The future of cloud computing

Technology experts and stakeholders say they expect they will 'live mostly in the cloud' in 2020 and not on the desktop, working mostly through cyberspace-based applications accessed through networked devices. This will substantially advance mobile connectivity through smartphones and other internet appliances. Many say there will be a cloud-desktop hybrid. Still, cloud computing has many difficult hurdles to overcome, including concerns tied to the availability of broadband spectrum, the ability of diverse systems to work together, security, privacy, and quality of service.

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THE FUTURE OF THE INTERNET

This publication is part of a Pew Research Center series that captures people's expectations for the future of the Internet, in the process presenting a snapshot of current attitudes. Find out more at: http:// pewinternet.org/topics/Future-of-the-Internet.aspx and http:// imaginingtheinternet.org.

Overview

A solid majority of technology experts and stakeholders participating in the fourth Future of the Internet survey expect that by 2020 most people will access software applications online and share and access information through the use of remote server networks, rather than depending primarily on tools and information housed on their individual, personal computers. They say that cloud computing will become more dominant than the desktop in the next decade. In other words, most users will perform most computing and communicating activities through connections to servers operated by outside firms.

Among the most popular cloud services now are social networking sites (the 500 million people using Facebook are being social in the cloud), webmail services like Hotmail and Yahoo mail, microblogging and blogging services such as Twitter and WordPress, video-sharing sites like YouTube, picture-sharing sites such as Flickr, document and applications sites like Google Docs, social-bookmarking sites like Delicious, business sites like eBay, and ranking, rating and commenting sites such as Yelp and TripAdvisor.

This does not mean, however, that most of these experts think the desktop computer will disappear soon. The majority sees a hybrid life in the next decade, as some computing functions move towards the cloud and others remain based on personal computers.

The highly engaged, diverse set of respondents to an online, opt-in survey included 895 technology stakeholders and critics. The study was fielded by the Pew Research Center's Internet & American Life Project and Elon University's Imagining the Internet Center. Some 71% agreed with the statement:

> "By 2020, most people won't do their work with software running on a general-purpose PC. Instead, they will work in Internet-based applications such as Google Docs, and in applications run from smartphones. Aspiring application developers will develop for smartphone vendors and companies that provide Internet-based applications, because most innovative work will be done in that domain, instead of designing applications that run on a PC operating system."

Some 27% agreed with the opposite statement, which posited:

> "By 2020, most people will still do their work with software running on a general-purpose PC. Internet-based applications like Google Docs and applications run from smartphones will have some functionality, but the most innovative and important applications will run on (and spring from) a PC operating system. Aspiring application designers will write mostly for PCs."

Most of those surveyed noted that cloud computing will continue to expand and come to dominate information transactions because it offers many advantages, allowing users to have easy, instant, and individualized access to tools and information they need wherever they are, locatable from any networked device. Some experts noted that people in technology-rich

environments will have access to sophisticated-yet-affordable *local* networks that allow them to "have the cloud in their homes."

Most of the experts noted that people want to be able to use many different devices to access data and applications, and – in addition to the many mentions of smartphones driving the move to the cloud – some referred to a future featuring many more different types of networked appliances. A few mentioned the "internet of things" – or a world in which everyday objects have their own IP addresses and can be tied together in the same way that people are now tied together by the internet. So, for instance, if you misplace your TV remote, you can find it because it is tagged and locatable through the internet.

Some experts in this survey said that for many individuals the switch to mostly cloud-based work has already occurred, especially through the use of browsers and social networking applications. They point out that many people today are primarily using smartphones, laptops, and desktop computers to network with remote servers and carry out tasks such as working in Google Docs, following web-based RSS (really simple syndication) feeds, uploading photos to Flickr and videos to YouTube, doing remote banking, buying, selling and rating items at Amazon.com, visiting with friends on Facebook, updating their Twitter accounts and blogging on WordPress.

Many of the people who agreed with the statement that cloud computing will expand as the internet evolves said the desktop will not die out but it will be used in new, improved ways in tandem with remote computing. Some survey participants said they expect that a more sophisticated desktop-cloud hybrid will be people's primary interface with information. They predicted the desktop and individual, private networks will be able to provide most of the same conveniences as the cloud but with better functionality, overall efficiency, and speed. Some noted that general-purpose in-home PC servers can do much of the work locally via a connection to the cloud to tap into resources for computing-intensive tasks.

Among the defenses for a continuing domination of the desktop, many said that small, portable devices have limited appeal as a user interface and they are less than ideal for doing work. They also expressed concern about the security of information stored in the "cloud" (on other institutions' servers), the willingness of cloud operators to handle personal information in a trustworthy way, and other problems related to control over data when it is stored in the cloud, rather than on personally-controlled devices.

Some respondents observed that putting all or most of faith in remotely accessible tools and data puts a lot of trust in the humans and devices controlling the clouds and exercising gatekeeping functions over access to that data. They expressed concerns that cloud dominance by a small number of large firms may constrict the internet's openness and its capacity to inspire innovation – that people are giving up some degree of choice and control in exchange for streamlined simplicity.

A number of people said cloud computing presents difficult security problems and further exposes private information to governments, corporations, thieves, opportunists, and human and machine error.

Survey participants noted that there are also quality of service and compatibility hurdles that must be crossed successfully before cloud computing gains more adopters. Among the other limiting factors the expert respondents mentioned were: the lack of broadband spectrum to handle the load if everyone is using the cloud; the variability of cost and access in different parts of the world and the difficulties that lie ahead before they can reach the ideal of affordable access anywhere, anytime; and complex legal issues, including cross-border intellectual property and privacy conflicts.

Among the other observations made by those taking the survey were: large businesses are far less likely to put most of their work "in the cloud" anytime soon because of control and security issues; most people are not able to discern the difference between accessing data and applications on their desktop and in the cloud; low-income people in least-developed areas of the world are most likely to use the cloud, accessing it through connection by phone.

Survey Method: 'Tension pairs' were designed to provoke detailed elaborations

This material was gathered in the fourth "Future of the Internet" survey conducted by the Pew Research Center's Internet & American Life Project and Elon University's Imagining the Internet Center. The surveys are conducted through online questionnaires to which a selected group of experts and the highly engaged Internet public have been invited to respond. The surveys present potential-future scenarios to which respondents react with their expectations based on current knowledge and attitudes. You can view detailed results from the 2004, 2006, 2008 and 2010 surveys here: http://pewinternet.org/topics/Future-of-the-Internet.aspx and http://www.elon.edu/e-web/predictions/expertsurveys/default.xhtml, Expanded results are also published in the "Future of the Internet" book series published by Cambria Press.

The surveys are conducted to help accurately identify current attitudes about the potential future for networked communications and are not meant to imply any type of futures forecast.

Respondents to the Future of the Internet IV survey, fielded from Dec. 2, 2009 to Jan. 11, 2010, were asked to consider the future of the Internet-connected world between now and 2020 and the likely innovation that will occur. They were asked to assess 10 different "tension pairs" – each pair offering two different 2020 scenarios with the same overall theme and opposite outcomes – and they were asked to select the one most likely choice of two statements. The tension pairs and their alternative outcomes were constructed to reflect previous statements about the likely evolution of the Internet. They were reviewed and edited by the Pew Internet Advisory Board. Results are being released in five reports over the course of 2010.

The results that are reported in this report are responses to a tension pair that relates to the future of the Internet and cloud computing.

Results to five other tension pairs – relating to the Internet and the evolution of intelligence; reading and the rendering of knowledge; identity and authentication; gadgets and applications; and the core values of the Internet – were released earlier in 2010 at the meeting of the American Association for the Advancement of Science. They can be read at: http://pewinternet.org/Reports/2010/Future-of-the-Internet-IV.aspx.

Results from a tension pair requesting that people share their opinions on the impact of the internet on institutions were discussed at the Capital Cabal in Washington, DC, on March 31, 2010 and can be read at: http://pewinternet.org/Reports/2010/Impact-of-the-Internet-on-Institutions-in-the-Future.aspx.

Results from a tension pair assessing people's opinions on the future of the semantic web were announced at the WWW2010 and FutureWeb conferences in Raleigh, NC, April 28, 2010 and can be read at:
http:// pewinternet.org/Reports/2010/Semantic-Web.aspx

Final results from the Future IV survey will be released at the 2010 World Future Society conference (http://www.wfs.org/meetings.htm).

Please note that this survey is primarily aimed at eliciting focused observations on the likely impact and influence of the Internet – not on the respondents' choices from the pairs of predictive statements. Many times when respondents "voted" for one scenario over another, they responded in their elaboration that both outcomes are likely to a degree or that an outcome not offered would be their true choice. Survey participants were informed that "it is likely you will struggle with most or all of the choices and some may be impossible to decide; we hope that will inspire you to write responses that will explain your answer and illuminate important issues."

Experts were located in two ways. First, several thousand were identified in an extensive canvassing of scholarly, government, and business documents from the period 1990-1995 to see who had ventured predictions about the future impact of the Internet. Several hundred of them participated in the first three surveys conducted by Pew Internet and Elon University, and they were recontacted for this survey. Second, expert participants were hand-picked due to their positions as stakeholders in the development of the Internet.

Here are some of the respondents: Clay Shirky, Esther Dyson, Doc Searls, Nicholas Carr, Susan Crawford, David Clark, Jamais Cascio, Peter Norvig, Craig Newmark, Hal Varian, Howard Rheingold, Andreas Kluth, Jeff Jarvis, Andy Oram, Kevin Werbach, David Sifry, Dan Gillmor, Marc Rotenberg, Stowe Boyd, Andrew Nachison, Anthony Townsend, Ethan Zuckerman, Tom Wolzien, Stephen Downes, Rebecca MacKinnon, Jim Warren, Sandra Brahman, Barry Wellman, Seth Finkelstein, Jerry Berman, Tiffany Shlain, and Stewart Baker.

The respondents' remarks reflect their personal positions on the issues and are not the positions of their employers, however their leadership roles in key organizations help identify them as experts. Following is a representative list of some of the institutions at which respondents work or have affiliations: Google, Microsoft. Cisco Systems, Yahoo!, Intel, IBM, Hewlett-Packard, Ericsson Research, Nokia, New York Times, O'Reilly Media, Thomson Reuters, Wired magazine, The Economist magazine, NBC, RAND Corporation, Verizon Communications, Linden Lab, Institute for the Future, British Telecom, Qwest Communications, Raytheon, Adobe, Meetup, Craigslist, Ask.com, Intuit, MITRE Corporation

Department of Defense, Department of State, Federal Communications Commission, Department of Health and Human Services, Centers for Disease Control and Prevention, Social Security Administration, General Services Administration, British OfCom, World Wide Web Consortium, National Geographic Society, Benton Foundation, Linux Foundation, Association of Internet Researchers, Internet2, Internet Society, Institute for the Future, Santa Fe Institute, Yankee Group

Harvard University, MIT, Yale University, Georgetown University, Oxford Internet Institute, Princeton University, Carnegie-Mellon University, University of Pennsylvania, University of California-Berkeley, Columbia University, University of Southern California, Cornell University,

University of North Carolina, Purdue University, Duke University , Syracuse University, New York University, Northwestern University, Ohio University ,Georgia Institute of Technology, Florida State University, University of Kentucky, University of Texas, University of Maryland, University of Kansas, University of Illinois, Boston College, University of Tulsa, University of Minnesota, Arizona State, Michigan State University, University of California-Irvine, George Mason University, University of Utah, Ball State University, Baylor University, University of Massachusetts-Amherst, University of Georgia, Williams College, and University of Florida.

While many respondents are at the pinnacle of Internet leadership, some of the survey respondents are "working in the trenches" of building the web. Most of the people in this latter segment of responders came to the survey by invitation because they are on the email list of the Pew Internet & American Life Project or are otherwise known to the Project. They are not necessarily opinion leaders for their industries or well-known futurists, but it is striking how much their views were distributed in ways that paralleled those who are celebrated in the technology field.

While a wide range of opinion from experts, organizations, and interested institutions was sought, this survey should not be taken as a representative canvassing of Internet experts. By design, this survey was an "opt in," self-selecting effort. That process does not yield a random, representative sample. The quantitative results are based on a non-random online sample of 895 Internet experts and other Internet users, recruited by email invitation, Twitter, or Facebook. Since the data are based on a non-random sample, a margin of error cannot be computed, and results are not projectable to any population other than the respondents in this sample.

Many of the respondents are Internet veterans – 50% have been using the Internet since 1992 or earlier, with 11% actively involved online since 1982 or earlier. When asked for their primary area of Internet interest, 15% of the survey participants identified themselves as research scientists; 14% as business leaders or entrepreneurs; 12% as consultants or futurists, 12% as authors, editors or journalists; 9% as technology developers or administrators; 7% as advocates or activist users; 3% as pioneers or originators; 2% as legislators, politicians or lawyers; and 25% specified their primary area of interest as "other."

The answers these respondents gave to the questions are given in two columns. The first column covers the answers of 371 longtime experts who have regularly participated in these surveys. The second column covers the answers of all the respondents, including the 524 who were recruited by other experts or by their association with the Pew Internet Project. Interestingly, there is not great variance between the smaller and bigger pools of respondents.

Main Findings: Will we live in the cloud or the desktop?

	CURRENT EXPERTS N=371	CURRENT TOTAL N=895	
%	72	71	By 2020, most people won't do their work with software running on a general-purpose PC. Instead, they will work in Internet-based applications such as Google Docs, and in applications run from smartphones. Aspiring application developers will develop for smartphone vendors and companies that provide Internet-based applications, because most innovative work will be done in that domain, instead of designing applications that run on a PC operating system.
	25	27	By 2020, most people will still do their work with software running on a general-purpose PC. Internet-based applications like Google Docs and applications run from smartphones will have some functionality, but the most innovative and important applications will run on (and spring from) a PC operating system. Aspiring application designers will write mostly for PCs.
	3	2	Did not respond

Background

"Cloud" is a metaphor for the internet. "Cloud computing" is a phrase that is being used today to describe the act of storing, accessing, and sharing data, applications, and computing power in cyberspace. The concepts of storing data in remote locations or renting the use of tools only when you need them are not new, but the positives and negatives of cloud computing present users with unprecedented opportunities and challenges.

A September 2008 Pew Internet Data Memo reported that 69% of Americans had either stored data online or used web-based software applications at least once. Using a Hotmail or Gmail account for email, storing Firefox or Google browser bookmarks online, sharing friendships in cyberspace on social networks like Facebook, maintaining a blog on WordPress, and storing personal videos and photos on YouTube and Flickr are just some of the ways many people are already "working in the cloud" every day.

Cloud architectures can allow people to easily and conveniently take advantage of larger amounts of storage and computing power; they also offer easy access to centrally located information reachable through any compatible device a user wishes to implement; they can provide a back-up to locally stored data; they allow people to easily share their data with others.

They also open up a wide variety of reliability, interoperability, privacy, and security concerns, as people put their information under the control of strangers in remote location anytime they trust in "the cloud." For instance, the corporate leaders at Facebook come under fire regularly for changing privacy settings again and again after signing up users who expected to participate under a different and more consumer-centered set of rules.

Respondents' thoughts

Survey participants were encouraged to explain their choice after they selected one of the tension-pair scenarios. They were asked to "share your view about how major programs and applications will be designed, how they will function, and the role of cloud computing by 2020." Following is a small selection of the hundreds of written elaborations, organized according to some of the major themes that emerged in the answers:

Cloud computing will continue to expand and dominate users' information transactions because it offers many advantages, allowing users to have easy instant and individualized access to tools and information they need, wherever they are, locatable from any networked device.

- "We don't have to wait until 2020 for this shift. It's already happened. The browser (a cloud interface) is already by far the most possible PC application, and cloud services like Facebook are the most popular computing services, whether accessed via PCs, netbooks, or smartphones. For consumers, the cloud revolution has already happened." **–Nicholas Carr**, writer and consultant whose work centers on information technology, author of "The Big Switch: Rewiring the World, from Edison to Google" and "Does IT Matter?" his next book is "The Shallows: What the Internet is Doing to Our Brains"; http://www.nicholasgcarr.com/index.shtml

- "It's 2010 and I could already basically use only cloud-based applications on my computer. Local storage is already increasingly irrelevant – I have my all my photos stored on Flickr, my address book is in my Gmail and I've got all my emails stored there as well. Apple will likely move iTunes online in the next few years, and streaming movies from Netflix will eliminate the need to download movie files. I use Microsoft Office and Photoshop out of familiarity as my main two desktop apps, but good alternatives already exist online. I predict most people will do their work on 'screens connected to the web,' There won't be any sort of 'computer' anymore." **–Davis Fields**, product manager, Nokia; http://www.linkedin.com/in/davisf

- "The cloud (a bad metaphor for broadening understanding of the concept by the way) will make it easier for individuals to have access to their data, applications, and tools 'anywhere, anytime.' That ubiquitous functionality will force migration from desktop PCs to the cloud." **–Gary Bachula**, vice president for external relations for Internet2, http://events.internet2.edu/speakers/speakers.php?go=people&id=1

- "This will bring smart machines in market with no software requirement, and no excessive RAM for separate machines, and no heavy hard-disk/data storage. Just a

simple machine with WiFi and internet browser." **–Maliha Kabani**, president, International Sustainable Development Resource Centre; http://pk.linkedin.com/pub/maliha-kabani/14/265/46b

- "This is a no-brainer. Today most people already live in the cloud for their mail, agenda, pictures, videos. By 2020, Chrome OS or equivalent will be running on 95% of our 'access tools' to the Internet, all of them mobiles, with 1000 Mbps wireless networks available everywhere." **–Louis Naugès**, president of Revevol, formerly president at Microcost; http://fr.linkedin.com/in/louisnauges

- "The cloud-based model is not something new. It has been evolving since the early 1990s, with the major barriers being bandwidth and latency. In addition, the PC as we know it is slowly dying due to increased desire of the marketplace to be mobile. In mobility, the key factors will be the user experience, not the underlying application. Lightweight platforms (both physically and software) are not just a requirement, they will be the expectation of the next generation of users. In addition the lifecycle of applications have become shorter with an increased desire to lower TCO [total cost of ownership] of the applications. In addition, to stay competitive, software firms need to have their users on the latest version of their application. In general most users do not maintain their software in accordance with the application vendors' release cycles. When executed properly, cloud-based applications can resolve this." **—Tom Golway**, Global technology director at Thomson Reuters and former CTO at ReadyForTheNet; http://www.linkedin.com/in/readyforthenet

- "First, we have witnessed virtualisation and abstraction for decades now – for example, think about the operating system wars in the 1990s and thereafter. Now we have things like Java, web browsers, etc., that allow for hardware-independent *and* OS-independent execution of entire application suites. The second reason comes in disguise: with the advent of the 'web of data' (from microformats/RDFa over Atom to Linked Data), which started in the last two years and will continue to be of even greater importance throughout, the abilities and possibilities to generate, share, and reuse content (be it an image or a microblogging post) will increase. Applications are defined as software that is being executed. Software consists (roughly speaking) of code and data. Now, if the code is 'in the cloud' *and* the data is there as well – what is to be left for the desktop other than a convenient, highly customisable and smart terminal?" **— Michael Hausenblas**, web of data researcher at the Linked Data Research Centre, Digital Enterprise Research Institute at the National University of Ireland in Galway; http://semanticweb.org/wiki/Michael_Hausenblas

- "The statement describes how many people are working today. Email has moved thoroughly into the cloud, and as more people work on mobile devices, the logic of keeping files on a server is increasingly compelling. It's getting harder to run complex services like email and web servers on a local computer – for reasons of convenience and security, we're seeing a shift to the cloud. Will everything run on the cloud? Probably not, but that's where the center of gravity is shifting, and will shift – well before 2020." **–Ethan Zuckerman**, research fellow, Berkman Center for Internet and Society at Harvard Law School, co-founder of Global Voices; http://ethanzuckerman.com

- "The drive will be to make money, and the most efficient way to do that is to build cloud computing whereby vendors can charge per application's use. This is already happening in the smartphone realm." **—Bill Leikam**, Leikam Enterprises, LLC; http://www.linkedin.com/in/billleikam

- "There is always going to be an optimum 'balance point' that identifies the 'best' mix of local (PC) processing and storage, on-premise (enterprise data center) processing, storage and networking, as well as 'cloud' processing. That balance point changes as the relative cost-effectiveness of processing power, storage, and data communication changes. These three horsemen are in a constant race with one another. At any given point in time, the formula favors a specific mix. In 2020, with true broadband data networking, greater dependability (and availability) of mobile networking and widely distributed data storage, we'll find ourselves being much more 'cloud centric.' Among the first 'victims,' the desktop PC will be rejected for 'thinner clients,' working with private (enterprise clouds) and the more public cloud services." **–Rich Miller**, managing director and principal, Cumulati, director, Truedomain, advisor at CloudSoft, Genetic Finance, AeroDynamic Solutions, VEXTEC and OptionMonster, board of directors, treasurer, Hybrid Vigor Institute; http://www.linkedin.com/in/richmiller

Mobile phones and other "pocket" devices are and will continue to be driving people to cloud-based services and applications.

- "No doubt that mobility is the key word. In the future, we will live in a transparent 3D mobile media cloud that surrounds us everywhere. This cloud gives us transparent information and real-time access. The cloud will consist of a white part (trusted and checked information), a grey part (question mark) and a black part (crap information: untrusted, unchecked, violent, fraudulent). In this media cloud, you are boss. The mobile phone will be your key instrument for navigating, for getting safe access, to check and self-check all claims made on the street, in the supermarket, at school, etc." **–Marcel Bullinga**, futurist and founder of Futurecheck, writing the book "Welcome to the Future Cloud"; http://nl.linkedin.com/in/futurecheck

- "The boundary between smartphones and the PC is already blurring by new, better, and more powerful mobile devices coming to the market. People have now the possibility to have the same computing power truly portable in their pockets, which was previously only available them on a bulky desktop or laptop. Being always connected to the services and applications on the Internet is a must and not an option in the future. The always-on connectivity also allows the usage of online applications that weren't previously practical. This does not necessarily replace the need of having local applications on the phones, but the available applications in clouds or generally in the Internet will augment the capabilities of the smartphones." **–Jonne Soininen**, head of Internet Affairs and former system engineering manager, Nokia Siemens Networks; http://fi.linkedin.com/pub/jonne-soininen/0/950/398

- "The iPhone changed everything. It accelerated the shift to cloud computing and made development of iPhone apps the next big opportunity for aspiring application developers. We may not all be using Google Docs in 2020, but we'll be getting weather,

news, and sports on our smartphone, not our PC. And we certainly won't be getting weather, news, and sports on our TV by 2020. This means that Gil Scott-Heron was right when he predicted back in 1970, 'The revolution will not be televised.'" **–Ken Jarboe**, president, Athena Alliance, a nonprofit exploring the potential of a global information economy

- "Driven by smart phones, information retrieval and use is increasingly becoming device-independent. 2020 will see a mix of handheld devices, public kiosks, and personal/workplace PCs, all tied into the cloud for most routine apps." **–Reva Basch**, self-employed consultant for Aubergine Information Systems (online research expert); active longtime member of The WELL, one of the earliest cyberspace communities; author of many books, including "Researching Online for Dummies"; http://www.well.com/~reva/

- "The better and faster the ubiquitous connection, the more widespread cloud computing and services will become. Local storage of applications and data is similar to the way of the old phone switchboard. Its time will come. Security concerns and outages will delay the process, but not stop it. Convenience and subsidized or free offers will drive adoption. The PC model will be replaced with nodes or servers at homes, distributing and syncing content to mobile devices of all shapes and forms." **– Steffan Heuer**, US correspondent for Brand Eins (German business magazine); http://www.linkedin.com/in/steffanheuer

- "The 'desktop' and current operating systems will be quaint metaphors the same way we look back at 8-track tapes, phones with dials, typewriters, etc. Shrinking size of computing machines, embedded smartness in everything from clothes to appliances, and more ubiquitous always-on networked devices will mean we have a whole suite of new integrated technologies that allow us to have access to tools and data when/where we need it – not that we need to go to a place or device to do computing. There ought to be an environment of small virtual applications that we easily swap in and out, rather than monolithic-like, closed, boxed software we are currently used to. The network will be the PC for sure." **–Alan Levine**, VP and CTO of The New Media Consortium

- "This further begs the question, 'What is a general-purpose PC?' By 2020, the norm will be pocket, powerful computer devices that are networks and utilizing data and applications from the cloud. The benefit of a general-purpose PC will increasingly beg the cost. While currently in a family household there may be multiple general-purpose PCs, in the future the need for a general-purpose PC will be significantly decreased and it will be hard to find more than one in a household – why do I need a general-purpose PC when I can do 90% of my activities on my iTouch, my Wii, and my smart phone? **– Robert Cannon**, senior counsel for Internet law at the US Federal Communications Commission; http://www.cybertelecom.org/cannon.htm

- "Forget PCs: we'll be wanting smaller, truly portable devices to access all the glory in the cloud. Here's another prediction: We won't call it the 'cloud,' because it will be everywhere at once – both local and distant, both shapeless and hard-edged. We won't need a word for it." **–Susan Crawford**, former member of President Obama's National Economic Council, now on the law faculty at the University of Michigan

Control over actions on the Internet will change with mass adoption of the cloud. When people store their information and applications on their own computers as they have been up till now, a certain amount of choice and control is distributed to the edges of the network. A switch to the cloud places users' data and tools behind walls owned by others, and the people in control of cloud companies may take action that constricts individual choice and restricts openness and innovation.

- "Innovation has benefited a great deal from the ability of ordinary computer users to bulk up their computers with a lot of software and interact with it at high speeds using high-quality keyboards and large monitors. That kind of grassroots innovation may go away along with the systems that provide those generous resources. So I suggest that cloud application providers recognize the value of grassroots innovation – following Eric von Hippel's findings – and solicit changes in their services from their visitors. Make their code open source – but even more than that, set up test environments where visitors can hack on the code without having to download much software. Then anyone with a comfortable keyboard can become part of the development team. We'll know that software services are on a firm foundation for future success when each one offers a 'Develop and share your plug-in here' link." **–Andy Oram**, editor and blogger, O'Reilly Media; http://radar.oreilly.com/andyo/

- Clouds are only as useful as connections permit. And right now the big cloud utilities (notably Google and Amazon) are way ahead of the carriers at imagining how connected computing needs to grow. For most carriers the Internet is still just the third act in a 'triple play,' a tertiary service behind telephony and television. Worse, the mobile carriers show little evidence that they understand the need to morph from phone companies to data companies – even with Apple's iPhone success screaming 'this is the future' at them. A core ideal for all Internet devices is what Jonathan Zittrain (in his book *The Future of the Internet – and How to Stop It*) calls *generativity*, which is maximized encouragement of innovation in both hardware and software. Today generativity in mobile devices varies a great deal. The iPhone, for example, is highly generative for software, but not for hardware (only Apple makes iPhones). And even the iPhone's software market is sphinctered by Apple's requirement that every app pass to market only through Apple's 'store,' which operates only through Apple's iTunes, which runs only on Macs and PCs (no Linux or other OSes). On top of all that are Apple's restrictive partnerships with AT&T (in the U.S.) and Rogers (in Canada). While AT&T allows unlimited data usage on the iPhone, Rogers still has a 6Gb limit. Bottom line: Handhelds will be no smarter than the systems built to contain them. The market will open widest – and devices will get smartest – when anybody can make a smartphone (or any other mobile device), and use it on any network they please, without worrying about data usage limits or getting hit with $1000+ bills because they forgot to turn off 'push notifications' or 'location services' when they roamed out of their primary carrier's network footprint. In other words, the future will be brightest when mobile systems get Net-native." **–Doc Searls**, fellow, Berkman Center for Internet & Society at Harvard Law School, fellow at Center for Information Technology and

Society, University of California-Santa Barbara; http://www.linkedin.com/pub/doc-searls/0/0/a54

- "Like anything, it will be a cost-benefit exercise: What do I gain from accessing the cloud, over and above what I could do if I just rely on my own desktop and programming skills? From the perspective of the provider of research services, the cloud, in theory, promises a level playing field. However, there are two factors that might work against this. Individual developers of research services will still need to work with standards and technologies that are being developed by the big players e.g. Google and increasingly Microsoft. The cloud will possibly eventually be dominated by large corporations such as these. As long as these standards are open and the cloud software free so that an application developer could build the cloud infrastructure themselves *if* they wanted to (but note: they probably wouldn't want to, and would rather focus on the application layer which is the research service) then this should be OK. If the cloud gets monopolised in the same way that the desktop has been, then this will inhibit the innovative potential of the cloud. So, we need the cloud to be built using free and open source software." **–Robert Ackland**, fellow in the Research School of Social Sciences at The Australian National University; http://www.oii.ox.ac.uk/people/?id=108

- "PC applications are inefficient and resource intensive. I see most 'everyday' applications moving to the web, at greatly reduced cost for service providers. However, if we continue moving towards app-store mentalities that require unique development for each platform, I'm not sure that web service models are viable. We must double-down on open standards that have wide vendor support." **—Fred Stutzman**, Ph.D candidate, researcher and teaching fellow, School of Information and Library Science, UNC-Chapel Hill; http://fredstutzman.com/index.html

- "By 2020 we'll still be feeling pulled in two directions: wanting the convenience of the cloud and the enhanced privacy, security, and speed of the local. But the local won't be confined to the desktop and general-purpose PCs. That paradigm will be exploded by ubiquitous computing, IPv6, and the primacy of mobile broadband, which will define the local in terms of our personal space. Cloud computing will become important enough to transfer internet gate-keeping powers from ISPs to firms like Google and Apple. By 2020, Google's vast array of well-made (and still largely free) products will create walled gardens based on customer consent rather than lock-in. The old-fashioned concepts of the desktop and general-purpose PC will fade away, hastening the demise of Microsoft, which will continue to lose share in growth sectors like mobile broadband. The iPhone and App Store will be the models for another kind of gate-keeping, in the local space – not in the cloud through MobileMe, because Apple's consumer appeal will remain rooted in its physical products. Apple's influence over application developers will continue to cross back and forth over the line between opportunity and exploitation." **–David Ellis**, director of communication studies at York University, Toronto, and author of the first Canadian book on the roots of the Internet; http://ca.linkedin.com/in/drdavidellis

Cloud computing presents security problems and further exposes private information to governments, corporations, thieves, opportunists, and human and machine error.

- "Trust not the cloud for reliability, security, privacy." **–Barry Wellman**, professor of sociology and Netlab director, University of Toronto; http://ca.linkedin.com/pub/barry-wellman/13/240/1b1
- "We'll have a huge blow up with terrorism in the cloud and the PC will regain its full glory. People will lose confidence as cyber attacks cripple major systems. In fact, cloud will be there but we'll be stuck in hybrid mode for the next 40 years as people live with some level of fear." **–R. Ray Wang**, partner in The Altimeter Group, blogger on enterprise strategy; http://www.altimetergroup.com/about/r-ray-wang-partner
- "I have a lot of faith in general-purpose boxes. That said, I also believe that convenience will drive us to use special-purpose devices for things that are used frequently. I've lived through several bounces of the centralized vs. decentralized bouncing ball of computer and networking technology. I don't believe that this is a particularly important issue in itself. Rather I believe that the more important issues are those of reliability of systems and data, the responsibility for them, and the rules of privacy and security that protect people and their data." **–Karl Auerbach**, chief technical officer at InterWorking Labs, Inc.; http://www.linkedin.com/in/karlauerbach
- "We'll just barely be using clouds by 2020. I think a big issue will be information privacy. How do you really control access to your valuable data if it is in the cloud? How do you retrieve your prized novel or your business records if the cloud fails?" **–Craig Partridge**, chief scientist, BBN Technologies, adjunct professor of computer science, University of Michigan; http://www.linkedin.com/pub/craig-partridge/2/660/3aa
- "Expect a major news event involving a cloud catastrophe (security breach or lost data) to drive a reversion of these critical resources back to dedicated computing." **–Nathaniel James**, Mozilla Foundation, formerly executive director, OneWebDay; http://www.linkedin.com/in/nathanieljames
- "Those users relying on mobile devices for their access (including substantial chunks of the developing world) may well be pushed towards cloud computing by necessity rather than choice." **–Axel Bruns**, associate professor, Media & Communication, Queensland University of Technology and general editor of Media and Culture journal; http://au.linkedin.com/in/snurb
- It will not replace the PC, but the desire of everyone to access information from anywhere using any device drives toward the cloud. The impact on privacy may give us pause. There are almost no protections for sensitive information stored in the cloud. Privacy rules were designed with the assumption that privacy protections were most reasonable at the ends (Electronic Communications Privacy Act). Reform efforts, we hope, will be successful." **–Jerry Berman**, founder and chair of the board of the Center for Democracy and Technology, an Internet public policy organization; president of the Internet Education Foundation; http://www.cdt.org/personnel/jerry-berman

People will generally not be able to distinguish the difference between when they are working within their local device and when they are accessing the cloud.

- "It's not really an either/or question. By 2020, people will work on the desktop *and* in the cloud, never really knowing where their data 'lives.' They'll just expect that if they have it at home, it will be available on their tablet machine in Starbucks." **–Charlie Martin**, correspondent and science and technology editor, Pajamas Media, technical writer, PointSource Communications, correspondent, Edgelings.com; http://www.linkedin.com/in/chasrmartin

- "In the future we will neither know, nor care where our data resides. In fact, our data will be distributed in the cloud, where it can be accessed any time, any place, on any device, by any authorized user." **–Hal Varian**, chief economist of Google and on the faculty at the University of California-Berkeley: http://people.ischool.berkeley.edu/~hal/

- "The line will blur sufficiently that people won't need to know the difference, and for many, care." **–Chris DiBona**, open source and public sector engineering manager at Google; http://sites.google.com/a/dibona.com/dibona-wiki/Home/Biographies-and-Photos

- "We'll see a clear integration between local and remote online places that we will use depending on what's most appropriate and effective, no matter the platform whether it's on your desk, on your lap or in your hand. The big thing here is that we won't make that decision: the platform and the apps will." **–Neville Hobson**, head of social media in Europe for WCG Group and principal of NevilleHobson.com; http://www.nevillehobson.com/

- "The traditional PC is a transitional form. A fish-shaped thing with both gills and legs. Too expensive. Too complicated. And too isolated to be interesting over the long haul. There may well be 'general-purpose PCs' doing all kinds of generally useful things, but they'll be overwhelmed by lightweight, connected devices of many shapes and kinds accessing applications and data in the cloud. Many of these may be able to work locally for those times that the cloud is inaccessible (and those cases will never quite disappear) but transitions will be seamless and nobody – with the possible exception of Microsoft – will care or even notice if they're living in the cloud or on the desktop." **–Walt Dickie**, executive vice president and chief technology officer for C&R Research; http://www.crresearch.com/sub.aspx?id=11&eid=_11049

- "Long before 2020, the complexity that individuals face of managing information across many devices will become burdensome, while the techniques for providing meaningful interfaces to vast data infrastructures that companies like Google and Apple develop will improve, so that the cloud will be taken for granted." **–John Monberg**, assistant professor, Department of Writing, Rhetoric, and American Cultures, Michigan State University; http://www.linkedin.com/pub/john-monberg/2/494/b4b

- "When the hard disk on my teenage daughter's computer crashed, we went about assessing how to recover. My first question, 'What files were local on this machine and what files were stored on the web?' didn't make immediate sense to her. She thinks first in terms of the activities she does (homework, Facebook, Gmail, listening to her iPod) and not in terms of where the files are stored (as it turns out: on the school server, facebook.com, google.com, and synced copies on disk and iPod). By 2020 most people will work and think this way. Some applications, such as editing HD video, will not want

to have communication latency in the inner loop, but most applications will, and the users won't care how they are implemented." **–Peter Norvig**, engineering director, Google, former division chief of computational sciences at NASA; http://www.linkedin.com/in/pnorvig

- "Regardless, most people won't even notice." **–Esther Dyson**, founder and CEO of EDventure, investor and serial board member, journalist and commentator on emerging digital technology; http://www.edventure.com/new-bio.html

The evolution of desktop and cloud-based computing will continue in tandem.

- "To some extent this is the wrong question. We went through the concept of large public centralized utilities to solve all problems by everyone in the '70s. Individuals need local tools to deal with their own creative and problem-solving abilities and to prepare locally materials that could contribute to group-oriented systems. Go back to the concept of a Memex system from the '40s and Ted Nelson's original concept of hypertext in the '60s (not the limited version we have on the web today). We have not scratched the surface of giving individuals the ability to do 'structural modeling' beyond simple statistical approaches. The PC's have just started to reach the point where they can really do this and when you add the artistic elements of visual creations this will be better served on the local computer than in a remote cloud. Have you tried to upload 100 gigabytes over most cable connections for individuals today? The communication trunks are still and will be the bottleneck for individuals." **–Murray Turoff**, professor of computer and information sciences, New Jersey Institute of Technology; http://www.linkedin.com/pub/murray-turoff/6/697/163

- "This is not an either/or proposition, with the rise of 'low'-end applications like Google Docs, email, and bookmarks on the cloud we have also seen dramatic increases in the usefulness and abilities of video and audio applications on the desktop. Both platforms will continue to evolve in concert with each other, and over time they will blend together more so than today." **–Mike Nelson**, visiting professor, Georgetown University; previously director of Internet technology and strategy at IBM and formerly on the White House technology team in the Clinton-Gore administration

- "The question won't really make sense in 2020. With HTML5, we are already seeing the emergence of a hybrid form of application that loads from the Web, but stores state information and data on the local computer. So the answer to this question is really, 'both.'" **–Jeremy Malcolm**, project coordinator, Consumers International, and co-director of the Internet Governance Caucus; http://my.linkedin.com/in/jeremymalcolm

- "The most innovative apps are more likely to come from the web, er, cloud, mostly because of their cost and delivery models, enhanced visibility, etc., rather than anything intrinsic to cloud. I also believe there will be some OS and local apps residing on the desktop/palmtop based on speed, latency, availability, privacy issues, etc. But the balance for applications will swing more distinctly towards the cloud." **–Gerrit Huizenga**, chair, Vendor Advisory Council, Linux Foundation, architect, IBM; http://www.linkedin.com/in/huizenga

- "There remains a set of huge issues for 'pure' cloud computing, notably speed-of-light limits on data transmission that will ultimately limit virtualisation. It will make sense to offload certain tasks to the cloud, but other elements will still be best-performed 'in situ.' There's also a huge imperative for continued use of PCs in enterprise and education which will change only slowly, although again they will exploit cloud apps where appropriate – although possibly 'private cloud' rather than 'public Internet cloud.'" **–Dean Bubley**, founder, Disruptive Analysis, an independent technology analysis and consulting firm; http://disruptivewireless.blogspot.com/

- "The correct answer is 'both.' I do not think by 2020 people will want to give up the autonomy and control they get by having software and data on their own device, but many of the services that we will expect (just as we 'expect' Google today) will require the power of a cloud supercomputer. I do not believe that a browser will be adequate as a window into the full Internet experience. But I do think that the PC as the central platform that defines the consumer experience will be eroded (but not displaced) by mobile devices." **–David D. Clark**, senior research scientist, MIT, an Internet pioneer who has been active in building its architecture since 1981, now working on the next-generation Internet; http://groups.csail.mit.edu/ana/People/Clark.html

- "It will be a mix of the two – smartphones as local-app platforms, alongside notebooks and desktops. The cloud is just too brittle, as Sidekick owners discovered." **–Jamais Cascio**, fellow with the Institute for the Future and the Institute for Ethics and Emerging Technologies and world-builder-in-chief for OpenTheFuture.com; http://openthefuture.com/

- "We'll operate both in the cloud and in 'local' devices, but rather than general-purpose PCs – which will still exist, to be sure – I expect to be using devices that do one or two tasks and not much else, or a set of components that might add up to a greatly extended version of today's PCs. They'll include what we call mobile phones today, and many other things." **–Dan Gillmor**, director of the Knight Center for Digital Media Entrepreneurship at Arizona State University's Walter Cronkite School of Journalism and Mass Communication and author of "We the Media"; http://cronkite.asu.edu/faculty/gillmorbio.php

- "In the future we'll all be amphibians, moving from one terrain to the other according to which is most favorable for what we want to do. For reasons of privacy, and because local apps generally are both more powerful and more customizable, some important things will remain on the desktop. But the convenience of the cloud will encourage other activities to migrate away from the desktop. On balance more time is likely to be spent in the cloud, but for concentrated bursts of heavy work, the desktop will remain predominant." **–Mark Edwards**, software innovator, co-director of the Berkman Center for Internet & Society and senior advisor to the dean of Harvard Divinity School; http://cyber.law.harvard.edu/people/medwards

- "Every part of the network will get smarter, but the desktop will lose ground. Clients will get thinner but not anorexic." **–Stewart Baker**, general counsel to the U.S. Internet Service Provider Association, former general counsel for the US National Security Agency and first leader of the policy directorate of the Department of Homeland Security; http://www.steptoe.com/professionals-762.html

The current mainstream discussion on cloud computing is not figuring in the expected development of bringing the "cloud to the desktop." It also does not always consider the potential of the internet of things, which includes a variety of networked smart appliances in smaller home and small-business networks that may also be tied into larger networks.

- "Neither of the choices frames the most probable reality. A main driving factor for cloud computing today is the relative difficulty of installing new software and updates on the desktop. Hence, people are choosing cloud not because of it being better for the task at hand, but for convenience; an example of a classical Christensen's disruptive innovation through the low market. I believe that the situation at the desktop is going to drastically change with Google Chrome OS and other, even more native 'cloud desktop' operating systems. They will 'bring the cloud to the desktop,' so to speak, providing the same convenience as the cloud but with better functionality, overall efficiency, and speed. Of course, such a 'desktop cloud' will still tap into real cloud resources for computing-intensive tasks, but those are relatively rare for the average computer user. A big issue in this space is also assurance about access to the data." **–Pekka Nikander**, Ericsson visiting senior research scientist, Helsinki Institute for Information Technology, chief scientist, Ericsson Research Nomadiclab; http://fi.linkedin.com/pub/pekka-nikander/0/43/b98

- "By 2020 the computational hardware that we see around us in our daily lives will all be peripherals – tablets, goggles, earphones, keyboards, 3D printers, and the like. The computation driving the peripherals will go on in any of a million different places, from local networks that run on your desk and in your room and building and on up." **–Fred Hapgood**, technology author and consultant, moderator of the Nanosystems Interest Group at MIT in the 1990s, he has written a number of articles for Wired, Discover and other tech publications; http://fhapgood.fastmail.fm

- "This either/or question doesn't work for me. By 2020, a 'general-purpose PC' and a 'smart phone' will have converged into a range of general-purpose interactive connection devices, and 'things' will have acquired agency by becoming smart. I don't have time to track the source, but I recently saw a comment that what was once a building-sized device now fits in the hand. And what now fits in the hand will soon fit into something the size of blood vessel. Anyone or anything will be able to generate 'cloud-like' functions that simulate' what if?' questions at any level of scale. Applications will emerge in relation to situations and experience, not by reference to platforms." **– Garth Graham**, board member of Telecommunities Canada, promoting local community network initiatives; http://www.salasan.com/frameset/people/gg.htm

- "PC operating systems won't be the same [in 2020]. People will have the cloud in their homes. Storage arrays based on OpenSolaris and ZFS with RAIDZ and deduplication are just beginning to appear in geek homes. Virtualization environments such as XEN and Virtualbox have been growing in use to the point where non-geek users have this at home. In 2020 you will see people running a virtual desktop with virtual storage that resides in their own home. Externally, this won't seem a lot different from someone who only uses Google apps from all their devices. Lots of people will like this model, but

will install home servers because they fear the risk of all their data being in someone else's hands." **–Michael Dillon**, network consultant at BT and a career professional in IP networking since 1992, member of BT's IP Number Policy Advisory Forum; http://uk.linkedin.com/pub/michael-dillon/4/663/4B

- "I have selected the non-cloud response not because I don't believe the cloud will be pervasive by 2020 – it will – but because some of the implications of the answer (and especially 'applications running on smartphones') will not be the primary instantiation. The idea of dividing the world of 2020 between smartphones and general-purpose PCs is absurd. We will be connecting to sound information and services with a variety of devices in our homes (from radios, televisions, appliances, etc.) and on our persons (audio, Skype-like, chat, videophone, camera, etc). Moreover, it is very unlikely that we will trust all, or even the bulk, of our data to the cloud. By 2020 we will have been disappointed enough times by online information services losing data, claiming ownership of data, sharing data without permission, etc., that we will keep our own data in our on in-home data store – a personal web server – and IT will be available (via the cloud) to our personal devices. In other words, we will all have the ultimate general-purpose PC in our homes, and much (if not more) of our data processing will take place on THAT, via the cloud." **–Stephen Downes**, senior research officer, National Research Council of Canada, and specialist in online learning, new media, pedagogy and philosophy; http://www.downes.ca/me/index.htm

Cloud computing will not really take off until...

- "It will be helped if we can get more spectrum out into the market. A decade is a long time in internet time, which makes it hard to predict, but I suspect we will live primarily in the cloud. A lot depends on our ability to make more spectrum available for wireless broadband – probably the most important broadband-related policy issue." **–Thomas Lenard**, president and senior fellow, Technology Policy Institute, author of many books including "Net Neutrality or Net Neutering: Should Broadband Services Be Regulated?"; http://www.techpolicyinstitute.org/about/staff/137.html
- "The scarcity of spectrum will mean that offline operation will continue to be as necessary in the future as it is today. Technological advances that allow more ubiquitous access are offset by increased consumption by an ever-growing population of internet users." **–Bill Woodcock**, research director, Packet Clearing House, a non-profit research institute, vice president of operations, Netsurfer Publishing, technical advisory board, Switch and Data / PAIX, co-founder and technical advisor, Nepal Internet Exchange and Uganda Internet Exchange; http://www.linkedin.com/pub/bill-woodcock/0/1/674
- "Significant security, quality of service, and compatibility hurdles will have to be leapt first." **–Robert G. Ferrell**, information systems security professional, U.S. Government, former systems security specialist, National Business Center, U.S. Department of the Interior; http://www.linkedin.com/in/rgferrell
- "The barriers to this evolution are many, but mainly inertia (we've been living based on ownership for the whole life) and rights (privacy, security, intellectual property, etc.) are amongst the ones that could be considered as more relevant." **–Ismael Peña-López**,

lecturer, School of Law and Political Science, Open University of Catalonia, researcher, Internet Interdisciplinary Institute; http://es.linkedin.com/in/ictlogist

- "This reminds me of a correspondence regarding change that I had with Bill Baker (then of Microsoft), his point: 'The future comes slower than we think yet change happens much quicker.' The concept that the 'network is the computer' has been around since the last century when we first tried to move out of the glass room to what is now the 'cloud.' Porting existing applications to a new platform is unlikely to be good enough to overcome the inertia, particularly in businesses, of the status quo. The cloud will succeed when it does something different, not something better." **–Anthony Power**, vice president, Studeo, author of *What's Still Missing from Web 2.0*

- "The line is very blurry between the desktop and the cloud. There is a point of 'cloud singularity' – where access is available everywhere (via wireless, 24/7), the cost is reasonable (essentially = LAN) and there are no performance penalties for the cloud (user interface, responsiveness, capacity) – at that point it will not matter where your storage or computing resides. We might get there in 10 years but it is unlikely." **–Glenn Edens**, technology strategy consultant, formerly senior vice president and director of Sun Microsystems Laboratories, chief scientist at HP, president AT&T Strategic Ventures; http://www.linkedin.com/in/glennedens

There are and will be divides. Cloud computing acceptance will vary, depending upon people's location, access, needs, and motivation.

- "While there is a long way to go before cloud computing becomes an acceptable corporate solution anywhere outside of a company firewall, the PC as a device is reaching its end in the home market, being replaced by mobile devices (witness Gen Y use of PCs vs. mobiles)." **–Ian Peter**, Ian Peter and Associates, Internet Mark 2 Project, active leader in Internet Governance Caucus and Internet Governance Forum

- "To a large degree this depends on *where* you are, geographically and demographically. Outside the US and most developed nations, the cloud will be the fundamental vehicle. Within the US, with its (by then) nearly 40-year foundation of desktop (and corporate internal) computing, the cloud will have various values, probably more useful to individuals than to institutions, although that too will depend on the changing structure of business." **–Gary Arlen**, president, Arlen Communications, founder of The Internet Alliance and member of the board for NTN Buzztime Inc.; http://www.arlencom.com/gary.htm

- "Business models will provide premium services and applications on the cloud for monetization. However most of the world population will continue to use pirated software on their desktops and alternative/free cloud services." **–Seiiti Arata**, Internet Governance Forum secretariat, United Nations; http://br.linkedin.com/in/seiiti

- "Hype runs rampant once again, with bold statements that most people will have something because some small, elite, leading-edge group has it today. Ten years may seem soon, but anyone honestly looking at the adoption of technology for the past three decades will admit that things take time until a majority of us have anything. By 2020, what's most likely is a splintering of people further into haves and have-nots.

Even in a developed country such as the US, one in seven households don't have regular food as of 2008, worse than the one in nine households in 2007. Worldwide, an estimated 2 billion people are similarly situated. Income disparity is also widening. So, how will such a rapid shift to widespread internet access happen with such basic needs unmet by so many people?" **–Dan Ness**, principal analyst, MetaFacts; http://www.linkedin.com/in/danness

- "Using the cloud requires broadband access. If we really want a smart and productive America, we've got to ensure that citizens have broadband access as a civil right, not just an economic choice. Populations that don't make it to the cloud are going to be a severe disadvantage. In turn, that's going to drag down productivity overall." **–Tim Marema**, vice president at the Center for Rural Strategies, http://www.linkedin.com/pub/tim-marema/7/b47/a82

- "Different markets and different parts of the world – and different types of communities – may find themselves choosing different mixes of tools for different reasons. Some bandwidth reasons, some for privacy reasons, and perhaps other reasons. Internet usage and habits are not globally uniform by any means and they certainly won't be by 2020. It's possible that the rise of cloud computing may lead to greater segmentation between those who function in the cloud and those who don't. Or smart enterprises will develop applications, software, and devices that bridge those two worlds so that they can communicate and collaborate with one another. Plus you are making assumptions about desktops. Many parts of the world will be using other kinds of devices to go online – many of them mobile – but may still not be reliant on the cloud. The PC is just a phase. Much of our computing then will be done by a whole range of devices – appliances, vehicles, clothing, accessories, what have you. But that doesn't mean that the computing done on these devices will necessarily reside in the cloud. It could reside on a local server in the home or office, for instance. For places where electricity and bandwidth are not so reliable that would make more sense." **– Rebecca MacKinnon**, visiting fellow at Princeton University's Center for Information Technology Policy, co-founder of Global Voices Online and board member at Global Network Initiative; http://www.linkedin.com/in/rmackinnon

The very essence of the idea of cloud computing continues to evolve, as does every aspect of the internet; it is difficult to predict what will happen because there are continuous adjustments to new realities and limitations, but we know that the drive to gain access to information everywhere and the rapid evolution of the tools to do this will continue to bring massive change.

- "The tension with cloud computing or client versus server side will always persist. I cannot tell which will advance more quickly, although I see positive signs from the crypto-in-the-cloud movement that makes this issue less relevant. However, recall that a lot of mundane tasks can still benefit from a local copy, and some people are always reluctant to submit their information. Persistent security breaches and data leaks will only reinforce this skepticism. Personally, I would like to see more in terms of always-on browserver technology that create a space for a third kind of relationship where

everyone has their own cloud. Opera's browser has led the way in many innovations in the past, and they are moving in this direction. I wonder whether others will follow suit and lead to a broad adoption of this." **–Bernie Hogan**, research fellow, Oxford Internet Institute, University of Oxford; http://people.oii.ox.ac.uk/hogan/

- "As the capability develops for 'power' in increasingly mobile devices, so does the risk of loss. It is that risk which will enable cloud, the ability to both access and protect from the trials of single-point-of-failure hardware that will drive adoption of cloud applications. However, such applications will NOT look like Google Docs, but more collaborative in nature. Google Docs is an attempt to mimic the PC model of standalone; cloud applications need to bring in more collaborative and integrated natures to social constructs." **–Dave McAllister,** director, open source and standards (OSS), standards, Adobe Systems, owner of OSB Technologies; http://www.linkedin.com/in/davemc

- "The question has more to do with how most apps will be developed and deployed. The answer to that, as far as I'm concerned, is through web apps that run in a browser-like environment. The simple reason is that computing is becoming more social, and when it comes to social applications, it's a lot harder to make assumptions about the technology or apps that are available to any given user. The way around this is to deploy apps through the web – that only require a net connection to function or operate. In this sense, it seems unavoidable that most apps will become more 'webby' – though there will still no doubt be 'native-only' apps that stick around, like Mac OS 9 apps or DOS apps. It's just that the network is now becoming a computing resource that developers take for granted; without a connection, an application is essentially dead. Given that, how can you resist a complete move to web-driven and delivered apps?" **–Chris Messina**, open web advocate at Google and a board member at the OpenID Foundation; http://www.google.com/profiles/chris.messina

- "Personal computers are an intermediate form. They are obsolescent. Once virtual keyboards and eye-oriented 'screens' become more common, PC's will be relegated to history." **–Bud Levin**, program head/psychology, Blue Ridge Community College and vice chairman of the FBI/PFI Futures Working Group; http://academic.brcc.edu/levin/prof.htm

- "We are moving to almost a science-fiction-type world in which we communicate with one another, and have access to our own past thoughts, wherever and whenever we desire. The device will be more and more like a 'Dick Tracy' watch with access to the world's data, and other people, with us at all times. Privacy will be an issue, as will how to make money from our original thoughts, yet we should be able to work this out. It will mean a breakdown or change to existing copyright laws, etc. The younger generation does not even worry about this; they share just as they were taught in kindergarten. Look at shared software, etc. Lawyers will delay this transformation since they are worried about their financial future in such a new world of ubiquitous information and collaborative work." **–Ed Lyell**, professor of business and economics, Adams State College, designer and consultant for using computers and telecommunications to improve school effectiveness through the creation of 21st century learning communities; http://www.edlyell.com/About.html
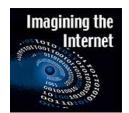
- "Ubiquitous connectivity advances ubiquitous computing. Geometric increases in broadband throughput, computer processing power and capacity combined with amazing advances in nanotechnology and microminiaturization of electronic components will, over the next ten years, permit communities to create virtualized spaces using something like super-RFID chips to monitor and connect personal devices for communications and computing. I'm thinking of spaces where something like an open, non-proprietary 'Second Life' merges seamlessly with real life. So by all means I choose 'the cloud,' and much, much more." **–Frank Paynter**, Sandhill Technologies LLC; http://www.google.com/profiles/fpaynter#about

- "Set aside the concept of 'smartphones.' In 2020, they will be viewed in the same way we look at the early brick cell phones – obsolete, foundational and good for a laugh. A new paradigm will be in place that will integrate personal communications, personal computing and personal who knows what. Look at how the iPhone has changed the mobile landscape in just a couple of years. We will definitely see two or three such paradigm shifts by 2020." **—Dave Rogers**, managing editor, Yahoo Kids at Yahoo, principal, UXCentric, Inc.; http://www.linkedin.com/pub/dave-rogers/0/780/b49

- "The trend in computing is for smaller devices that run faster and more cheaply. Computers will be implanted in the body, and thought interfaces are becoming more practical. This is already a reality for some prosthetic devices. As far as cloud computing goes, we will be using encrypted high-security resources in the cloud, dedicated to our own purposes and certified for privacy." **–Hal Eisen**, senior engineering manager at Ask.com; http://www.linkedin.com/pub/hal-eisen/0/95/a24

- "As more and more people get comfortable with the idea of the cloud, and the enhancements to the mobile access points improve driving greater day-to-day efficiencies, more people will seek to create for and build systems for the cloud. We will experience amazing results for business, relationships and society as a result." **–Brian O'Shaughnessy**, head of global communications at Skype; formerly director of global communications and public affairs, Google, director of corporate communications, VeriSign, director of policy communications, Network Solutions and director of public policy, Internet Alliance; http://lu.linkedin.com/in/brianoshaughnessy

About the Pew Research Center's Internet & American Life Project

The Pew Research Center's Internet & American Life Project is one of seven projects that make up the Pew Research Center, a nonpartisan, nonprofit "fact tank" that provides information on the issues, attitudes and trends shaping America and the world. The Project produces reports exploring the impact of the Internet on families, communities, work and home, daily life, education, health care, and civic and political life. The Project aims to be an authoritative source on the evolution of the Internet through surveys that examine how Americans use the Internet and how their activities affect their lives.

The Pew Internet Project takes no positions on policy issues related to the Internet or other communications technologies. It does not endorse technologies, industry sectors, companies, nonprofit organizations, or individuals.

URL: http://pewinternet.org

About the Imagining the Internet Center at Elon University

The Imagining the Internet Center's mission is to explore and provide insights into emerging network innovations, global development, dynamics, diffusion and governance. Its research holds a mirror to humanity's use of communications technologies, informs policy development, exposes potential futures and provides a historic record. It works to illuminate issues in order to serve the greater good, making its work public, free and open. The center is a network of Elon University faculty, students, staff, alumni, advisers, and friends working to identify, explore and engage with the challenges and opportunities of evolving communications forms and issues. They investigate the tangible and potential pros and cons of new-media channels through active research. Among the spectrum of issues addressed are power, politics, privacy, property, augmented and virtual reality, control, and the rapid changes spurred by accelerating technology.

The Imagining the Internet Center sponsors work that brings people together to share their visions for the future of communications and the future of the world.

URL: http://www.imaginingtheInternet.org

Methodology

The survey results are based on a non-random online sample of 895 Internet experts and other Internet users, recruited via email invitation, Twitter or Facebook from the Pew Research Center's Internet & American Life Project and the Imagining the Internet Center at Elon University. Since the data are based on a non-random sample, a margin of error cannot be computed, and the results are not projectable to any population other than the experts in this sample.