Comments of members of the MIT Media Lab in the matter of FCC NPRM 14-28 "In the Matter of Promoting the Open Internet"

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Summary

This document is the response of members of the MIT Media Lab to NPRM 14-28, "In the Matter of Promoting the Open Internet." We recognize that the Internet has become the platform for a great many innovations that have changed the face of society and industry. It has provided opportunity for people throughout the world to gain from unfettered access to information and, most important, to create a universal platform upon which advances in computing can propagate and impact the well-being of people everywhere. We therefore feel it is imperative to secure a future where the Internet remains open, without the constraints or restrictions that benefit some economic entities at the expense of the population at large, both in the United States and throughout the world.

We recognize that the Commission has a critical role to play in ensuring that this essential component of modern society–one that will only grow in importance over the coming years–remains an accessible forum. We further believe that Internet access is a human right and that universal access should be an integral part of Open Internet regulation and design.[1].

In this document, we highlight the aspects of the Internet that have fostered a new wave of social and economic invention and innovation. We also want to emphasize the importance of keeping the Internet open to evolve while, at the same time, retaining its ability to offer all participants the opportunity to realize the economic advantages that they as innovators have created. We believe this position supports many of the points that the Commission and the Chairman have already articulated.

We base our comments on five points that are often overlooked in the discussion. First, while a common metric for the value of the Internet is the commercial success of new enterprises it has enabled, we would argue that a far more important metric is the number of *attempts* at innovation it has allowed. The permission-less ability to try new ideas is of primary benefit to society, to learning, and to our economic health. The court (in Verizon

[1] The preamble to the Communications Act of 1934 sets universal service for wired and wireless communications at a reasonable price as its goal. The most reasonable price for the Internet is zero.

2014) notes the existence of Google as an example of innovation. We agree, but would amplify that example by noting that Google was preceded by Alta Vista, Yahoo, and a host of other Internet web search and exploration platforms. While these other undertakings have had less market success, they remained important in both inspiring Google and creating the climate in which any number of other creative Internet endeavors could succeed. It is these continued attempts that pave the way for an inventive, flexible, and vibrant society. *The Internet is not just about its successes; it is about the freedom and ease by which one can experiment.*

The second point is that this freedom to experiment has significantly advanced the principle of learning both in the US and worldwide, with perhaps as much–if not more–impact as more directed educational initiatives. The notion of creating, testing, debugging, and realizing an idea is an inherently educational process, as was noted repeatedly by leading thinkers in the field of learning, such as Jean Piaget[2] and Seymour Papert. Moreover, the ability to do this in an environment of exploration–where the work of others feeds one's own activities–amplifies that process. This has been amply demonstrated by contributory reference materials, as well as work conducted at the Media Lab by Professor Mitchel Resnick.[3] One need only look at the growth of the open-source community or the ability to view the source code of a web page to witness the impact of the easy access to, and creation and distribution of, ideas. *The Internet is a learning engine as well as an economic one.*

A third point is about symmetry. We at the Media Lab make little distinction between consumers and businesses in the use and development of ideas that are tied to the Internet. We do not believe that society is best served when people are mere consumers of data served by "content industries." Instead, we enjoy unrestricted and unmetered access to the Internet backbone without firewalls or intermediaries of any sort. As a result, we spawn servers on demand to test ideas or merely to promote ease of use among members of our Lab and the public. For many of us, the Internet is of greatest value as a forum for expression, rather than as a means of consumption. We consider this the essence of network service, and we see no reason for anyone to be denied that right. *The Internet must remain a two-way street.*

Fourth, we propose that Internet providers who hold a public franchise for public airwaves or public rights of way–both wired and wireless–be required to deploy *at a minimum* an open, non-discriminatory pathway through their Internet gateways for free access. In other words, an Internet service provider must be *at least a dumb pipe.* As long

[2] Paraphrasing Piaget: "Children *create* knowledge rather than *receive* it."

[3] Resnick's Lifelong Kindergarten research group developed Scratch, a programming language and online community that enables children to create their own interactive stories, games, music, and animations for the Web. Scratch has reached a broad, worldwide audience with over three million users registered and over five million projects uploaded.

as non-discriminatory[4] Internet access is available, we see no reason to prevent the addition of other specialized, for-fee services. Nor do we see the need to restrict a vibrant market in developing and implementing them. Hence the importance of the phrase "*at least."*

And finally, we propose that providers be required to offer open Internet access with bandwidth, performance (as is apparent at any end terminal), and accessibility that is *at least as good* as any specialized service they offer. If a provider elects to add a high-bandwidth media service that has its own private access for delivery, then it must provide its subscribers with the option for an equivalent, financially accessible increase in throughput for the open Internet. Likewise, it must ensure that improvements to proprietary service channels be matched by improvements to the open Internet. *Simply put, if there are two lanes on the highway, any improvement to one must be matched by equivalent improvement in the other. We call this equal access a Pipe++ strategy.*

As we will argue, we see no regulatory impediment to this policy. Quite the opposite: the sense of the courts and the attitude of the FCC itself mitigate in favor of it. Yet regulation of the open Internet has often been bound by obsolete classifications that date from an era of monopoly telephone service or segregated computer services. Shoehorning the modern Internet into various pigeonholes that associate an application with its delivery technology demonstrates a misunderstanding, and poorly frames the discussion. Equally deleterious is saddling any public franchise with heavyweight regulation that might impede innovation and progress. It is clear that polarizing this discussion into fully packaged regulatory regimes that do not apply is counterproductive; we can do better and most wish to.

Finally, we make special note of the distinction between wired and wireless Internet access. Much of the current discussion implicitly addresses the wired path that ultimately reaches homes and businesses. However, the critical mass of development is migrating toward creating a wireless future, particularly in areas of commerce, health, and the sustainability of our environment. While many of us believe that Internet access ought to be available to all, we also note that in the near future, wireless connectivity will likewise become as socially and economically important as wired access is today. We therefore hope for a future where the same regulatory regimes apply to both.

[4] In general, this implies common carriage in the traditional sense of providing a service to the general public, without discrimination, for the public convenience and necessity. The requirement of being open, however, does not preclude innovation.

What the Internet is:

Paraphrasing David Clark (*An Insider's Guide to the Internet*, 2004), the Internet is a general-purpose communications vehicle that is designed to connect computers so that they can exchange information of any sort. Unlike special purpose networks such as those designed specifically for telephony or television, the Internet was designed for raw digital data in the most general sense. Its architecture separates applications from transport, thereby allowing simultaneous and unimpeded development of both. It can deliver bits through fiber optic channels as well as airwaves, through telephone lines and dedicated links, and it can support applications such as watching movies and renewing one's driver's license. One can argue that since it was designed without a specific economic application or market in mind, it is equally good–or bad–at all of them.

At the core of the Internet are a small number ideas that differ in essential ways from the networks that had existed before. It is a *packet network* where all data are divided into universal packets that are transported by various other mechanisms that are generally unaware of the payload. In this, it is similar to–and perhaps a derivative of–containerized shipping, which we can think of as "packet shipping," where goods are packaged in universal containers that can then be carried equally well on marine vessels, trucks, or railways, by equally universal and standardized means. The efficiencies of packet shipping are well documented and proven through 60 years of use and expansion.

The Internet is also defined by the end-to-end principle that shifts the intelligence to the devices at the edge. It was therefore conceived as being "stateless," where each packet entered the network and was treated the same as any other. In this it differs somewhat from the shipping model in practice if not in theory. A by-product of this principle is that the infrastructure itself need not be changed to suit new technologies; most often those devices that connect to it change. This notion implies a relatively lightweight infrastructure akin to the road system that serves a wide profusion of vehicles, each with its own purpose and history. Economically, this allows innovations to be viral: starting small and diffusing into general use at a their own rate, from the edges.

In modern terms, the network "virtualizes" the communications that occur within it. Services are abstracted to general, open interfaces that allow development at each separate layer to be independent of developments at any other.

These simple predicates are what make the Internet extensible and universal. They also are at the root of why the Internet has been a regulatory morass. It is not easy to shoehorn it into regulations that were created specifically for a single purpose, especially when the regulations were drawn at a time when the application and the transport were inextricably wedded. Further complicating the situation is the existence of services whose placement are somewhat ambiguous. DNS, the name-to-IP-address lookup service, is an essential element of the network, but is not implemented in network hardware.

An important byproduct of the Internet's history is that it came into widespread use without dominant economic applications that had implications for its hardware and expansion. Streaming media, such as video, for example, is a large bulk bit flow whose requirements are quite different from email, chat, reference, file transfer, and voice communications. It emerged only recently and is accommodated quite well. Conversely, peer-to-peer applications and bulk flows of data from sites to central repositories (for example, in medical monitoring and physical-space monitoring), may well prove to be important drivers in the future. We have to be cautious about closing future opportunities to suit current favorites; the history of the Internet has been a repeated demonstration of the advantages of being "futureproof" by ignoring current trends.

In addition, there is strong general sentiment that regulation of the Internet should mirror its development: guidance should be reserved for when it is truly required, and should be lightweight. We endorse the notion that communication on the Internet should be as open as is possible. Access to it has become the ticket of entry into modern society throughout the world, and therefore cannot be left to pure economics, nor should it be tied to what seems to be the current dominant or even successful applications.

Put another way, access to the Internet is–and will continue to be– regulated. The question is whether the FCC can apply guidance in the public interest or whether that regulation will be de facto, by the industries that control access. There is ample evidence that this will happen if the access controlling industries are left to their own devices.

The MIT Media Lab

The MIT Media Lab was organized in 1983, largely from research groups from across the MIT campus that were all dedicated to the common vision of technology in service of human expression and learning. Over the last 30 years, the Lab has expanded its scope of technologies and activities, but has remained dedicated to this mission. We see technology in general as being a potential amplifier of human aspirations, and we attempt to demonstrate, realize, and scale that goal. The Lab is largely funded by a consortium comprising many corporate sponsors and is therefore independent of any one sponsor or one sponsor's interests. This consortium funding model allows faculty and students at the Lab to form their own research agenda. There is also a significant amount of federally funded research.

In addition, we maintain a graduate program with approximately140 students. Lab alumni have gone to work in industry, academia, and as entrepreneurs in business and in service of social causes. There have been notable successes in creating industries and businesses that have contributed to the global economy; we also run courses and programs in global development. Many in the Lab view the Lab's overall goals as enriching our lives and addressing societal needs.

The Media Lab is strongly committed to learning in the most general sense. Most members endorse the notion that young people are natural learners who do so through exploration, experimentation, and both personal and social expressions of creativity.

We put forth the following five "principles" that present our position with respect to the open Internet–principles that we hope will help inform the debate and rulemaking process. The first three are statements of intent and observations of the social, economic, and intellectual value of the open Internet. The last two are an articulation of regulatory goals and directions that we feel are inevitable and useful.

Principle One: The Metric is Attempts, Not Successes

We believe that the metric of impact of the open Internet can best be measured by the number of *attempts* more than by the number of *successes*. While the latter is important, the broader measure is how many people, businesses, and governments have tried new ideas and what they have learned and contributed to humankind through their development. The Internet has transformed every living room and laptop into a space for exploration and experiment–a place where it is easier to try something new than to argue about it. And this transformative experimentation has been in all domains of life, from the arts to the sciences. Success certainly matters in all fields, but successes are built on attempts, and it is the attempts that reflect the network's value.

When one considers invention and innovation, an important aspect is understanding what barriers stand in the way. In some cases, the technology can be expensive and hard to assemble. This is certainly the case with launching a mission to Mars–it is not likely to be a small enterprise. In addition to physical impediments, there have traditionally been intellectual ones: it can be hard to learn what is needed to accomplish a task; it can be daunting to assemble a team to realize an idea; and it can be hard to join a community that is both motivated and knowledgeable. Opacity, complexity, and isolation are just sample barriers, but they are notable.

The Internet has drastically changed the inventive playing field. Nowhere has this been more true than in the domain of software.[5] Open software is inextricably linked to communications and ready access to public repositories. Equally important is the discussion of software that takes place, for example, on sites such as StackOverflow. And code itself is freely interchanged and embedded in new projects. Clarity replaces opacity, community replaces isolation, and complexity is reduced by building on what has been done and shared.

A direct result of the democratization of software has been a profusion of entrepreneurial activities in the US and globally. In essence, the cost of failure has been lowered to such a degree that it has created for many the attitude that they can try anything. This attitude is reinforced by a commitment in the US to people rather than companies. Many entrepreneurial ideas–even without commercial success–add great value to the world community and intellectual marketplace. The latter often occurs along a scale from utter loss to phenomenal success, and we at the Media Lab have seen our share of all of these.

[5] Software coding is more than an example. These days it is considered by many to be an essential skill for problem solving and a style of thought for all aspects of modern life.

Increasingly, these same barriers are being reduced for hardware initiatives, coincident with a popular emphasis on the extension of the Internet itself to the world of physical devices. This, in turn, has led to a vibrant "Maker Movement" that has empowered people to pursue creative expression in areas well beyond more familiar programming.

One result of this is exemplified by an international development course taught for the past 15 years by Media Lab Professor Alex Pentland and Joost Bonsen. In this course, students propose and realize projects oriented toward the developing world. Over the years that it has been taught, hundreds have been demonstrated, and scores have been deployed. The notion of doing this kind of effective work in the short window of a semester is possible only because of the ability to leverage software, hardware, and communications that are already in place, openly accessible, and reusable.

By contrast, Scratch, a programming and exploration language for children by which they learn a variety of principles that range from programming to animation design, was initially rejected in 2010 by the Apple App Store due to a prohibition instituted by Apple on distributing programming languages for the iPhone. At that time, over one million projects done for purely exploratory reasons were in place, and the project has since grown to include more than five million projects. While Scratch does not map precisely onto the importance of an open Internet, it is indicative of how commercial interests can have the side effect of damping educational and entrepreneurial opportunities.

Our point in noting these examples is that democratization of opportunity is the hallmark of the Internet and these goals can go awry when they conflict with corporate goals, regardless of intention. We therefore unabashedly support an Internet where metaphorically, access is accessible to all, unconstrained, and ever-present.

Principle Two: The Internet is a Learning Engine

We support the hypothesis that the Internet is a significant engine of learning, independent of its value in inspiring an entrepreneurial society. Indeed, its value as such may be more significant than any directed educational initiative.

An essential element of learning is the ability to conduct research and exploration– basically a library function. Over the course of its life, the Internet has been a repository of information that is uncensored by industrial interests. Examples include the Internet Archive, Wikipedia, and, more recently, open-university courses.

More important, learning is in large measure related to the opportunity to explore and invent. It is all about building a creative society as opposed to the organized inculcation of specific knowledge.[6] We are not alone in arguing that the most productive members of society today are those who are the best learners; mere facts become obsolete, but the ability to think creatively and explore new areas is the hallmark of successful education

[6] See, for example, JS Brown and RP Adler, "Minds on Fire," *Educause*, January, 2008.

that drives a vibrant society.

A subtle and immeasurable impact of access to the Internet has been its role in encouraging learners to question, to build, and to realize new ideas. Great effort has been dedicated to doing this in schools, but the Internet is the forum where it happens naturally. More important, since these learning activities often occur outside the domain of traditional academics, they are not often counted in the measures used to assess societal progress. They are a by-product: something one might consider *over-the-top* education.

This is inextricably intertwined with an open Internet for the simple reason that the freedom to ask questions, explore freely, and invent limitlessly are the metric of an educated society.

Principle Three: Symmetry Must be the Norm

The Internet is primarily about expression, not consumption. It may well be that the bulk of the bits that currently flow through the Internet are media-related, but that does not mean that the Internet is merely a new television-delivery platform, nor does it mean that the Internet is about the connection between bit "consumers" and "providers." We cannot allow the predominance of those data to unduly direct the evolution the network as if delivery of content were the Internet's end game. It is the generality of the Internet that has provided both opportunity (described above) and reward (social, educational, and economic). To declare that it is about delivery of content by providers assumes a future not yet in evidence. *To do so would be enshrining industrial policy in the more basic and generic goal of providing universal access.*

American universities are a better model. Many universities provide unfettered high-quality access to the network, combined with the resources for students and researchers to build ideas and promulgate them in the real world. Researchers can create web sites and other sources of information instantly and freely. In this environment, the Internet is inherently symmetric and divorced from any mass media linkages, commercially or conceptually. We strongly believe that this is an appropriate model to follow for everyone. Examples that are speculative but rooted in experience include:

• A home monitoring service where a robotic "watchman" floats through a home, vacuuming and transmitting video to the resident. It would be a media service run in reverse: massive video flows from users to a central server.

• A crowd-sourced, distributed computation platform where large groups of individuals can pool processor time on their personal computers for large clients. A generalized "SETI at home."

• A peer-to-peer platform for massive open, online courses, where content is redundantly stored and transmitted directly among users.

In these examples, there are no "edge providers" to negotiate paid prioritization agreements.

We thus abhor the notion that the current debate is in large measure fueled by evident commercial successes that might themselves tilt the playing field in a direction that insulates them from newer inventions, or by inserting gatekeepers to enforce economic redistribution rather than inventing replacement ideas. Most important, we abjure the notion that there are "edge providers" and "consumers," and that the twain shall not meet. We are all some of each at different times and require the opportunity to cross the line freely and easily. For this reason, we argue that there must be no impediment to the two-way flow of information such as an insertion charge or penalty. The Internet is a network of peers and must remain so to stay vibrant.

Media Lab Principle Four: Franchise-Plus

We endorse policies that foster the continued growth of the open Internet, its penetration to an increasing number of people in the US, economic opportunity for those who provide basic services, and a low barrier for innovation and learning throughout society.

In the spirit of the above, we believe that any holder of a public franchise that sells or distributes access to the Internet via wired or wireless connections, to homes or businesses, provide at least a (virtual) channel that adheres to the FCC's open Internet order, *as they have done in the past*. That is to say access not subject to traffic shaping, inspection, commercial limitations, or any restrictions on the best efforts transmission of data. We argue that the end-to-end principle and best-efforts delivery scheme are what created the network as we know it, and we as a society cannot allow that to disappear.

This is common carriage in its simplest, most reductionist form: nondiscriminatory in content or access. It is consonant with the design of the Internet itself, and imposes no undue regulatory burdens. Instead, it is a recognition that the duty of a franchise holder is *at least to* serve the public in an open and non-discriminatory way while still retaining for themselves the ability to evolve and develop new businesses.

We view a provider of Internet access as offering *at least a dumb pipe*[7]. We also note that to many of us, this outcome is inevitable. There is little question that access to the Internet is the entry ticket to modern society, as important as a driver's license or the right to an education. It is not all that is required by an informed and empowered citizenry, but it is the ante. Lacking this, one is effectively locked out of the game. A corollary of this is that open Internet access is a human right.

In essence, this is an extension and codification of the situation we have today. For example, cable television combined with Internet access (a double play), has both dedicated bandwidth and priority access to subscription television coupled with open Internet access (generally). The television signal is not generally delivered as an Internet

[7] A dumb pipe is one where the data are not metered, managed, inspected, or censored.

service today, but it will be in the future, in which case, it would be a virtual network overlaid onto generic access. A second example is a (hypothetical) business arrangement between a cable provider and a media distribution company, where the media is given priority service on a virtual Internet connection, as a TV channel is today.

Principle Five: Coupled Development

We are concerned that provision of proprietary services that are overlaid onto Internet access can potentially result in what some people call a dual highway, with a high-speed toll lane and a dirt road on the side. That dirt road is the open Internet. To prevent that from happening, we advocate an "equal and opposite development" for Internet access: any enhancement to a proprietary channel, be it virtual or actual, must be linked to an equal development of the open channel. A suitable metric for that is to require all such proprietary provisioning to be coupled with an equal increase in the provisioning for the open Internet. We call this equal access *Pipe++,* to signify that as the pipe grows through commercial investment and public acceptance, it grows in all dimensions.[8]

The notion of equal improvement obviates the need to cast into concrete the speed associated with broadband access or even the mechanism by which we measure throughput.[9] What's good for the goose is good for the gander: if end-to-end connectivity works for toll-road applications, equality of provisioning insures that the open Internet's capacity to homes, schools, and businesses will automatically keep pace.

Likewise, we need not be specific about "network management." It is sufficient to state that it must operate at a capacity that mirrors any side-channel capability, and by dint of being non-discriminatory, any and all management must support the end-to-end principle and best-efforts delivery.

It is also important to note that we distinguish between "broadband access" and "open Internet access." In this note and throughout our discussion, broadband access applies to the wire to the home, school, or business. Open Internet access applies to the entire link to the backbone and to any other Internet termination points. This includes the routers and switching equipment. It would violate the spirit of equal enhancement of open and proprietary channels to add capacity to one without adding capacity to the other; i.e., a gigabit connection to the home is of little use if the backbone connection is 10 megabits for a neighborhood. The point we are trying to make is that the Internet cannot be throttled, shaped, or intruded upon at any point in the chain. To do so would indeed result in a fast lane and a dirt road in terms of overall throughput.

We also recognize that the notion of "best-efforts" delivery will always prevail in the Internet, whereas it might not in a proprietary channel. This is similar to the case today

[8] In reality, one way to achieve this is to make the offering in parallel: as more proprietary services are offered, a similar offer for more capable open Internet access accompany it. A given customer need not accept this offer, but as long as it is affordable and available, the parallel development requirement is met.

[9] Right now, we are still using static metrics for broadband speed that sorely misstate the idea.

where, for example, one can watch a television program both via a cable channel and via Internet delivery. The cable channel may use IP for delivery, in which case it is a virtual distinction rather than an electrical one. We recognize that the Internet channel delivery may differ from the cable delivery, but as long as this is not the result of under-provisioning the open Internet, we make no comment on it. In practice, this has not been a problem and there is little reason to think that it will become one in the future. It is in everyone's interest to maintain a vibrant and capable backbone.

Nor is anything in our comment meant to impede an ISP's ability to provide core Internet services such as DNS. Nor do we intend to prohibit CDNs. Our intent should be clear: Internet access is a non-discriminatory service that must be built up at the same rate as any other service added to the same franchise. In spirit, this is possible and economic; it has been so demonstrated throughout the world. We suggest that Title II regulation is the best way to do this since it can be done in the lightest possible manner, but with the potential for more stringent requirements should the open Internet be violated by an access provider.[10]

We note that this is the situation in much of the rest of the world. In the UK, for example, the wired Internet business is horizontally divided, with infrastructure providers at one layer and service providers above. BT Open Reach provides access, increasingly via fiber optics near or in the home, and all ISPs can offer subscriptions on those connections. BT has an ISP service, and it must purchase the broadband link from BT Open Reach at the same rates as Virgin, Sky, or anyone else. A similar situation exists in satellite transmission where some channel space can be purchased by BT to offer its sports television, which is delivered by Sky via its satellite. ISPs typically deliver open Internet access (with no caps or restrictions) packaged with other services that make it attractive. There are also raw providers that compete on price.

A glance at the ads shows that the various consumer companies compete on features, but do not intrude on Internet access. This is Pipe++ in operation. Open Reach does not shape traffic or block because it is cheaper to add capacity. Moreover, it would be hard for them to do so with the variety of ISPs using the wires.

We recognize that in the US, the business model is different. In most places, there is only one high speed[11] wired Internet provider. This structure is likely to remain for some time and it entails risks associated with monopoly services. We do not address those specifically since others have already done so. Classifying Internet access as a franchised Title II service opens the door for other controls to be administered as the need arises, i.e., if monopoly power was misused. Clearly, whether a business or home user, one

[10] Title II refers to the Communications Act section on common carriage. The 1996 Telecommunications Act also notes that in the interest of promoting broadband access and advanced services, the FCC can "forebear" from applying sections of the act to meet this goal.

[11] One definition of broadband access is 4Mb/s, which is clearly below the rates we associate with high speed today. Internet access, however, cannot be defined by a rate. To do so misrepresents the evolving technology and applications and could stunt innovation.

ought to be able to purchase pure Internet access with nothing bundled with it.

Wireless

We reserve special consideration for wireless Internet access because we believe that wireless is likely to become the predominant forum for applications and innovation in the near future. Indeed, we see universal wireless access as a social necessity in the coming years.

This perspective is in part due to the nature of mobile devices. Since the advent of smart phones, our mobile phones have migrated from being devices on which one makes a telephone call to being the personal applications engine that PCs only simulate. Relative to mobile terminals, wired PCs are business machines that have been warped by necessity into personal servers. Wireless terminals, however, take on that role naturally: they are carried on the person, their design reflects individual ownership, the suite of applications loaded and run on them typically reflects the personality of the owner (and we lend them to others as rarely as might lend a toothbrush), and they carry deeply personal and sensitive data. Further, they are emerging as the nexus of personal, on-body sensing, communications, and interface.

Wireless mobile is also critical in that over the course of the next few years–unless there is some unforeseen breakthrough in processor technology–the stand-alone capabilities of these devices may well plateau. The measure of quality of a wireless device is tightly coupled to its battery life; a new product might have more functions, but it seldom is designed to require more frequent charging. But the battery itself cannot improve vastly without becoming a dangerous energy repository (more like a gas tank than a C-cell), and the processing/interface cannot readily drop its consumption. Therefore, the mobile device is increasingly defined by its network interactions.

Further, radio technology is far more open to innovation than wired access; it is proportionately less mature. While one can foresee wired demand and draw upon readily available technologies to meet it, radio communication is a resource that has become scarce in part as a result of a perceived need to adhere to long-lived standards. But the future of radio is wide open, both theoretically and practically. We don't know the limits of distributed antenna systems; we have not pushed directed energy to its natural extreme in practice; we have not forced access nodes to make maximal use of the physical space before we auction off more spectral space. For now, we increasingly allocate long-term licenses that reinforce the status quo.

With regard to obsolescence, we stress the changing nature of hardware. It is no longer the slowest element of change in commercial systems; it is becoming as malleable and replaceable as software–not quite a download, but not as far off as one might expect. Also, mobile devices themselves are replaced at rates unimaginable even five years ago. Unlike the era when analog radio and television were standardized, we no longer need to assume standards that will be used for 30 years; we can consider radio to

be far more revolutionary.[12]

It is therefore critical that wireless regulation adheres to the same principles described above. We therefore suggest two key regulatory components: the first is that wireless regulation be aimed at deliberate, timed obsolescence of existing systems and their periodic replacement as newer technologies emerge. The second is that a more stringent view of the limitation of network management be taken to insure that there are no artificial or industrially created synthetic control points placed between an application and the flow of bits associated with it.

Most important, we reiterate that in short order wireless access will be a social requirement, just as wired broadband is today. We cannot, as a society, allow the regulation of information flow in that environment to be left solely to corporate interest and concerns. That would be an abrogation of the charter of the FCC. For those reasons, we strongly urge that the *Pipe*++ strategy be applied equally to wireless and wired access. We also advocate that the default on associating a transmission standard with a spectrum allocation expire after approximately five years so that the technology can be refreshed.

Conclusion

We see the open Internet–both wired and wireless–as the primary platform for learning and development, characterized by a uniquely low barrier to experimentation and commercial attempts that benefits society. We also see it as a proving ground for ideas whose ultimate realization may be on special-purpose networks. We therefore propose a dual development path for both of those networks: first, an open Internet, the provision of which is a requirement of those holding a public franchise. This open Internet needs to be regulated by the principles of non-discriminatory access common carriage. Second, this open Internet may be coupled with the development of special-purpose, real and virtual networks that co-exist *provided that they result in expansion of the open Internet at the same time*. This model provides a solid, entrepreneurial basis for the development of both.

[12] Both WiFi and carrier-based wireless devices evolve and diffuse through society quite quickly. New bands inspire mobile phone upgrades, and better WiFi designs are installed quickly, especially as compared with historic radio systems, such as TV/HDTV, FM, and citizen's band radios.