEAKER: Exactly.

SHELANSKI: And the fact that we should — We should let people go in and use this stuff more efficiently. I’m not objecting to that at all. But what I’m suggesting is that it is regulation to say, you cannot come to market solutions but must define it at the equipment level.

BENKLER: And there, I think, the trade-off I think very useful this morning in identifying both the quality of service and the cashing [??] from this morning, identify a situation where potentially temporary problems of capacity are solved in ways that push the technology not towards maximum capacity utilization, and pushing application to the end, but in the sense towards
reintroducing network market-based allocation, which is precisely why I don’t like, for example, any norm solution to having dynamic auctioning, but rather forcing a solution, if it were forcing, but preferring, in any event, a solution that is about building better radios and maintaining a nonmarket-based allocation, but a capacity maximization and optimizing in-use utilization.

SHELANSKI: I think as long as we can agree there’s a trade-off there, we can disagree on where the balance lies.

MODERATOR: Mark and then Kevin.

SPEAKER: I would like to endeavor to try and drag you all up the network stock one layer. And that is, from an IP perspective, this sounds like you got a lot of opportunity in wireless [??] use, okay? But I have a question. It’s more fundamental. If you want to force end-to-end in wireless, is the FTC willing to step up and say this spectrum allocation will support end-to-end in the devices in the network?

WERBACH: How are you defining “will support end-to-end?”

SPEAKER: Well, it will all be sorted out [??]. But we were just discussing end-to-end all day today.

SPEAKER: Actually, I have a relevant question because I don’t understand the regulation in the smart [??] in relation to [??].

I’ve been told by a number of vendors: Motorola, Nokia, and so forth that the idea of introducing programmability into a handset is barred by regulation.

SPEAKER: Because they want it to.

SPEAKER: Because the operators want it to.

SPEAKER: No. I’m not talking about [??] cellular [??] new spectrum.

SPEAKER: No. I understand.

SPEAKER: The [??] thing about new programs.

SPEAKER: But what I’m curious about is then — so that — so, if indeed that is true, that there’s something in the regulation that is a [??] thing that says that if you put something in a cell handset that it must be — somebody has to certify that it doesn’t break the cellular system, you know, which is that kind of thing.

SPEAKER: No.

SPEAKER: Then the FCC.

SPEAKER: There’s nothing like that in the rules.

SPEAKER: No.
HATFIELD: I’d sure like to know what they’re referring to because there’s nothing — we’re about keeping our hands off of all that, if you can imagine. There’s RF exposure issues and some things like that, of course.

CHARTIER: Well, for instance, in the STRNOY —

MODERATOR: Your software-defined radio notice of —

CHARTIER: — almost the unanimous response to that from the commentors was that, you know, who controls now the software downloads to this device? And almost the unanimous response was that you should let status quo. The OEM should control by virtue of a business agreement with third parties, if these third parties software the downloads to the device. And that’s —

SPEAKER: [??].

SPEAKER: Well, it’s one device.

SPEAKER: No.

CHARTIER: Unless you have a market demarcation in here, where — it’s one device.

SPEAKER: Here’s an example. If the device occupies [??] will not see — you know — that’s something that you’d want to get involved with.

SPEAKER: Are we talking about [??] device [??] program?

SPEAKER: What I’m saying is that seems to be the claim of the [??].

CHARTIER: Well, absolutely. In that way, you maintain control over the device. You know. It’s like — whether it’s going to be like video games, with Sega, Nintendo, and all and where they control, you know, they get 30 points on the software that’s developed for their platform, where it’s more like the PC environment where you have some plug-in pipe, you know, whether it’s a wireless modem or a wired modem, and it’s separated by an abstraction layer like Indus where you don’t have to worry about contaminating the network.

MODERATOR: Okay, in the back, right here.

SPEAKER: I have a question. [??]. If you have a competitive market as Dale has referred to earlier [??] carriers offering services in a particular area, how can you justify the government’s getting involved in the decision about whether end-to-end required or not [??] essentially different systems out. How do you justify that?

HATFIELD: I think that’s a fundamental — very fundamental question.

SHELANSKI: One answer is [??]. If you believe that these [??].
SPEAKER: I didn’t create this next round.
SPEAKER: It’s the best place to go.
SPEAKER: If these five people will slice that up [??] incompatibilities that destroy the extranilities, volume, etcetera, then you have a right to come in and say, no, you have to preserve the characteristics that produces that extranality.
SPEAKER: [??]. Isn’t that [??] essentially the debate between what the Japanese and European markets [??] governments involved in the standards setting question versus the U.S. [??] government stays out of it, because essentially your extranality [??] involved in the standard setting.
MODERATOR: Howard, you and Kevin on this?
SHELANSKI: I think those are pretty distinct issues. On the question of having a harmonized standard is one question and one could debate whether or not that is actually beneficial. Competing standards, so long as there is interconnection, can lead to very beneficial innovation developments. Having a standard on which innovations can ride can also be beneficial. But I think when you talk about end-to-end in the wireless network I want to be clear what you’re talking about. If you’re talking about multiple competing users providing similar services, one level of end-to-end, although not a pure technical level, is simply a mandated interconnection. And there’s nothing novel about that. The government does that in many, many areas. It finally got its act together to do it in local telephony a hundred years too late. But that would not be something that I would do as an onerous, regulatory requirement that would, in any way, interfere with many layers of innovation in the networks.
SPEAKER: [??].
MODERATOR: That’s a nice jiujitsu move there.
SHELANSKI: Yes. That’s a nice jiujitsu move. And I think it’s cartoon jiujitsu, but I can’t figure out why.
BENKLER: This concept of government interference is a problematic one. There are some places where, for example, the claim of requiring cable access in order to prevent end-to-end.
What did I say?
MODERATOR: “Prevent.”
BENKLER: And to protect end-to-end. I’m sorry. Where you need, in a sense, a set of regulatory move in order to further a particular social policy goal or engineering goal, we’ve talked about already today, a lot about the fact that we’re talking about an
engineering concept with specific, and to some extent, defined economic and social consequences that we've set out as reasons to pursue it.

But there are other suggestions and spectrum policy is one. We're acknowledging the economic and social value of use of end-to-end, not only at lower layers but iterated at higher layers, as well. For example, the competition context that we had this discussion this morning between Dave Clark and Larry Lessig that involved the “quicksand” and the notion of all competition being served by having — by not preventing innovation in certain ways, by implementing certain solutions at lower layers. This isn't enough to have it — and this actually goes to [??] also, it's a question of at what layer do we implement end-to-end? And the answer is, depending on the value. If the value is one, where any layer can lock off, say, competition or innovations above it, then if you're interested in attaining that policy goal in itself, you need to iterate the end-to-end argument at each layer for all high layers. Because for each of these higher layers, innovation and competition will benefit from not being locked in to implementations at lower level.

Coming back to the question of government interference. If you understand this, that there are certain social and economic [??] that are served by a commitment to end-to-end design at multiple layers, you can design your institutional decisions, your rules, in ways that respond to your predictions of what will emerge. Will there emerge an end-to-end solution or not? So again, the argument for license-free spectrum is not government interference, but in a choice between whether to have equipment manufacturer — in a sense — no prohibition on radiation in the RX spectrum, plus subject to equipment sharing protocols and equipment certification versus prohibition plus licensing, auctioning for property rights.

In those choices you need to say, we saw quality of service, we saw cashing, we saw IP over telephony, we talked this morning about all sorts of reasons why private owners of infrastructure like ISPs will try to differentiate themselves, partly by undermining end-to-end, partly to good consumer of it, and partly because they can't capture the social gains that they produce.

So, there, it's not a question of government interference. It's a question of government choices about [??] alternative institutional paths that are cognizant of the social value of end-to-end, and the interrelated nature of certain choices, some of which will push us towards end-to-end, and some of us will push towards defection from end-to-end for private gains.
MODERATOR: Okay. We’re coming to an end. We’re winding down. There are a couple more comments that I want to make sure that I wasn’t silencing the far left of [??].

MCLAUGHLIN: Well, I have a story to tell that I don’t think it probably makes sense to tell at this time. It has to do with a different kind of impediment to end-to-end, particularly in the wireless realm. It has to do with Internet addressing. I gather from this sort of exhaustion level in the room that it may make sense not to go into that into too much detail. But —

MODERATOR: Can you tell it at 78 RPMs?

MCLAUGHLIN: Well, let me tell you the very quick version, because this is sort of in the nature of an update more than anything else. I mean, asking — having me describe the new version of the Internet protocol in a room like this is like sitting around with Snow White and the Seven Dwarfs and saying, Hmm, who could we get to seduce the prince? Uh, Sneezy?

But I can talk about the part which I’m responsible for, which is — within the I-Can structure there is a distributed system for making allocation policies for Internet protocol numbers. Now, if you’re running your own — I’m sorry — Internet addresses, Scott reminds me. So — ’cause there are other kinds of numbers as well.

If you’re running your own network that doesn’t connect up to the global capitol “l” Internet, you can use webber numbers you want on your machines. Once you decide that you’re going to connect to your network to the global Internet, you’ve got to make sure that the numbers for your machines — the addresses for your machines — aren’t the same as the addresses that are being used to identify other resources elsewhere in the Internet, other connections to interface with elsewhere in the Internet.

So, in order to make that happen, we have this system that’s called IP Version 4.0 which is a 32-bit string that’s used to make those identifications. They are allocated by three separate Internet registries around the world. The one for North America is Erin and the way that they do it is designed to sort of serve two primary values. There are some others as well, but one has to do with conserving the address face so that you don’t run out of available numbers. And the second has to do with preserving aggregation, promoting aggregation, so that you can do routing more efficiently.

The result of the conservation policy has, in part then, the use of devices like network address translation in order to conserve the
use of addresses across the Internet.

There are some other reasons why NET gets used, in fact, Scott would tell you there’s a very good argument that it has much more to do — the NET, anyway, has much more to do with the pain that it is to renumber your machines, and so if you just have one publicly routable address dropping traffic at one NET box, you just have to renumber that box rather than every machine in your network.

We’re now in the process of doing allocations of the next version of the Internet protocol, IPB-6. And one of the things that I’ve been doing for I-Can is trying to sort of evangelize a good allocation policy within the regional Internet registry, so that each would set their own policies for how they want to do it, and very quietly, in my way, I’ve been trying to do that.

The Internet Architectural Board and the Internet Engineering Steering Group have produced a recommendation that two out of the three regional Internet registries, so far, accepted which has to do with making basic allocations at the level of — what they call a “slash 48” or the “48-bit” in this 128-bit string. As it turns out, the second 64 bits of 128-bit string are used as an interface identifier, the first bit is the part the network uses to get the traffic to the network destination and within that 64-bits, the first three bits are sort of set aside to describe which chunk of the IPB-6 universe you’re talking about, there are eight of them, and then you use the other 43-bits — 45-bits you have available to do your numbering. So, 45 — two to the 45th power is about 35 trillion addresses, as the IEBI SG recommendation points out, if every single human being in here 20, 50 had one using conventional estimates of what the population is going to be if you were given a slash-48, you would be utilizing .03 percent of the total number of available addresses in that one-eighth block of the IPB sick space.

So, there are a lot of addresses to play around with and the objection to it, I suppose, has to do with the fact that each slash-48 gives you 65 thousand unique numbers within that block.

So, the question is not, [??] insanely profit was wasted if your going to be assigning them to, you know, users may only have a couple of machines on their home network.

Anyway, this was just a flagging issue that you all ought to be aware of. It’s percolating through the regional Internet registries, and my sense is that this is an area that could be an obstacle to end-to-end, but will not be an obstacle to end-to-end because there seems to be generally sensible conversions around a generally sensible set of policies for making the availability of
IPB-6 addresses vastly easier than it has been in the IPBG-4 universe.

MODERATOR: Okay? I’m calling for final comments here. I think — on spectrum.

SPEAKER: This has actually been a fascinating discussion because I think what we have been trying to do, in fact, it moved toward more unlicensed uses and applications, and we set aside some chunks gigahertz and we’ve been looking, for example, ways at 700 megahertz trying to overlay new applications licensed on top of existing broadcasters, you might imagine what response that has been. But as a practical matter in moving towards your vision, which, you know, I think is not an unreasonable goal to be working towards. There are some practical issues to be had, but nobody has talked today about the government users. I mean, the government incumbents in these bands, and if you think there are problems with the commercial incumbents —

SPEAKER: if you talk to the FAA. You get two responses. If the FAA — you think this airplane is going to fall out of the sky, and if you go talk to the that they use, they’re going to say, well, you know, somebody shoots down the airplane, it’s going to fall out of the sky. So, you know, if you’re talking about block.

(Laughter)

The problem here is the fact — is a very pragmatic one of how do you begin to migrate? And this is why one of the things — the analysis undeservedly modest people you’ve ever met. And one of the things that Dale’s done in the last year, year-and-a-half is really push this ultra wide band stuff and the experiment evolves or. And it seems to me that it — this is a community that — I think you’re right. The extent to which the kind of research and thinking that went into development of, you know, these kinds of technologies can be extremely important. But we’re not even close to being there yet. It’s all a very theoretical level. It’s all pragmatic in terms of being able to figure out how to actually, you know — you’re working within the amateur community. That’s like working within the Internet community in 19 — 1980. It’s a well-known-to-one-another group, you can do all of these things, you play by the rules. It’s a different environment than Internet today with 3 million users globally. The questions is how do you scale from your amateur community in South Bay to the global overlay or ultra wide band applications and uses, which spread across, you know, 30 to 3,000?

SPEAKER: I think there are ways of framing that debate and moving forward.
MODERATOR: As long as we’re agreed on — that we’re agreed on the end point. Right.
Okay. Mark? Him and Mark.

SPEAKER: I was going to offer an observation on [??] final point, and one of the things that strikes me in this discussion was — the end-to-end principle attracted me as a consumer advocate, and there’s a policy version who runs around punching, talking to regulators and real people.

MODERATOR: As opposed to us?

SPEAKER: Well, there you go. Consumers who don’t have your sophistication, but that — my job is trying to explain it to them. And there was a remarkable convergence, and the reason this issue has remained so public, if you were to ask anybody [??] sitting here debating this about open access at this date, two and a half years after we started —

MODERATOR: It’s only been eight hours.

SPEAKER: What?

MODERATOR: It’s only been eight hours.

SPEAKER: — [??] crazy, right? The convergence between the end-to-end principle at a technology concept competition, decentralized competition, as an economic concept and discourse of democracy as a political concept. And they have converged, and Yohai ends with that assertion about values and [??]. And when I walk into a room of my members, I start with that statement of value. And I introduce a technology level to them that they’re not used to, and that convergence is very important. And so it’s worth fighting — and the most interesting thing is from the end of the point today, is that while there’s a technology-to-date, there’s really not a technology — a killer that prevents that convergence from going forward. That’s what I feel even though there’s tremendous debate about the economics. But economics is not a technological end point. Economics is always a starting point in a certain sense. And so, but again, my world and the technology world, and the economic world coming together is that this convergence is something that we have thought about. And the thing is, if in fact, we’re fighting for.

MODERATOR: Okay. Mark?

SPEAKER: Real quick point. One is, I was a little disturbed with this conversation [??] stack. [??] With the IP layer.

SPEAKER: Why?
SPEAKER: It was never the argument.
SPEAKER: Really?
SPEAKER: Yeah.
SPEAKER: Yeah.
SPEAKER: Well, excuse me. [??].
MODERATOR: Number two.
SPEAKER: I wish we could find some way to really promote open access to wireless and then [??] and just give a [??] and third, there are existing proofs of existing systems out there [??] where you could do programing on an average basis [??] you’re not touching the [??] player radio. It’s just a matter of [??].
MODERATOR: Yeah. Right. Right. Well, under number two you will be spanned by information about an organization that we intend to be farming very soon to push exactly that idea. So that solves two. Scott did you have a —
BRADNER: Yeah. Actually I had something [??] sort of thing.
SPEAKER: Excellent.
BRADNER: This afternoon we talked about things, we did not talk about the network. We talked about cable, a little bit about DSL, a little bit about wireless. We were talking earlier about — I said well, they just — the people who if they [??] too crowded, people would just move. But what didn’t get through there was for many applications, not all, not for the [??] called “handies”, but for a lot of other applications, Dewayne’s application, a lot of other applications of wireless, they’re alternative [??] books. There is cable, there is DSL, there is fiber, and so what we’ve been talking about this afternoon are different things differently; whereas the Internet ties all of those things together. [??] tied to any one of them. If things get tough in one of them, we can move to another.
SPEAKER: I just wanted to add that one of the best [??] things to me is that [??] of you [??] example is that we do — or for that matter, Internet cable access, is that we do an enormous amount of [??] to cross subsidize things, for example, you know, we think about rural broadband Internet access, we try to make sure that that’s possible DSL cable, but in fact there are potentially alternative technologies like satellite, or whatever, that are well-tuned to that, whereas the alternative — and it basically gets back to this point, which is that if you stop thinking of the network as a collection of equipment and start thinking of the network as abstract conductivity, which is layered on some equipment [??] lower level. Many policy questions change their thing
dramatically and we didn’t really touch on that today.

SPEAKER: When you [??] stand this stuff existed the concept of [??] some kind of agency or foundation to defend the [??].

MODERATOR: It’s not that global yet. No. We’re talking about spectrum. It’s still pretty important, come on.

SPEAKER: [??].

SPEAKER: Right. Right. Okay. So you’ve been an extraordinary group here. Eight and a half hours talking about the concept, policy implications of end-to-end. I want to thank you, first of all, for being here. I want to thank Andy who actually made it possible that you were to be here. And also —

SPEAKER: [??].

MODERATOR: Yeah. I promise. The last word. And Barbara van Schewick who also helped organize, conceptually, a lot of what happened today and again, this has been an extraordinary conversation which I hope we will continue the first time that we talk about this in this organized way is not, I hope, the last. So we have a dinner tonight for those who are hanging around for it which will be much drinking, at least, but thank you very much.