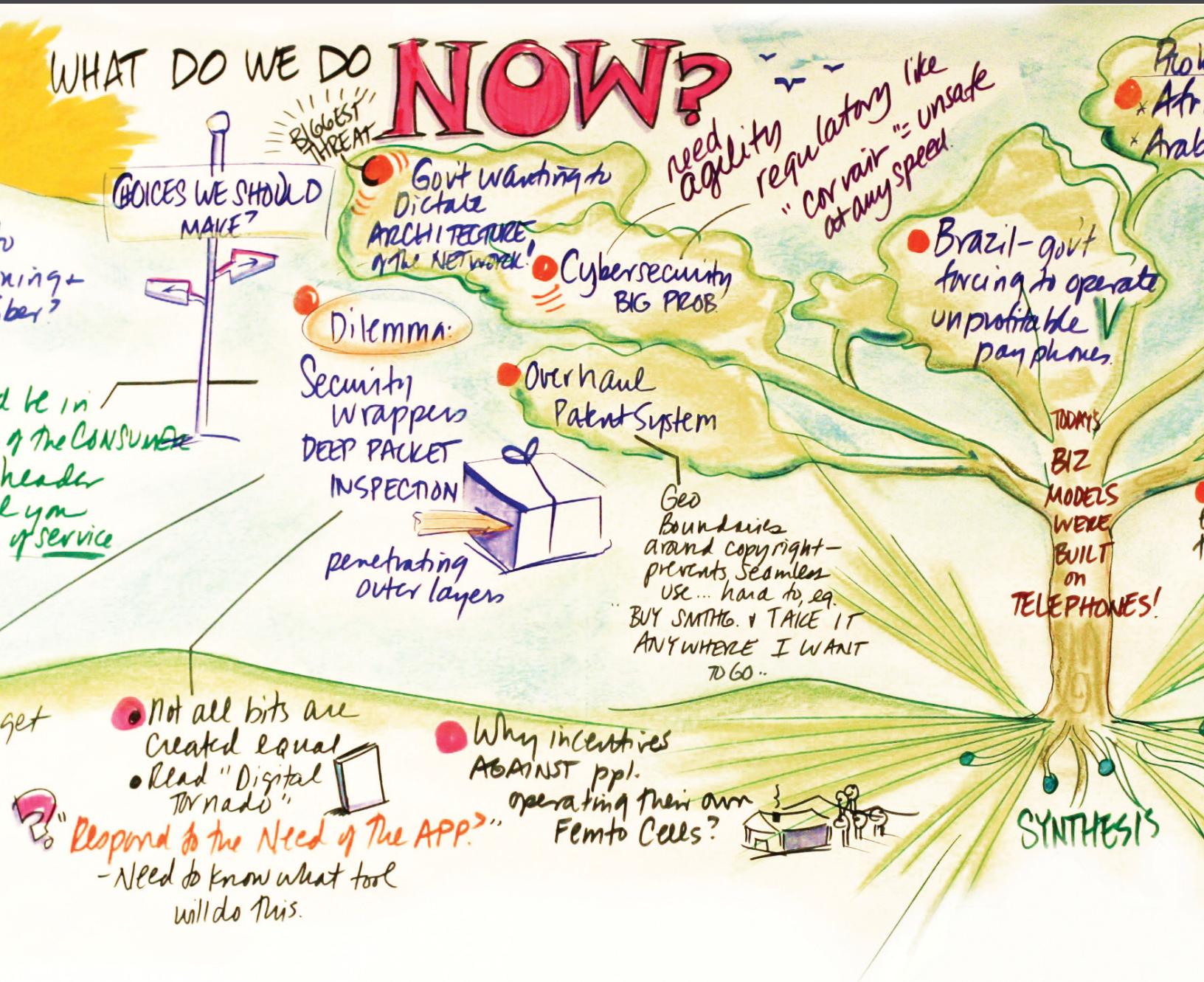


AFTER BROADBAND

Imagining Hyperconnected Futures

San Francisco, April 17, 2012



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Foreword

by: kevin werbach | THE WHARTON SCHOOL

In times of significant change, it is particularly easy to miss the forest for the trees. Even as we trumpet the importance of digital connectivity, we fail to appreciate just how much has changed in business and daily life since the commercial Internet emerged in the mid-1990s. More importantly, we tend to forget that technological change is continuous, if not accelerating. The broadband environment of 2022 promises to be as different from 2012 as the world of 2002: before the iPhone, Facebook, and widespread broadband adoption.

The decisions of technologists, executives, and policy makers over the next few years will shape that future environment. Failures of imagination can derail beneficial change as surely as technical or economic lapses.

How can we step outside our current perspectives and imagine the pathways toward hyperconnected futures? The good news is that the technological trends that will shape the world of 2022 must already exist in nascent form. Yet it's difficult to envision how they will unfold, as they intersect with each other and with the macro environment.

To overcome this hurdle, I partnered with the Mack Center for Technological Innovation at the Wharton School and the Institute for the Future (IFTF), an influential Silicon Valley technology think tank. We assembled a wide-ranging group of technical and business visionaries, each of whom brought insights on some aspect of the problem. Through an intense day of focused interactions and collaborations, we developed a mosaic of the hyperconnected future. IFTF Distinguished Fellow Mike Liebhold co-hosted the meeting, and IFTF Distinguished Fellow Richard Adler produced this report.

The workshop discussion identified six primary challenges deserving of attention:

NETWORK DIVERSITY

The future of broadband is more about supporting a diversity of application performance requirements than increasing maximum download speeds.

BALKANIZATION

Heterogeneous applications push against the universal, best-efforts interconnection that defines the Internet. Can we prevent the Internet from fragmenting? Do we want to?

SECURITY

As digital connectivity becomes more critical, security will become increasingly paramount, and will require tough choices about openness and privacy.

PUBLIC POLICY

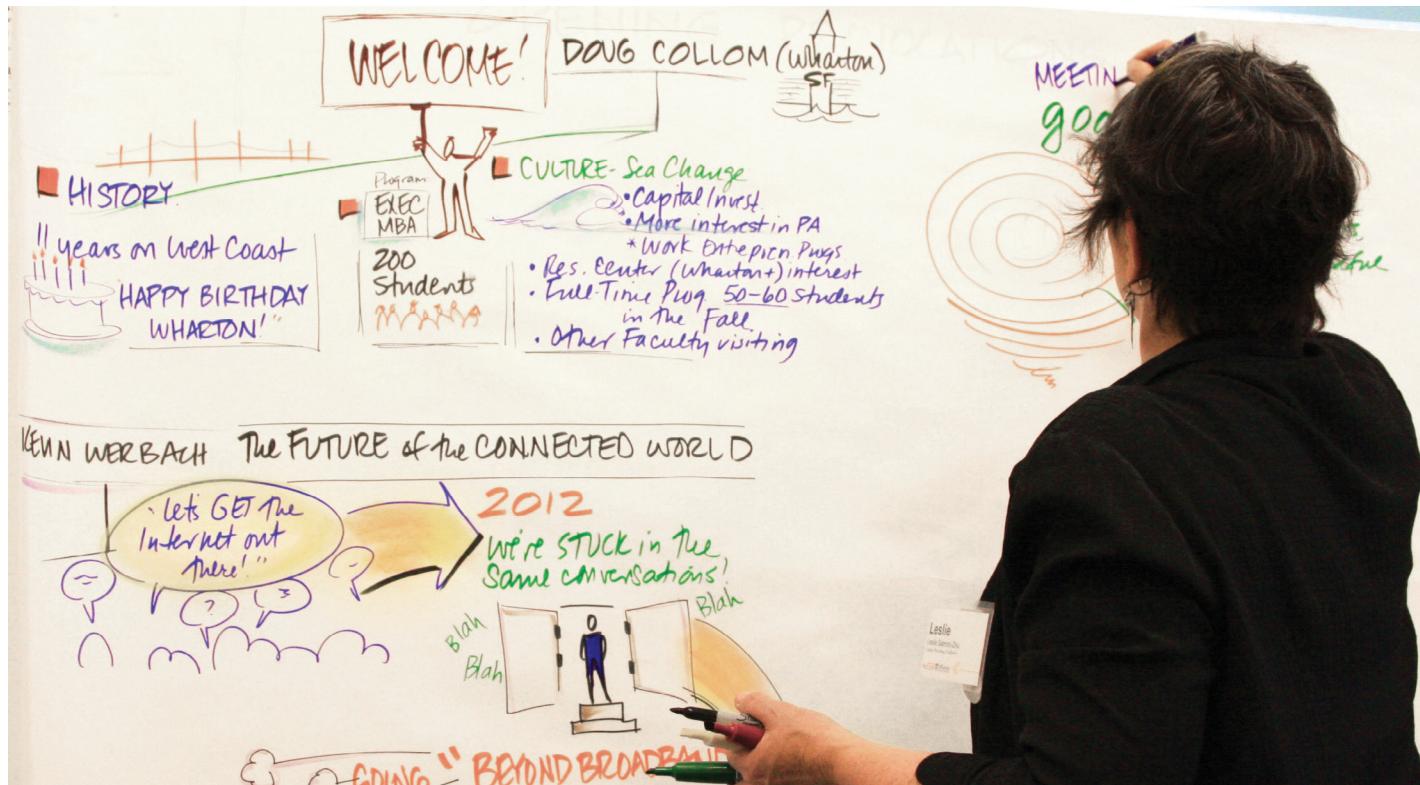
Communications regulators must recommit to the goal of expanding connectivity. Spectrum policy and Internet governance are particular concerns.

COMPETITION

Network operators and application providers need each other, but they see the world differently. Is there enough infrastructure competition to support innovation?

CONTROL OF INFORMATION

As users put more content online and have their online activities tracked, who controls that information and how can user access be ensured?



All workshop photos in this report courtesy of Lori Furman

The report provides further details on these issues, and summaries of eight topical workgroups that delved into specific market segments. These are by no means the only issues that communities, industries, and governments face. Our goal was to highlight blind spots and latent tensions that are not obvious.

We hope this work helps to make sense of the choices before us in building toward the hyperconnected future. Thanks to the Mack Center, IFTF, and all the participants for contributing to this endeavor.

For additional information about the themes and conclusions of the workshop, including video interviews with participants, please visit afterbroadband.com.

AFTER BROADBAND: IMAGINING HYPERCONNECTED FUTURES

san francisco, april 17, 2012
by richard adler | INSTITUTE FOR THE FUTURE

FROM CONNECTION TO HYPERCONNECTION

Thanks to the growth of the Internet and the spread of broadband over the past decade, much of the United States—and much of the rest of the world—have become connected to a vast array of online resources. And the proliferation of wireless devices and wireless networks has led people to expect to have the ability to be online almost anytime and anywhere. Many social functions and industry sectors—including communications, entertainment, publishing, commerce and even government—have been impacted by this phenomenon.

As the broadband revolution continues to unfold, where is it taking us? If we are living in a highly connected world today,

what will life in a hyperconnected world a decade from now look like? To address these questions, the Wharton School and the Institute for the Future convened a one-day workshop in San Francisco in April 2012, which brought together a group of leading technologists, entrepreneurs, academics, and policymakers to explore the future of broadband over the next decade. Workshop participants also envisioned some of the new applications that are likely to emerge as a result of the continued development of the technology.

Provocations

To provide a framework for the day, several workshop participants were invited to describe how they saw the emerging broadband environment and to identify some of the key issues that will shape the evolution of broadband over the next decade.

BY THE NUMBERS

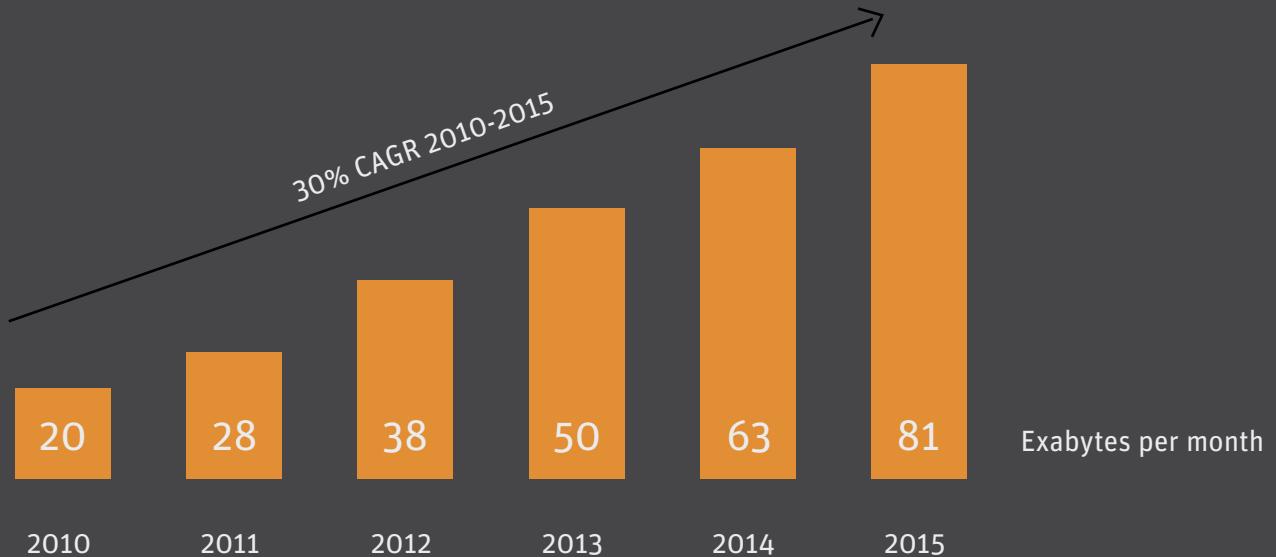
Robert Pepper, Vice-President for Global Technology Policy at Cisco, provided an overview of the stunning growth of Internet usage based on Cisco's Visual Networking Index (VNI), a much-cited set of forecasts the company publishes on a regular basis. Some of the forecasts include numbers so large they are difficult to grasp: for example, according to the VNI, total global Internet traffic will increase four-fold from 2010 to 2015, from 20 exabytes (EB) per month to 81 EB per month (one exabyte is equal to one million terabytes). Mobile data traffic

will grow even faster: it will increase eighteen-fold over the next five years, from 0.6 EB per month in 2011 to 10.8 EB per month in 2016, and 70 percent of it will be video content. The fastest growth of all will be machine-to-machine mobile data, which is forecast to increase 22 times.

The sources of Internet traffic are also shifting dramatically according to the VNI: by the end of 2012, there will be more Internet users in China than in North America and Western Europe combined, and the number of users in the Middle East and Africa will surpass the number in North America. By 2015, nearly half of all Internet users globally will be in Asia, and the BRIC countries will generate nearly as much consumer traffic as the United States. And there will be some 10 billion mobile connections to the Internet, or more than one for each person on earth.

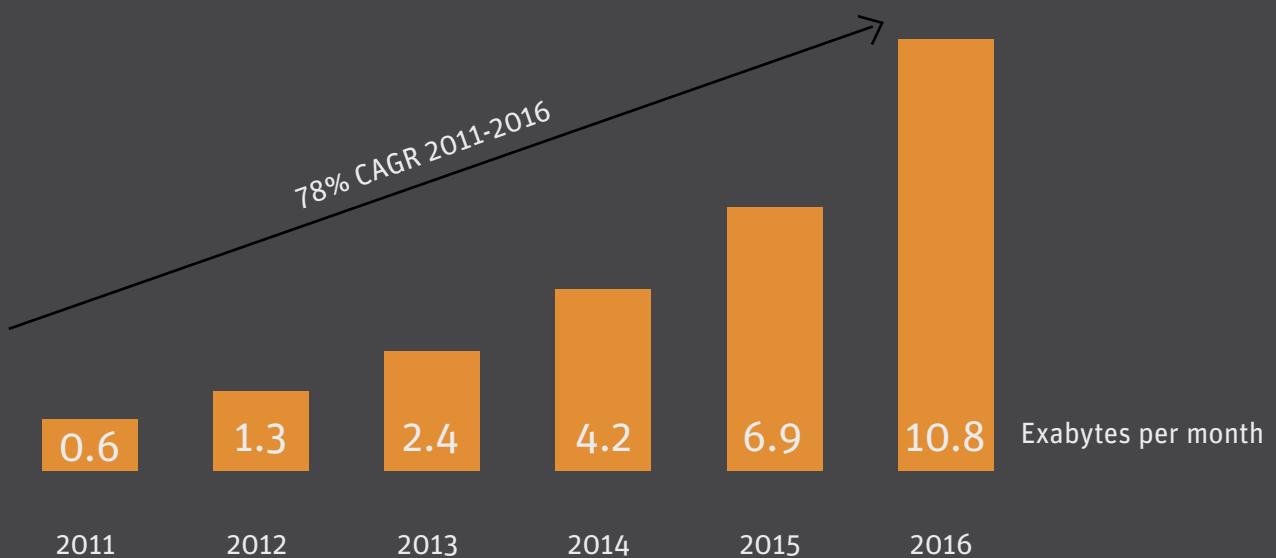
CONTINUED INTERNET TRAFFIC GROWTH

Global IP traffic will increase 4-fold from 2010 to 2015



MOBILE DATA GROWING EVEN FASTER

Global mobile data traffic will increase 18x from 2011 to 2016



GRAND CHALLENGES

Joe Mambretti, Director of the International Center for Advanced Internet Research (iCAIR) at Northwestern University, pointed out that the scientific community tends to be a decade ahead of the public in its uses of network resources. Looking at how researchers are using high performance networks can provide clues to the future of the broader Internet. Based on these experiences, Mambretti identified several “grand challenges” that will have to be addressed as we move from the current to the future broadband environment. These include:

- Enabling the Internet to scale from supporting two billion users to accommodating four or even six billion users globally. The Internet has proved to be remarkably resilient in growing from just a handful of users to several billion users today. But the next wave of users, most of whom live outside of the developed world, will be quite different in terms of their abilities and interests from the current population of users. In addition to adding massive new capacity, new technical capabilities will be needed to accommodate the next generation of users.
- Building a “better Internet” that has fewer limits, more capabilities, and provides more security than the current “antique” Internet. The original design of the Internet, much of which survives today, never contemplated many of the uses that take place online today, nor was it designed for the vast, heterogeneous number of users who have come to depend on the Internet in their daily lives. Protecting the security of the network is a growing concern. Ironically, the openness that has been one of the hallmarks of the Internet’s architecture since its earliest days and that has been responsible for much of the unfettered innovation it has unleashed has also been responsible for making the Internet vulnerable to a variety of security threats. Making the Net more secure (without stifling creativity) is critical to maintaining users’ trust that their online activities are safe.

Are we going to have an Internet in ten years where capacity is abundant and applications spring into existence that depend on abundant capacity, or are we going to have an Internet where capacity is rationed?

- Dave Clark

- Migrating the Internet from being largely data-, text- and image-centric to a network that supports “full, rich multimedia” content. While video material already accounts for nearly half of all consumer Internet traffic,¹ the quality of that video today is relatively “crummy” and will have to improve substantially as video continues to grow in quality, popularity, and importance. More bandwidth is needed to support continued expansion of video traffic, and better service quality (i.e., reduced latency) is needed to support real-time video-based communications. (Mambretti cited experiments underway with 4K video that provides image quality that is four times greater than current HDTV and will further expand demand for bandwidth. He also noted that ultra-high resolution 8K video, with even greater bandwidth requirements, is already under development.)
- Empowering edge processes, applications, and users. Today, Internet service is essentially a “take it or leave it” proposition, where one size necessarily fits all, with users having no access to the management or control



planes of the Internet (e.g., protocols embedded in network routers that manage the flow of traffic over the Internet). In the future, users will have access to these resources so that they can easily create ad hoc, customized “personal networks,” depending on the applications they wish to run at any given time.

- Creating a robust “Internet of Things” comprised of 20 billion to as many as 40 billion nodes, not of people but of individually identifiable sensors or actuators that function automatically to collect data and/or control an activity with minimal human participation. The traffic generated by these devices will be quite different than that typically created by people and will require substantially different network capabilities.

Stepping back from these individual challenges, Mambretti called for a fundamental paradigm shift from the “traditional” Internet—a static network that offers access to invisible, fixed resources defined by a strictly layered architecture—to a more flexible, decentralized structure that includes highly distributed, programmable resources that are visible and accessible to all users and that can be integrated as needed, rather than being kept apart in separate layers. This next-generation paradigm will make it easy to create a variety of specialized networks serving different user communities as well as individuals who will be able to establish their own private networks. (Mambretti noted that iCAIR operates Starlight, an exchange facility for advanced networks where many of the future capabilities he described are currently implemented in a research environment.)

AN ABUNDANT FUTURE

Milo Medin, Vice President of Access Services at Google, offered a vision of what he described as “a future of abundance” for broadband. He noted that the growth of wireline broadband to date has been driven by steady improvements in network technology, which have made it possible to deliver increasingly high performance with little or no increase in cost. Over the past 25 years, for example, optical fiber capacity has increased by nearly five orders of magnitude while the cost per bit transmitted has fallen by an equal amount.

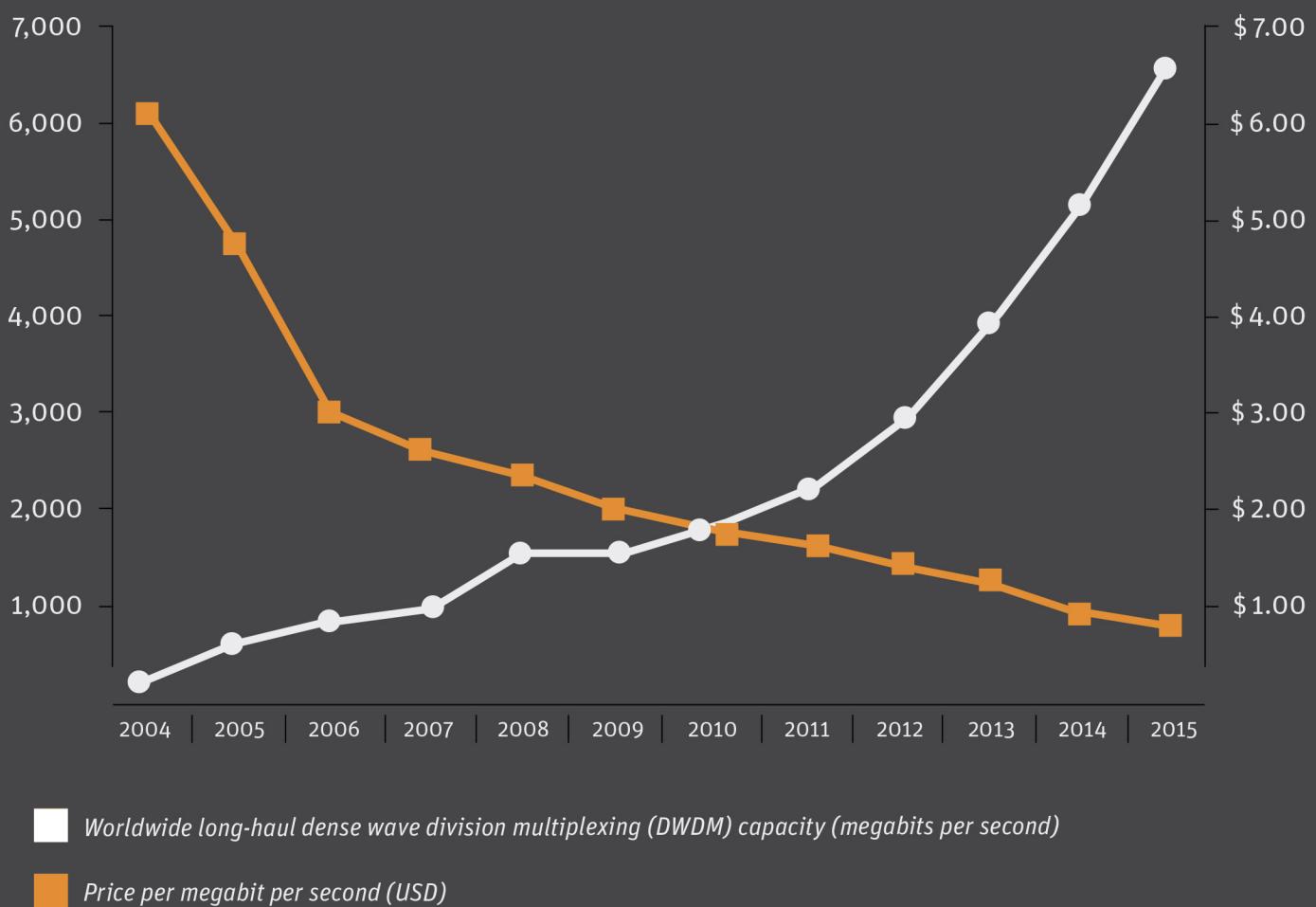
Unfortunately, wireless (cellular) broadband has not experienced similar improvements, mainly because of constraints on the availability of spectrum, which Medin described as “odd” because much of the airwaves are currently underutilized. The federal government, which controls spectrum allocation, has not done a good job of increasing access. The key to expanded use is to look at spectrum as a

“temporal resource”: employing a variety of technological means (e.g., smart antennas, microcells, agile radios) to allow multiple parties to share the use of this finite and highly valuable resource more efficiently. Rather than responding to soaring demand for broadband service by rationing access to it (for both wireline and wireless networks), Medin called for more competition to spur greater investment and faster innovation.

We are not looking at one gigabit per second as the end, but as the beginning.

- Milo Medin



FALLING COSTS = MORE CAPACITY AT THE SAME PRICE*Internet long-haul transit capacity vs. price per Mbps*

MUSING ON HYPERCONNECTIVITY

Dave Tennenhouse, a partner at New Venture Partners and former chief scientist at DARPA, believes that the next generation Internet offers “spectacular opportunities for impact” on many aspects of society. We have already achieved widespread broadband connectivity that is serving a massive number of users. There has also been a “tremendous spurt of innovation in user interface design” that has made computing much friendlier and more interactive. Now, ever more powerful resources that are available in the cloud are ushering in an era of proactive computing that is able to anticipate users’ needs and act autonomously on their behalf.

But some challenges are looming: like Medin, Tennenhouse is concerned about constraints on mobile broadband access. Although cellular networks were originally designed for voice communications, they are rapidly becoming used predominantly for broadband access. Tennenhouse described the wireless carriers as “reluctant innovators” who have been slow to respond to burgeoning demand for mobile broadband. Rather than providing additional capacity, mobile operators have imposed caps on usage and encouraged customers to “offload” some of their traffic onto Wi-Fi or wired networks.

Tennenhouse noted that after a period of relatively little innovation, this is a time of active experimentation in the development of new network protocols and techniques. Although this is an exciting time for researchers, he warned that a growing asymmetry in the structure of the Internet may be approaching a “breaking point”: while the consumer-facing Internet continues to be based on the use of IP as the common transport protocol, operators of large resources “in the cloud” have implemented advanced architectures to support ultra-high performance network connections with extreme bandwidth and near-zero latency within (and between) large-scale data centers.² If the use of these alternative architectures continues to grow, the traditional IP-based Internet could shrink until it serves as little more than a means of interconnecting disparate networks.



A second challenge stems from the emergence of the Internet of Things, which is beginning to generate a flood of data that could easily overwhelm the ability of enterprises to make use of it. As Tennenhouse put it, how can we “avoid having to interact with billions of edge nodes?” The solution, he suggested, is to deliver “Things as a Service” (TaaS) where remote sensors operating autonomously are bundled with processing capabilities that allow data to “go around rather than through” users, providing access to the processed information only when needed (an example of proactive computing).

Finally, Tennenhouse cited an essay titled “The Second Economy” by W. Brian Arthur³ that describes the growth of a largely invisible web of business processes that were once carried out by human beings and are now being conducted



electronically and automatically. (To illustrate the scale of this phenomenon, Arthur traced the cascade of events, which he describes as “a huge conversation conducted entirely among machines,” that happens automatically each time a passenger checks in, either online or at an airport kiosk, for a commercial airline flight.) As the Internet expands and takes on more functions, we are essentially building a “second economy” that functions alongside (or underneath) the physical economy. While this development promises to provide great improvements in productivity, it also carries the potential for destroying even more jobs than have been lost to date to automation and off shoring. Tennenhouse challenged workshop participants to think about what a “third economy” based on the surplus labor that has been freed up by this revolution might look like.

*The broadband platform
is the commons of knowledge
exchange. One thing that
is hindering it today in the United
States is bandwidth.
We haven't removed bandwidth as
a barrier to innovation.*

- Blair Levin

CONNECTED HEALTH

Deborah Estrin, Professor of Computer Science at UCLA, focused on a specific instance of how computing and communications technologies are coming together to create what she described as “participatory mobile health (mHealth).” The availability of billions of smart mobile phones equipped with capabilities such as GPS, imagers, sensors and touch screens, as well as Internet connectivity, are making it possible to “transform previously unmeasured behaviors and practices into personalized, evidence-based and evidence-producing health care” on an unprecedented scale. The creation of an “open mHealth” infrastructure will provide benefits to patients (particularly those with chronic conditions), who will be empowered to provide themselves with much better self-care; to clinicians, who will be better

equipped to keep track of their patients and the effectiveness of prescribed treatments for each one; and to medical researchers, who will gain access to powerful new tools for determining what treatments work best in different contexts.

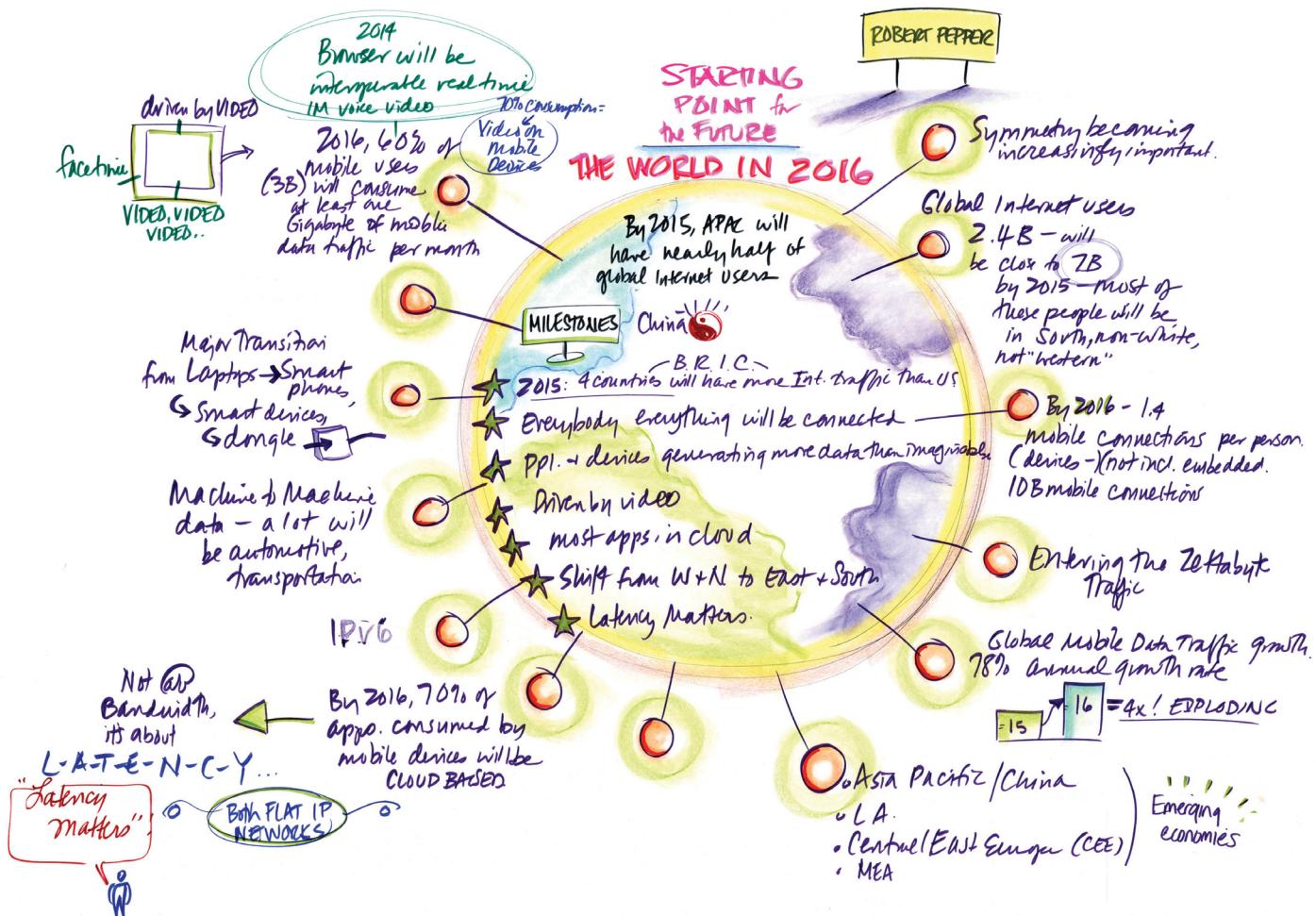
Looking more broadly at the future of network technology, Estrin foresees the emergence of “broadband to the him and her”—the ultimate evolution of personal and personalized networks that will provide continuous monitoring of each individual’s health.⁴ Of course, many technical and regulatory issues remain to be resolved for this to happen, including developing new systems architectures, authoring and sense-making tools; devising robust mechanisms to protect user privacy; and attracting the capital investment necessary to create this new infrastructure.



Technology is the enabler. It's about what people do with devices, the ability to put a device on the network and see what people do with it.

- Leslie Daigle





Leslie Salmon-Zhu, a professional graphic recorder, created a series of large-format real-time illustrations from the conversations at the After Broadband workshop. These images helped the participants to crystallize and conceptualize key insights during the course of the meeting.

A segment of another one of the illustrations can be found on the cover of this report.

Additional images are available at afterbroadband.com.

THE END OF READING?

Finally, **Bran Ferren**, co-chairman of Applied Minds, provided a very long-term perspective on the changes being wrought by new technologies. He noted that some venerable institutions, such as encyclopedias and newspapers, are disappearing because of the digital revolution. Many dictators have also disappeared thanks to grassroots uprisings that have made creative use of ad-hoc networks to evade surveillance by repressive regimes.

Large-scale disruptions are happening with increasing frequency and typically come from outside of a company's immediate industry: for example, newspaper publishers paid little attention to "a guy named Craig" until his list cannibalized a huge portion of the industry's most profitable revenues (from classified ads). And the publishers of the Encyclopedia Britannica never anticipated that a loosely organized group of volunteers could create an online encyclopedia that would supplant their long-established reference work. Today, Google is radically re-inventing the automobile with its self-driving car.⁵ When a "connected car" is aware of every other vehicle on the road, efficiency will go up and accidents will go down.

The demographics of Internet users is also changing dramatically: reinforcing a point made by Dave Tennenhouse, Ferren noted that the first online users were highly educated people in the developed world, but the next wave of users will be very different. The most intensive users of teleconferencing in the future may well be illiterate. In fact, Ferren predicted that over the next 200 or 250 years, reading and writing, which have been at the core of Western civilization, will disappear (or perhaps become archaic skills, like speaking Latin). But what will certainly survive is storytelling, which has always been the "killer app" for communications media. Rather than print or even movies or TV, the next generation of stories may be transmitted through mobile, distributed networks which, in turn, will help create new types of communities.

In light of the critical importance of our media, Ferren suggested we need to consider whether freedom of speech

should be reframed as the freedom to connect.⁶ Do we need to protect "the ether of the Internet" as much as we do the quality of air and water in our communities?

The number of devices is growing rapidly, and communications capacity isn't going to grow as fast, so we are bound to utilize resources more efficiently.

- Jan Rabaey



Future Scenarios

Participants in the Wharton/IFTF workshop were invited to explore the implications of a hyperconnected world in a number of specific domains. Working in small groups, participants developed scenarios describing the likely impact of next-generation broadband networks in different sectors of society (See Appendix 1 on page 18.) These eight domains suggest how broad the impact of hyper-connectivity is likely to be.

1. EDUCATION AND LEARNING

How will the evolution of connectivity influence the formal systems of schools, universities, and training, as well as informal learning inside and outside of companies?

2. ENTERTAINMENT

As technology evolves, people are finding new ways to entertain themselves and each other. As a result, content industries have experienced dramatic disruptions with digital creation and distribution and socially shared media. What will emerge from this ferment?

3. MANAGEMENT, OPERATIONS, AND ANALYTICS

Cloud computing and big data, and cloud served supercomputing are all the rage, but will they change how people in organizations operate? How will broadband and wireless influence business strategy and practice?

4. COMMUNICATIONS AND COLLABORATION

In just a few decades, we've moved from landline-only telephones to a world with two billion broadband Internet users and five billion mobile wireless subscribers. What will we use all those connections for, and how will they develop?

5. COMMERCE, IDENTITY AND SECURITY

Commercial transactions depend on robust trust. How will doing secure business online get easier (or harder) for individuals and enterprises in the years to come?

6. HEALTH, WELL-BEING, AND LIFE MANAGEMENT

Healthcare transformation is a massive opportunity for broadband, as is the larger space of personal wellness, effectiveness, and sustainability. How much of this opportunity will be realized as broadband continues to evolve?

7. SOCIAL, HOME, AND COMMUNITY LIFE

What effects will ever-denser connectivity have on how we relate to our families, friends, and communities? And how will kids who take broadband as a given grow up?

8. CREATION AND PRODUCTION

We've witnessed the rise of user-generated content and a dramatic reduction in the costs of developing and distributing professional-quality material. What will the creative and productive landscape look like with another decade's worth of evolution?

Key Themes and Issues

The workshop concluded with reflections on the main themes and key insights that emerged from the day's discussion. In a number of cases, the questions regarding the next generation of broadband were more evident than the answers:

WHAT TECHNICAL CHARACTERISTICS ARE MOST CRITICAL FOR THE FUTURE OF BROADBAND?

While much discussion of the future of broadband has focused on faster transmission speeds, that is not the only characteristic that matters. Many advanced applications depend on improvements such as minimizing packet loss, reducing latency and jitter and increasing symmetry between downstream and upstream data rates. As one participant observed, "We don't yet have the networks we need to support advanced applications."

CAN WE AVOID BALKANIZATION OF THE INTERNET? DO WE WANT TO?

Up until now, the Internet has grown by creating a homogenous environment that has ensured universal interoperability. But will this continue? Should it continue? Different users and uses have very different requirements: medical applications need absolute reliability while streamed video-based entertainment is dependent on low-latency and low-cost, high-capacity connections. The concept of software-defined networks, which has already been implemented within large data centers, gives users the ability to configure network features to suit their individual needs. A number of workshop participants called for providing users with greater control over the network capabilities available

to them. Will the value of optimizing the network to support these disparate uses outweigh the value of maintaining uniformity? Are ordinary users ready to assume control over the networks they use? Is there a minimal level of interoperability that is compatible with providing users with greater flexibility?

IS IT POSSIBLE TO SUBSTANTIALLY IMPROVE ONLINE SECURITY?

A veteran journalist observed that cybersecurity has been getting worse every year since the 1970s. Serious breaches of security occur regularly, but little progress has been made in protecting against these threats.⁷ In fact, the sophistication of cyber attacks has escalated faster than our ability to protect against them.

As Joe Mambretti noted, the openness of the Internet's architecture that has stimulated so much innovation is also responsible for many of its vulnerabilities. As the number of people on the Net and the range of critical functions performed online continue to grow, improving security becomes more urgent and more challenging. Moreover, increasing network security will unavoidably involve difficult trade-offs with individual privacy and autonomy. (One example is deep packet inspection of Internet traffic, which can be used to optimize network performance and improve security, but can also be a tool for surveillance.)

CAN GOVERNMENT POLICY KEEP UP WITH THE PACE OF TECHNOLOGICAL CHANGE?

The recent divisive but ultimately unresolved debate over protecting intellectual property rights online illustrates the difficulty that government has with developing appropriate policies to regulate the rapidly evolving broadband environment.⁸ Although demand for mobile broadband service is outstripping the availability of wireless spectrum, the government has been slow to re-allocate spectrum as well as to explore the possibility of more intensive use of the airwaves through spectrum sharing.

There is a cyber security arms race underway.

- Mike Liebhold

Concern was also expressed that regulation could stifle innovation and limit the freedom to communicate. It was noted that Brazil has made the sharing of Wi-Fi connections a criminal offense while a number of countries in Africa and the Middle East have banned the use of Skype to protect their PTTs. A proposal to shift governance of the Internet to the International Telecommunications Union could give participating governments greater ability to restrict or impose new fees on Internet use.

WILL GREATER COMPETITION SPUR FASTER INNOVATION?

The place where competition seems to be most lacking is in the last mile that links end users to the larger Internet. The major ISPs have shown little desire to engage in the kind of competition that frequently spurs innovation. On the other hand, a representative of a large Internet service provider asserted that they stand ready to upgrade and expand their networks as long as someone will pay for it.

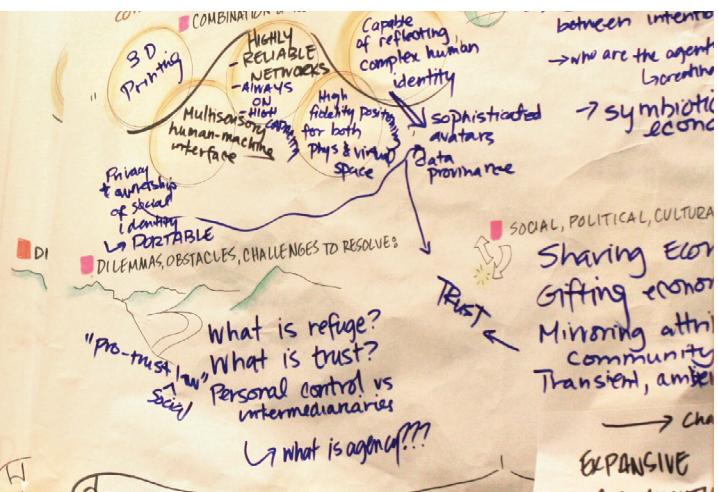
HOW CAN USERS BE GUARANTEED ACCESS TO THE CONTENT THAT THEY GENERATE?

Social media have vastly increased the amount of information users put online, while even larger amounts of personal

data are being created every day by users' online activities. Continuing controversies over who controls this information and how it can be used demonstrate that considerable uncertainty remains about the rules governing user-generated content. Are new mechanisms—legal, regulatory or technical—needed to safeguard this content and ensure that individuals maintain the ability to access and control it?

There are fewer ways of getting wired Internet access today than there were, say, ten years ago. That's not the direction we thought it would take.

- KC Claffy



appendix 1:

Broadband Future Scenarios

1. EDUCATION AND LEARNING:

REPURPOSING EDUCATION

How will the evolution of connectivity influence the formal systems of schools, universities, and training, as well as informal learning inside and outside of companies?

The potential of broadband to expand access to education is already being demonstrated by initiatives ranging from the Khan Academy for K-12 students to the open educational resources (OER) movement for college-level instruction. As broadband continues to develop, it can provide a powerful platform for expanding lifelong learning, not only for training in job skills (capital “E” education), but also for learning for personal self-development (lower-case “e” education). Technology will make it possible to enhance learning by supporting dynamic curricula that can be customized for different learning styles and updated to incorporate new knowledge. These new channels will provide opportunities to develop new pedagogies. Expanding access to education beyond the schools will require new means for documenting accomplishments (e.g., badges, reputation systems).

2. ENTERTAINMENT: MORE OF EVERYTHING...

BUT NOT NECESSARILY BETTER

As technology evolves, people are finding new ways to entertain themselves and each other. As a result, content industries have experienced dramatic disruptions with digital creation and distribution and socially shared media. What will emerge from this ferment?

The core of entertainment will be, as always, stories. The archetype of the hero’s journey (in three acts) will survive. What will change is how those stories are embodied and delivered. The future of entertainment lies at the intersection of content, interactivity and social interaction. As bandwidth increases, entertainment will become more

immersive, including rich virtual reality that provides a “holodeck experience.” As the number of channels proliferates, the amount of entertainment content available to fill them will increase as well, giving audiences a gamut of choices ranging from passive consumption to active involvement. Some programming will still appeal to a mass audience, but the amount of niche appeal content will expand much more rapidly. Among the factors limiting the availability of high-quality content will be the availability of talented creators. Working out copyright rules that provide necessary protection for content creators, while preserving freedom for users and innovators, will be a continuing challenge.

3. MANAGEMENT, OPERATIONS, AND ANALYTICS: BIG DATA FINALLY CREATES EFFECTIVE GOVERNANCE FOR LARGE COMPANIES

Cloud computing and big data, and cloud served supercomputing are all the rage, but will they change how people in organizations operate? How will broadband and wireless influence business strategy and practice?

The classic financial metrics (revenue, profit or loss, return on investment) are essentially retrospective indicators of corporate performance. The integration of social networks with business enterprises, both internally and externally, along with the development of powerful tools to analyze data generated by these networks, are creating new opportunities for better corporate governance. For example, data on the morale of an organization’s individual employees (or its customers) could be used to monitor, in near real-time, the health of an enterprise at an unprecedented level of detail. The availability of these new metrics will increase the transparency of large organizations to their boards—making it possible for them to exert more effective governance—and to other stakeholders as well.

A related scenario, titled “Big, Open Data Changes Governance,” focused on the public sector and the way governments will be impacted by the combination of big data sets, a demand for open access to data in government hands, and the availability of powerful analytical tools to make sense of the data. The result will be a shift in the role of government from making decisions based on privileged access to data to providing citizens with access to the data they need to make decisions for themselves. Of course, not all governments will welcome this shift. Places like China are likely to resist this trend, while Scandinavian countries are likely to be in the forefront of embracing change, with the U.S. somewhere in the middle. Among the challenges for everyone will be finding incentives to encourage governments to openly share their data and finding ways to filter out the noise from the genuine data. One barrier that may be difficult to overcome is the fact that much potentially valuable data is not in the hands of public entities but rather is controlled by private companies that have their own reasons for keeping it confidential.

4. COMMUNICATIONS AND COLLABORATION: THE UNIFORM ACCESS VISION IS DEAD

In just a few decades, we've moved from landline-only telephones to a world with two billion broadband Internet users and five billion mobile wireless subscribers. What will we use all those connections for, and how will they develop?

Broadband is a multidimensional technology: it's not just a matter of speed, but also is critically defined by other factors such as latency and reliability. As the technology moves forward, it is likely to evolve in multiple directions serving different needs and different markets with different architectures. For example, entertainment has always been a major driver of network performance because of its sheer

volume of content. Healthcare is another vitally important area but has very different requirements. Telebusiness is expanding rapidly with yet another set of use cases and requirements. There are also likely to be regional differences as places like Kansas City get wired up with fiber (thanks to Google) while other communities lag behind. Finally, we are likely to see many different types of wireless access, as it becomes, perhaps, the dominant form of broadband connectivity. In the end, the vision that everyone should have the same type of access, which has been the dominant paradigm, especially for policymakers, may fade away.

5. COMMERCE, IDENTITY, AND SECURITY: THE UNITY OF BALKANIZATION

Commercial transactions depend on robust trust. How will doing secure business online get easier (or harder) for individuals and enterprises in the years to come?

This group also envisioned an increasingly virtualized world in which many different broadband flowers bloom. But some big trends seem clear: more and more commerce will take place online, speeding up the transition to a cashless society. It is likely that the role of banks as financial intermediaries will be diminished while non-banking entities will emerge to offer alternative payment mechanisms and even create new digital-based currencies. This new world will have to confront new legal and regulatory problems, including an increased risk of transaction fraud, greater uncertainty in determining appropriate jurisdictional boundaries, and the challenge of establishing fair and effective tax schemes. The biggest challenges in a cashless society may well be to individual freedom and privacy.

6. HEALTH, WELL-BEING, AND LIFE MANAGEMENT: HEALTHSTREAMS

Healthcare transformation is a massive opportunity for broadband, as is the larger space of personal wellness, effectiveness, and sustainability. How much of this opportunity will be realized as broadband continues to evolve?

We know that a large portion of disease is caused by lifestyle choices around factors such as eating, smoking and exercise. One of the biggest obstacles to motivating people to live healthier lives is that we don't experience in the moment the longer-term health consequences of our actions or inactions. It could be possible to address this problem by harnessing technology to enable us to feel these future impacts of our behavior choices in real-time. Intelligent mobile devices are rapidly developing the ability to track many aspects of our behavior and physiological responses, while always-on analytics will be able to make predictions about the impacts of our actions generated by personalized health models. The accuracy of these models will depend on the willingness of people to share data on their individual experiences in order to create the big data sets on which the models are based.

7. SOCIAL, HOME, AND COMMUNITY LIFE: CHOCOLATE HAPPENS

What effects will ever-denser connectivity have on how we relate to our families, friends, and communities? And how will kids who take broadband as a given grow up?

In a hyperconnected world, the boundaries between physical and virtual places are likely to blur further or even disappear. One measure of this evolution would be a Turing test for communities: Is it possible for these two spheres to blend together so seamlessly that one can move between them without noticing the difference? Could an actual city have a virtual sister city (where residents exchange gifts of chocolate online)? Because the boundaries of a community can

be more expansive in the virtual world, such a blending could enhance the diversity of a physical community and even make it more autonomous. But there will be new questions as well: How will trust be established in these hybrid communities? Where can someone find refuge in such an environment? What new tools will be needed to manage a community's virtual as well as its physical resources?

8. CREATION AND PRODUCTION: DISINTERMEDIATION

We've witnessed the rise of user-generated content and a dramatic reduction in the costs of developing and distributing professional-quality material. What will the creative and productive landscape look like with another decade's worth of evolution?

The starting premise for this scenario is that bandwidth is increasing more rapidly than human capacity to fill it up with original material. We can't create new content at the speed that technology is able to deliver it. The result will be an even greater focus on user-generated content, but with more emphasis on techniques such as re-mixing and mash-ups that take off from existing content. The evolving technology infrastructure will generate new distribution channels and usage models. New user-generated content will emerge from activities in virtual worlds that are recorded and shared. We will see new versions of classic movies created through crowdsourcing and crowdfunding. As bandwidth increases, there will be similar innovation around video as we have seen with music: new Shazam and Pandora-type applications will emerge for movies. While all this activity will generate many legal and regulatory concerns, the overall shape of content creation will mainly be determined by the marketplace rather than government policymakers. For example, just as market forces set the price for a digital music track at \$1, which is the "nuisance factor point" of the cost of obtaining the same content from an alternative source, movies and video content will reach a similar price point.

appendix 2:

The State Of Broadband: Globally and Nationally

As of early 2012, there were more than 600 million broadband users globally.⁹ Approximately two-thirds of Americans now live in households with a broadband connection.¹⁰ About half of these broadband homes use a cable-based service and 41 percent use DSL, while about 8 percent have a fiber optic connection and the remaining one percent subscribe to a satellite service. Cell phone penetration today is nearly universal, and 40 percent of adult Americans have smartphones capable of providing mobile broadband access, while millions of Americans go online wirelessly using tablets and other mobile devices.

Although this country has been a leader in the development of innovative Internet applications and digital technologies, the U.S. lags behind a number of other countries in several categories of broadband statistics. In late 2011, for example, the U.S. ranked 12th in the world in terms of the average Internet connection speed of users, behind a number of countries in Asia and Europe. While the average measured speed for the U.S. was 5.8 Mbps, residents of Korea had an average connection speed of 13.8 Mbps. Korea (where population density tends to be much higher than the U.S.) also had the most households with broadband service, at 95 percent, compared to 70 percent in the U.S. In terms of peak broadband speeds, the U.S. ranked 16th in average peak speed, at 22.1 Mbps, compared to 44.4

Mbps for residents of Hong Kong, the global leader in this category.¹¹

There are also significant differences among the states in the U.S. in terms of the quality of broadband service. As of the second quarter of 2011, residents of Rhode Island, the fastest state in the country, enjoyed an average connection speed of 8.2 Mbps, while average speed in the slowest state, Arkansas, was just 3.3 Mbps. The good news is that the increase in average speed was strong in almost all states: five states grew at more than 30 percent year-over-year, while an additional 26 states experienced an annual increase of more than 20 percent.

States also vary widely in terms of penetration of home broadband. According to the National Telecommunications and Information Agency (NTIA), Utah, with a rate of 80 percent, had the highest penetration level, while Mississippi, at 52 percent, had the lowest rate. There are also differences between adoption in urban and rural areas: As of October, 2010, 70 percent of urban residents had home broadband, compared to just 60 percent of rural residents. People with low incomes, the disabled, seniors, minorities, the less-educated, non-family households, and the non-employed tend to have lower rates of home broadband adoption.¹²

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The Institute for the Future (IFTF) is an independent nonprofit research group. We work with organizations of all kinds to help them make better, more informed decisions about the future. We provide the foresight to create insights that lead to action.

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- Technology and society
- Health and health care
- Global business trends
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The Institute is based in California's Silicon Valley, in a community at the crossroads of technological innovation, social experimentation, and global interchange. Founded in 1968 by a group of former RAND Corporation researchers with a grant from the Ford Foundation to take leading-edge research methodologies into the public and business sectors, the IFTF is committed to building the future by understanding it deeply.

ENDNOTES

¹Cisco Visual Networking Index: Forecast and Methodology, 2010-2015, June 1, 2011, www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360.pdf

²At the same time as the Wharton/IFTF workshop was taking place in San Francisco, a Google executive at another conference in San Jose was describing how the company has completely reconfigured its internal networks linking its data centers. Google has implemented the OpenFlow standard to create internal software defined networks that can be quickly reconfigured depending on the type of data traffic that the networks carry. See Rick Merritt, "Google describes its OpenFlow network," EE Times, April 17, 2012, www.eetimes.com/electronics-news/4371179/Google-describes-its-OpenFlow-network.

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⁴In May, 2012, the FCC voted to allocate a portion of the spectrum for body area networks (BANs) that would support wireless medical monitoring in hospitals and at home. See Jaimy Lee, "FCC sets aside wireless spectrum for MBANs," Modern Healthcare, May 24, 2012, www.modernhealthcare.com/article/20120524/NEWS/305249986/fcc-sets-aside-wireless-spectrum-for-mbans#.

⁵See, for example, Hayley Tsukayama, "Google's self-driving car: Is this the next generation of autos?" The Washington Post, May 9, 2012, www.washingtonpost.com/business/technology/googles-self-driving-car-is-this-the-next-generation-of-autos/2012/05/09/gIQAtiMDU_story.html.

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⁷ See for example, Cyber-security: The vexed question of global rules, Security and Defense Agenda, January 31, 2012, www.securitydefenceagenda.org/Portals/14/Documents/Publications/SDA_Cyber_report_FINAL.pdf.

⁸For a more extended discussion of the policy implications of this issue, see Richard Adler, Updating Rules of the Digital Road: Privacy, Security and Intellectual Property, Aspen Institute Program on Communications and Society, 2012, www.aspeninstitute.org/publications/updating-rules-digital-road-privacy-security-intellectual-property.

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¹¹The State of the Internet, Volume 4, Number 2, 2nd Quarter, 2011. Akamai, www.akamai.com/stateoftheinternet.

¹²Digital Nation: Expanding Internet Use, National Telecommunications and Information Agency, U.S. Department of Commerce, February 2011, www.ntia.doc.gov/report/2011/digital-nation-expanding-internet-use-ntia-research-preview.

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